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# CANADA

## FINANCIAL SECTOR ASSESSMENT PROGRAM

January 2020

## TECHNICAL NOTE—STRESS TESTING AND FINANCIAL STABILITY ANALYSIS

This Technical Note on Financial Safety Net and Crisis Management for the Canada FSAP was prepared by a staff team of the International Monetary Fund as background documentation for the periodic consultation with the member country. It is based on the information available at the time it was completed in October 2019.

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## FINANCIAL SECTOR ASSESSMENT PROGRAM

December 20, 2019

# TECHNICAL NOTE

## STRESS TESTING AND FINANCIAL STABILITY ANALYSIS

Prepared By

**Monetary and Capital Markets Department**

This Technical Note was prepared by IMF staff in the context of the Financial Sector Assessment Program that visited Canada in October 22–November 14, 2018 and February 6–26, 2019. 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

| | |
|---|---|
| ABS | Asset-backed Securities |
| AC | Amortized Cost |
| AIRB | Advanced Internal Ratings Based |
| AMF | Autorité des marchés financiers |
| AUM | Assets Under Management |
| BMA | Bayesian Model Averaging |
| BOC | Bank of Canada |
| Can$ | Canadian Dollar |
| CCB | Capital Conservation Buffer |
| CET1 | Common Equity Tier 1 |
| CMHC | Canada Mortgage and Housing Corporation |
| D-SIB | Domestic-Systemically Important Bank |
| D-SIFI | Domestic-Systemically Important Financial Institution |
| DSB | Domestic Stability Buffer |
| DSR | Debt-servicing Ratio |
| DTI | Deposit-taking Institution |
| EBITDA | Earnings Before Interest, Taxes, Depreciation and Amortization |
| ECL | Expected Credit Losses |
| FSAP | Financial Sector Assessment Program |
| FVOCI | Fair-value Through Other Comprehensive Income |
| FVTPL | Fair-value Through Profit or Loss |
| G-SIB | Global-Systemically Important Bank |
| GFC | Global Financial Crisis |
| HELOC | Home Equity Line of Credit |
| HoA | Heads of Agencies |
| IFRS | International Financial Reporting Standards |
| IRB | Internal Ratings Based |
| LCR | Liquidity Coverage Ratio |
| LGD | Loss Given Default |
| LTV | Loan-to-Value |
| MBS | Mortgage-backed Securities |
| NHA | National Housing Act |
| OSFI | Office of the Superintendent of Financial Institutions |
| PD | Probability of Default |
| PiT | Point-in-time |
| RCAP | Regulatory Compliance Assessment Program |
| ROW | Rest of the World |
| RWA | Risk-Weighted Assets |
| SAC | Senior Advisory Committee |
| STA | Standardized Approach |
| TDS | Total Debt Service-to-Income |
| TN | Technical Note |
| VaR | Value-at-risk |

# EXECUTIVE SUMMARY[1]

**The financial system's performance has been strong.** The banking sector has enjoyed solid profitability and sizeable capital buffers. The insurance sector has remained financially sound even in the low interest rate environment. Other nonbank sectors have grown considerably, with pension funds and mutual funds dominating the institutional and retail asset management landscape. Major banks, life insurers and pension funds have expanded their footprints abroad. Canada has strong financial linkages with the United States.

**Macrofinancial vulnerabilities—notably, elevated household indebtedness and housing market imbalances—remain substantial, posing financial stability concerns.** During the decades-long credit upcycle, low interest rates, and low capital charges for mortgage lending, together with policies promoting housing ownership, have fueled borrowing to finance home purchases in the face of rapidly rising house prices. Downside risks to house prices in the medium term are sizeable given existing overvaluation, and Canada-specific housing finance characteristics may amplify procyclical effects of falling house prices due to borrowers' refinancing pressures and lenders' sudden adoption of risk-based mortgage pricing. During severe downturns, the household sector would be affected, with a significant increase in debt belonging to financially weak households, while the corporate sector would remain more robust.

**Major deposit-taking institutions would be able to manage severe macrofinancial shocks, but mortgage insurers would probably need additional capital.** In a severe adverse scenario, major deposit-taking institutions would be able to rebuild their capital positions to meet the regulatory requirements. Although credit and market risk related risks appear to have a substantial impact under stress, the relatively high starting point capital ratios, the robust structural profitability and the dual layered mortgage market structure that partially mitigates some of the risks provide a generous buffer for deposit-taking institutions. By contrast, mortgage insurers would face some capital shortfalls. Nevertheless, financial stability implications are limited given the government's backstopping of mortgage insurance contracts.

**Major deposit-taking institutions also hold sufficient liquidity buffers to withstand sizeable funding outflows.** However, increased balance sheet complexity and reliance on wholesale and FX funding, and the extensive use of derivatives are some areas of concern that would warrant closer monitoring by the competent authorities and a more comprehensive quality assurance in the context of supervisory or macroprudential stress testing exercise.

**Large life insurers appear somewhat exposed to financial market stress and lower interest rates.** The solvency of some major life insurers could become under pressures during severe financial market stress, largely due to the impact of widening credit spreads and falling equity prices.

[1] This Technical Note was prepared by Phakawa Jeasakul, Adrian Alter, Farid Boumediene, Henry Hoyle, and Dimitrios Laliotis. The stress tests and other analyses were conducted as part of the 2019 Canada FSAP led by Ghiath Shabsigh (mission chief) and Phakawa Jeasakul (deputy mission chief).

This stems from the fact that life insurers hold a sizeable amount of low-rated and unrated bonds. Furthermore, life insurers' solvency would be hit hard in a more sustained low interest rate environment.

**Increased investor risk-taking, stretched asset valuations, and dependence on foreign creditors raise the risk of market volatility and a sharp tightening in financial conditions.** Pension funds and other institutional investors have increased use of private market strategies and derivatives, which are adding to leverage and liquidity risks. Fixed income-focused investment funds have grown rapidly and have been increasing exposure to credit and duration risk, increasing the risk of a redemption shock. Fixed income and real estate asset valuations are stretched, while dependence on foreign investors for corporate bond market funding has increased significantly. In a market stress scenario, rising valuation and liquidity risks could magnify losses and amplify market volatility, with spillovers to banks and insurers owing to their holding of securities and derivatives. Furthermore, elevated dependence on foreign funding increases the risk that financial conditions would tighten sharply.

**Additional required capital for mortgage exposures, along with measures to increase risk-based differentiation in mortgage pricing, are desirable.** While banks' overall capital buffers are adequate, lenders' risk weights for mortgage exposures should be higher. Mortgage insurers' capital requirements should also be tightened so that required capital is enough to absorb tail-risk shocks. In addition to properly accounting for through-the-cycle credit risk, these measures can help improve mortgage risk-pricing and limit procyclical effects of falling house prices. In addition, risk-based pricing of insured mortgages should be improved by increasing the risk sensitivity of insurers' capital requirements or guarantee fees paid to the government and limiting insurance coverage of loans that fund insurance premiums.

**Enhanced risk monitoring is essential especially in the areas of emerging vulnerabilities.** These include (i) banks' external, foreign-currency funding; (ii) extensive use of derivatives; (iii) rising risk-taking by life insurers, pension funds, and other nonbanks; (iv) non-prime mortgage lending outside the regulatory perimeter and HELOCs; and (v) spillovers from overseas operations and cross-border exposures. Continued efforts to address data gaps—particularly related to cross-sectoral exposures, unregulated nonbank financial intermediation, and funding market activities (e.g., securities lending)—would help gather a more complete picture of risk buildups.

**The top-down stress testing capacity for banks and insurers should be enhanced.** A priority should be given to further development of the BOC's bank solvency stress testing framework; the lack of granular data impedes the ability to project key financial items by significant geographies and the capacity to fully model all risk components.

**Given their systemic relevance, strengthening oversight of large public pension funds would be helpful.** Increasing the detail, standardization, and reporting frequency of financial disclosures, as well as introducing standardized liquidity stress testing requirements, would improve risk monitoring and assessment.

| Table 1. Canada: Recommendations to Bolster the Financial System's Resilience | | |
|---|---|---|
| **Recommendations** | **Priority** | **Timeframe** |
| Raise required capital for mortgage exposures at both banks and mortgage insurers to fully account for through-the-cycle credit risk (OSFI, AMF) | H | NT |
| Enhance risk monitoring of banks' funding and use of derivatives, risk-taking by nonbanks, housing finance-related vulnerabilities, and cross-border and intra-system interconnectedness; carry out Canada-wide surveillance in key sectors such as deposit-taking and insurance (BOC lead; HOA, SAC; OSFI, AMF) | H | NT |
| Strengthen oversight of large public pension funds, and increase transparency of their financial disclosures (DOF, provincial governments) | H | NT |
| Enhance the scope and level of granularity of bank specific data that is reported on a regular basis to fully capture the data requirements for fully-fledged microprudential and system-wide/macroprudential stress testing (BOC, OSFI, AMF) | M | MT |
| Develop a coherent framework (including appropriate data sets, indicators and analytical models) for the monitoring, assessment and mitigation measures of risks linked to household and corporate balance sheets. The framework should be tailored to capture domestic market specificities (renewal and roll-over risks, affordability and indebtedness constraints, lack of historical data covering full economic cycles, risk-based pricing, and product related vulnerabilities) (BOC lead) | M | MT |
| Further develop macroprudential stress testing capacity to fully account for some risk types that are currently partially covered (market risk, counterparty risk, and derivatives-related risk) (BOC lead) | M | MT |
| Closely monitor life insurers' portfolios of low-rated and unrated debt securities (OSFI, AMF) | M | MT |
| Carefully consider how risk margins interact with the regulatory solvency framework for life insurers in the context of preparation for the new accounting standards (IFRS 17) (OSFI, AMF) | M | MT |
| Use proxies from the international experience or innovative modelling to complement the limited historical episodes of economic downturns in assessing downturn or stressed parameters in their prudential or supervisory tasks (BOC, OSFI, AMF) | M | MT |
| Strengthen capacity to monitor risks in the complex and fast-evolving nonbank financial sector, including strengthening data collection for private fund structures, captive financial institutions and money lenders, and other nonbank financial institutions, to improve their ability to track their growth, financial system linkages, and risk profile (BOC; CSA) | M | MT |
| Strengthen risk surveillance for investment funds; enhance bond funds' liquidity risk management capabilities by requiring enhanced disclosures to supervisors or investors on relevant policies and assessments; consider liquidity management tools such as redemption gates, fees and swing pricing (BOC; CSA) | M | MT |
| Note: Institutions in parenthesis are the agencies with responsibilities. In terms of priorities, H, M and L stand for high, medium and low. In terms of timeframe, I, NT, and MT stand for immediate (within one year), near-term (within 2–3 years), and medium-term (within 3–5 years). | | |

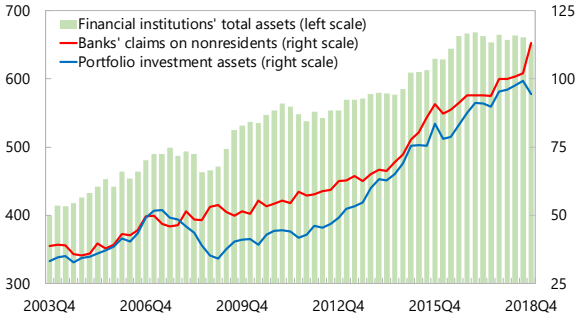
# INTRODUCTION

## A. Financial System Structure

**1. Canada has one of the largest and most developed financial systems in the world** (Figure 1, Table 2)**.** As of end-2018, total assets of Canadian financial institutions reached US$10.2 trillion or 626 percent of GDP, and outstanding debt securities and stock market capitalization amounted to US$2.2 and US$1.9 trillion, or 133 and 119 percent of GDP, respectively. Deposit-taking institutions, pension funds, mutual funds, and insurers dominate the financial system, accounting for about 45, 18, 17, and 13 percent of financial institutions' total assets, respectively. Each segment of Canada's financial system—deposit-taking, insurance, pension, asset management, and capital markets—is among the largest in the world in nominal terms.

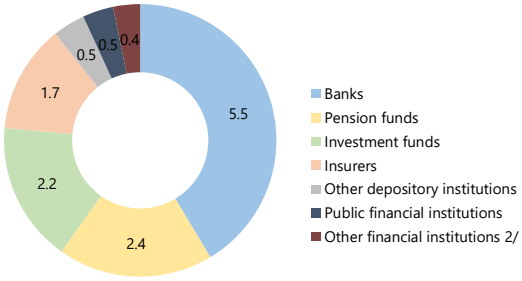
**2. The financial system has enjoyed solid overall growth and international expansion since the 2014 FSAP.** Total assets of financial institutions have increased by 31 percent (since end-2013), underpinned by robust assets growth of banking sector, mutual funds and pension funds. Overall banking sector growth is partly driven by the expansion of U.S. operations, with total claims on nonresidents increasing to 41 percent of banking sector assets (from 31 percent). Royal Bank of Canada became a global systemically important bank in 2017. Mutual funds and pension funds have also expanded their cross-border investment, driving Canada's international portfolio investment assets to 95 percent of GDP (from 60 percent). Domestically, banks finance about two-thirds of private sector credit, while bond issuance and nonbanks are important alternative funding sources.

**Financial System: Size and Internationalization, 2003-18**
(In percent of GDP)




Source: Bank of Canada; IMF, International Financial Statistics and World Economic Outlook database; Haver Analytics.

**Composition of Financial Institutions' Total Assets, 2017[1]**
(In trillions of Canadian dollar)




Source: IMF staff estimate based on data from Canadian authorities, FSB, Haver Analytics and OSFI.
1/ Based on consolidated balance sheet basis.
2/ Excluding captive financial institutions and money lenders.

**3. The financial system is highly concentrated.** The six largest banks and Québec's major credit cooperative group—designated as domestic systemically important financial institutions (D-SIFIs)—account for about 90 percent of deposit-taking sector assets, while the three largest life insurers account for about 70 percent of total net premiums. These banks and life insurers, together with large public pension funds, are globally active and systemically relevant for Canada's financial system. Retail and wholesale banking, wealth management, and capital markets are the main business lines of major banks; their subsidiaries are among leading securities market intermediaries and asset managers.

**4. Financial markets also provide an important venue for public and private sector financing.** While bond markets continue to expand by about 39 percent since end-2013, Canadian corporates and financial institutions have increasingly issued debt internationally, driving up the share of foreign-currency debt securities from 26 percent to 34 percent. The public debt market also includes provincial debt securities and government-guaranteed mortgage-backed securities (MBS), which jointly account for two-third of public debt instruments. Other core funding markets include money markets (repo, securities lending, and bankers' acceptances) and foreign-exchange markets (spot and swap).

**5. The government plays a central role in housing finance.** The government provides mortgage insurance through CMHC and backstops private insurers' mortgage insurance (subject to 10 percent deductibles of original mortgage principal). Furthermore, CMHC provides a timely payment guarantee for securitization of qualified insured mortgages. As of 2018Q3, insured mortgages and government-guaranteed MBS (i.e., National Housing Act (NHA) MBS) amounted to Can$723 and Can$485 billion, respectively.

**6. Various parts of the financial system are directly exposed to the housing market and/or linked through housing finance.** Total residential and nonresidential mortgage credit amounted to Can$1.8 trillion, or 81 percent of GDP, at end-2018. Mortgage credit is provided by banks (69 percent) and other financial institutions; households are the main borrowers (81 percent), followed by corporates. Life insurers and pension funds have increased their investment in commercial real estate, while financial institutions hold around Can$180 billion in NHA MBS. The government's central role in housing finance fortifies the financial-sovereign nexus.

## B. Macrofinancial Conditions

**7. The economy regained momentum following a slowdown driven by low oil prices** (Figure 2, Table 3)**.** Canada has enjoyed macroeconomic stability since the global financial crisis (GFC). Amid a sharp decline in oil prices, real GDP growth moderated significantly in 2015, with resource-rich provinces being particularly hard hit. The economy recovered during 2016–17, led by robust private consumption, and performed well in the first three quarters of 2018. With weak performance in recent quarters, real GDP growth is projected to be at 1.5 percent in 2019 before picking up to 1.9 percent in 2020, respectively. The medium-term outlook looks less promising, with growth expected to slow to around 1.6 percent by 2024, reflecting longstanding structural problems related to low labor productivity growth, population aging, and deteriorating international competitiveness.

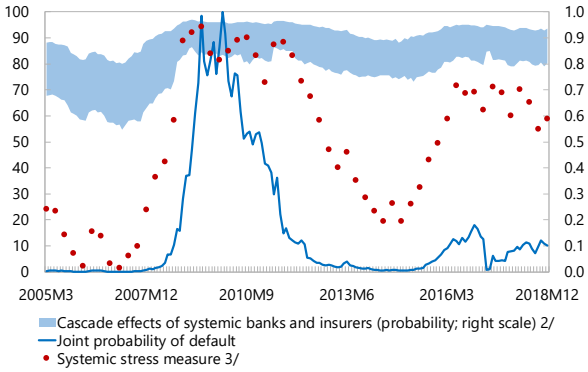
**8. Financial conditions remain loose due to still favorable pricing of risk.** In response to rising inflationary pressures, the Bank of Canada (BOC) initiated a tightening cycle in mid-2017, with five rounds of rate hikes. More recently, the BOC has communicated that an accommodative monetary policy stance is warranted. Long-term bond yields have subsequently declined following the rise during the tightening phase. Despite some bouts of market volatility in recent months, overall pricing of risk, which captures term and credit premiums, remains near historical lows.

**9. Credit growth has moderated in line with the softening housing market due to monetary tightening and prudential measures.** As of 2019Q1, credit growth moderated to 4.8 percent year-on-year. Several rounds of policy measures have successfully reduced insured mortgage lending and improved credit quality, with the share of banks' new lending to highly indebted borrowers falling sharply. Meanwhile, house prices have been broadly stable in the past couple years, and housing market-related activities—including construction, inventory and sales, and mortgage lending—have also moderated. However, home equity lines of credit (HELOCs) have grown rapidly, some of which feature interest-only payment.[2] Borrowers may utilize available credit lines to satisfy the loan-to-value (LTV) requirements when obtaining new mortgages, consolidate existing higher-cost debt, or meet regular payments on other loans.

**10. Market data suggests that systemic stress of financial institutions is low.** Based on the market-based analysis of 19 large financial institutions as of December 2018, the probability that several financial institutions experience distress simultaneously was near historical lows. The systemic stress measure, which captures the number of institutions potentially becoming distressed and the system-wide expected loss, has been broadly stable over the past few years. Nevertheless, potential contagion effects appear to have risen over the past decade, reflecting interconnectedness among financial institutions and/or growing common exposures to the housing market.

**Market Perception of Systemic Stress, 2005-18[1]**

Index between 0 and 100, representing from low to high systemic stress




Sources: Bloomberg; Moody's Analytics; and IMF staff estimates.

1/ The analysis is based on the "Surveillance of Systemic Risk and Interconnectedness" approach. See Segoviano and Goodhart (IMF WP/09/4) and Technical Note on Systemic Risk and Interconnectedness Analysis, 2016 United Kingdom FSAP (IMF Country Report 16/164). The sample includes 10 deposit taking institutions, 7 insurers, and 2 other nonbank entities.

2/ Cascade effects capture the probability that at least another institution became distressed given than a particular institution became distressed.

3/ The systemic stress measure comprises (i) number of institutions to become distressed given than at least one became distressed; and (ii) expected loss related to 1st-percentile tail risk. Both indictors are combined based on their percentile ranking.

**11. Macrofinancial vulnerabilities have declined recently but are still substantial.** Given relatively limited fiscal and external vulnerabilities (Figure 3), financial stability risks remain heightened mainly due to:

- **High household indebtedness.** Household debt reached 96 percent of GDP at end-2018. Canadian households are among the most indebted in advanced economies. Their debt-servicing obligations, already relatively large, could increase as interest rates rise. Households as a whole have large buffers, with net wealth of 489 percent of GDP. However,

[2] This credit growth of HELOCs has been primarily concentrated in the amortizing mortgage component. Based on regulatory data on residential secured lending from federally-regulated Canadian banks, Al-Mqbali, Bilyk, Caputo, and Younker (2019) found evidence that HELOC growth has outpaced that of mortgages over 2017–18, but total outstanding balance has recently contracted.

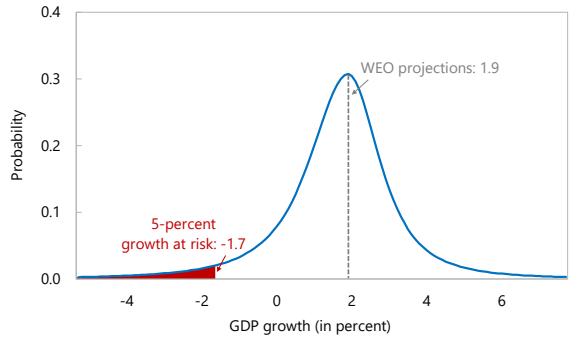
pockets of financially weak households in terms of excessive indebtedness or weak debt servicing capacity exist.

- **Persistent housing market imbalances.** Overvalued house prices (relative to fundamentals such as income or rent) continue to underpin the imbalances. While house prices have largely stabilized over the past year, imbalances continue to persist in major cities such as Toronto and Vancouver.

- **Growing corporate debt.** Corporate debt has risen rapidly to 111 percent of GDP at end-2018, largely driven by debt issuance (including in foreign currency) and non-mortgage borrowing. Overall profitability has recovered from the economic slowdown, but firms in the oil and gas and mining sectors continue enduring weak earnings. The rapid increase in debt of firms in the real estate sector raises a concern, especially given their weak income growth.

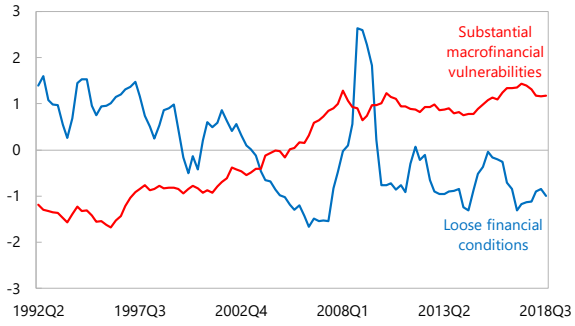
**12. Growth-at-risk analysis points to substantial downside risk to growth due to significant macrofinancial vulnerabilities.** Growth-at-risk analysis provides a distribution of real GDP growth forecasts conditional on financial conditions and macrofinancial vulnerabilities. The latter captures corporate and household sector vulnerabilities, housing market imbalances, and credit-to-GDP gap. As of 2018Q3, the analysis suggests a 5 percent probability that real GDP growth would be -1.7 percent or less over the next year, and -1.6 percent (annualized) over the next three years. Downside risk to growth has declined over the past year due to some reductions in housing market imbalances and credit-to-GDP gap.

**Distribution of GDP Growth Forecasts, 2018Q3**
Based on growth over the next 4 quarters; annualized




Source: IMF staff estimates.

**Financial Conditions and Macrofinancial Vulnerabilities, 1992-2018**




Source: IMF staff estimates based on data from Haver Analytics.

## C. Scope of the Financial Stability Analysis in the FSAP

**13. The FSAP took a comprehensive approach to assess financial stability risks (Figure 4).** The analysis presented in this technical note included assessing key macrofinancial vulnerabilities, the resilience of deposit-taking institutions and insurers against macrofinancial shocks, and risk-taking in nonbank financial sectors and markets. Additional analysis on intra-system and cross-border interconnectedness, systemic liquidity, and housing finance is presented in other FSAP documents. The FSAP exercise comprised the following modules:

- **Analysis of macrofinancial vulnerabilities.** The analysis focused on vulnerabilities in the corporate and household sectors as well as those related to the housing market. The FSAP team employed the debt-at-risk approach to quantify the amount of debt-at-risk, which is owed by financially weak corporates and households. The FSAP team also performed house price-at-risk analysis to gauge downside risk to house prices.

- **Bank solvency stress tests.** The FSAP team conducted a top-down exercise based on the balance sheet approach for the seven largest deposit-taking institutions, which cover more than 90 percent of deposit-taking institutions' total assets, using regulatory and supervisory data. In parallel, the BOC carried out a top-down exercise, using the same sample of banks, but relied on its own methodology. All tests used the same baseline (October 2018 World Economic Outlook projections) and the adverse scenario (see the next section). In addition, a set of sensitivity tests were performed by the FSAP team.

- **Bank liquidity stress tests.** The FSAP team performed a top-down exercise for the seven largest deposit-taking institutions, using regulatory data. The exercise comprised Liquidity Coverage Ratio (LCR) tests and cash-flow analysis to examine the ability of banks to handle funding outflows, including in foreign currencies.

- **Life insurance solvency stress tests.** The FSAP team conducted a top-down exercise for the five largest life insurers, which cover about 80 percent of life insurers' total net premiums, using regulatory and supervisory data. The exercise assessed the instantaneous impact of macrofinancial shocks (consistent with the adverse scenario) on the solvency position of life insurers.

- **Mortgage insurance solvency stress tests.** The FSAP team conducted a top-down exercise for all three mortgage insurers, using regulatory data. The exercise was carried out in a manner consistent with the bank solvency stress tests to assess system-wide capital buffers for mortgage lending. The exercise thus considered two scenarios—the baseline and the adverse scenario.

- **Analysis of risk-taking in nonbanks and financial markets.** The analysis examined the landscape of nonbank financial institutions and financial market participants, analyzed risk-taking among institutional investors—particularly, pension funds—and assessed asset price valuations.

- **Investment fund liquidity stress tests.** The FSAP team conducted a top-down exercise for fixed income-focused mutual funds, which account for about 20 of mutual funds' assets under management (AUM), using publicly available data. The exercise focused on examining potential effects of large redemption shocks on the corporate bond market; the sample captured 77 percent of corporate bonds held by mutual funds. In parallel, the BOC carried out a top-down exercise, using the same sample of banks, but relied on its own methodology.

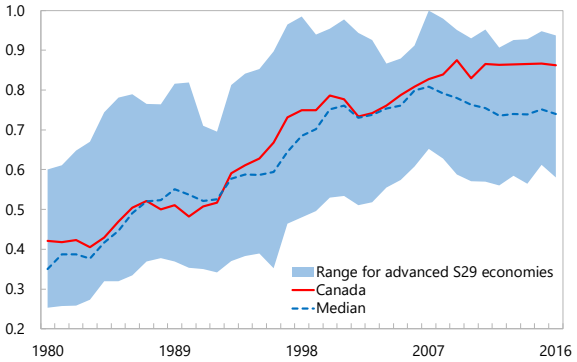
**14. The remainder of this technical note is structured as follows.** Section II presents key macrofinancial risks and the scenarios underpinning the financial stability analysis. Section III discusses macrofinancial vulnerabilities—particularly, in the corporate and household sectors and related to the housing market. Sections IV, V, VI, and VII cover bank solvency stress tests, bank liquidity stress tests, life insurance solvency stress tests, and mortgage insurance solvency stress tests, respectively. Sections VIII analyzes risk-taking in nonbank financial institutions and financial market activities, while section IX covers investment fund liquidity stress tests. Each section also concludes with relevant policy issues necessary to manage identified risks.

## Figure 1. Canada: Financial System Structure

*Canada's financial system is well developed based on the combined metrics of depth, access and efficiency.*[1]

### Financial Development Index, 1980-2016

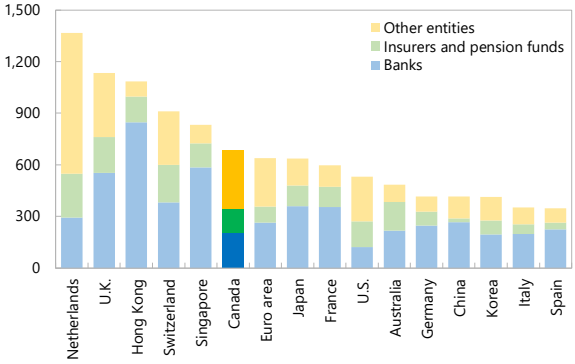
Value between 0 and 1, with the higher value, the more developed financial system




*The financial system is large, with banks, investment funds and pension funds dominating the landscape.*

### Total Assets of Financial Institutions, 2017

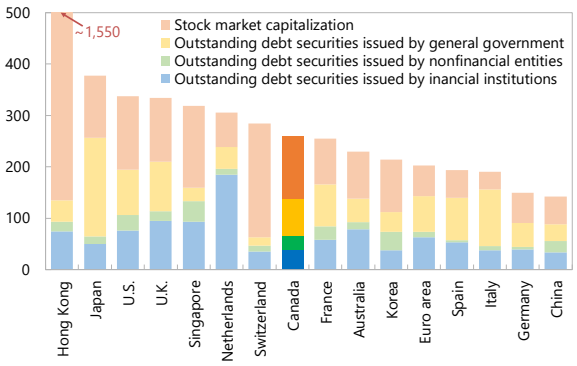
(In percent of GDP)




*The bond and stock markets are deep, serving as important venues for governments, financial institutions, and nonfinancial entities to raise funding.*

### Value of Financial Markets, 2018Q1

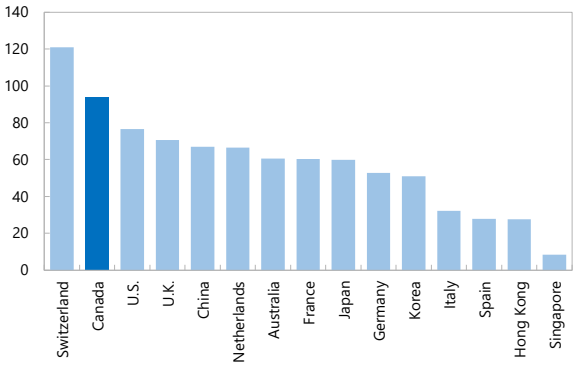
(In percent of GDP)




*Nonbank financial intermediation is relatively large, but mainly comprises collective investment schemes susceptible to run.*

### Nonbank Financial Intermediation, 2017

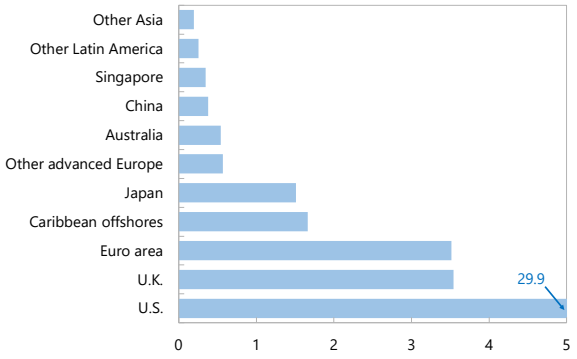
Based on the FSB's "narrow measure" of "shadow banking" (in percent of GDP)




*Canadian banks have significant exposures to the United States due to their overseas operations via subsidiaries and branches.*

### Banking Sector's Overseas Exposures, 2018Q4

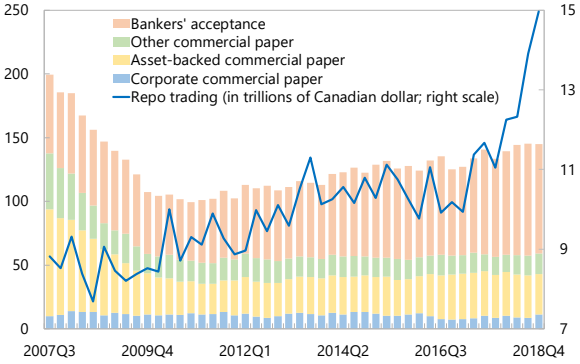
(In percent of total claims; based on the ultimate risk basis)




*The money market continues to function well, though asset-backed commercial paper activity not fully recovering to pre-2008 levels.*

### Selected Outstanding Money Market Instruments, 2007-18

(In billions of Canadian dollar)




Sources: Bank of Canada; Bloomberg; FSB, Global Monitoring Report on Non-Bank Financial Intermediation 2018; Haver Analytics; IMF, Financial Development Index database and World Economic Outlook database; and IMF staff calculations.

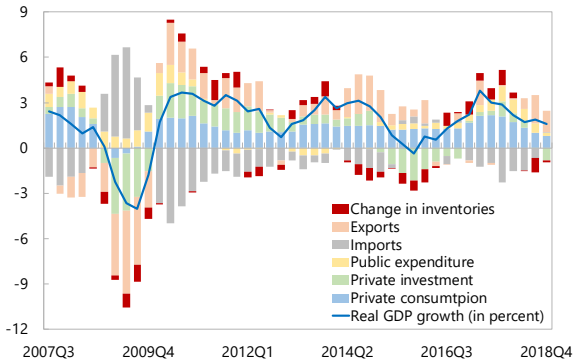
[1/] For more details about the financial development index, see IMF SDN/15/08 and IMF WP/16/5.

## Figure 2. Canada: Macrofinancial Developments

*The Canadian economy has been very resilient since the global financial crisis, …*

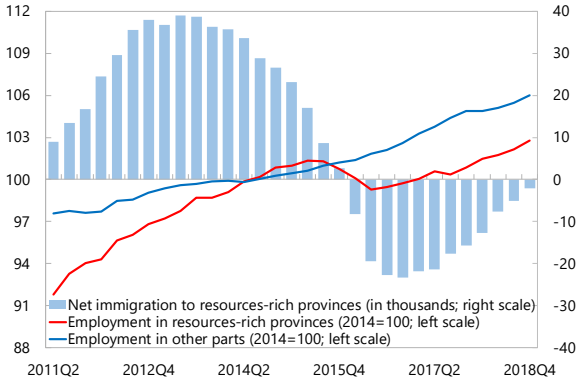
**Contribution to Real GDP Growth, 2007-18**

(In percentage points; year-on-year)



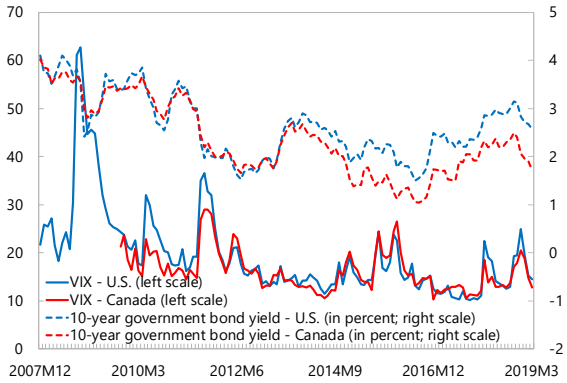

*Resources-rich provinces were disproportionately affected, with the recovery partly benefiting from internal labor mobility.*

**Employment and Interprovincial Migration, 2011-18**



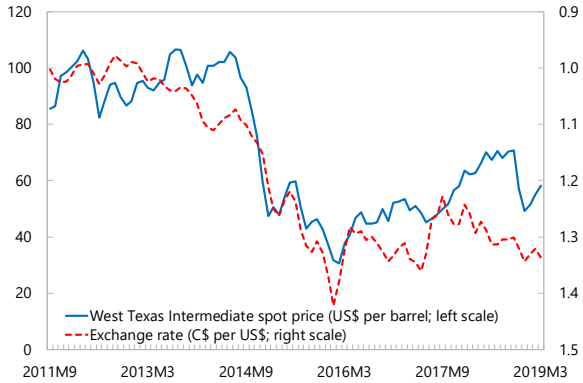

*Long-term bond yields had increased during monetary tightening but have declined more recently, along with greater market volatility.*

**Market Volatility and Long-term Bond Yields, 2007-19**




*… including its adjustment to lower oil prices.*

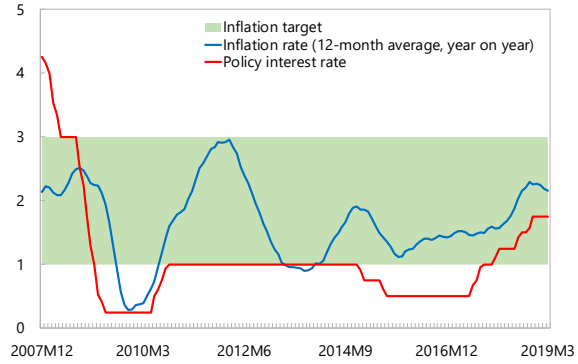
**Oil Prices and Exchange Rates, 2011-19**




*A tightening cycle of monetary policy started, with inflation within the target band.*

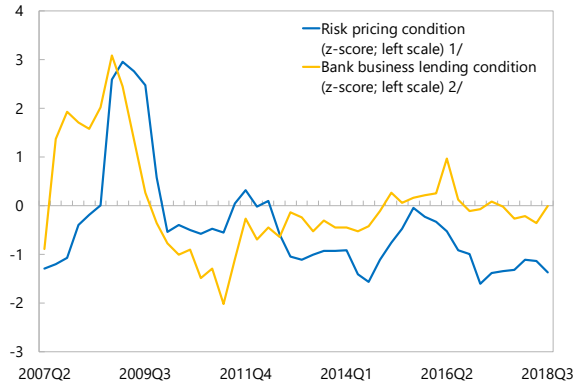
**Inflation and Monetary Policy, 2007-19**

(In percent)




*Nonetheless, financial conditions remain loose due to still favorable risk pricing conditions.*

**Financial Conditions, 2007-18**




Sources: Haver Analytics; and IMF staff estimates.

[1/] Capturing term premiums, interbank spreads, real long-term interest rates, bond and equity returns and corresponding volatility measures, all in Canada, as well as global financial conditions.

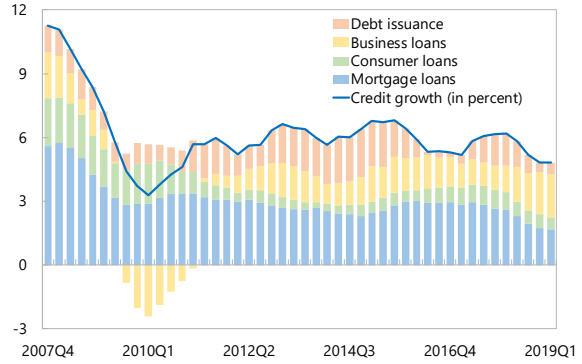
[2/] Showing percentage balance, with a positive (negative) value indicating tightening (loosening) conditions.

## Figure 2. Canada: Macrofinancial Developments (concluded)

*Credit growth has moderated due to monetary tightening and prudential measures that curb mortgage lending, …*

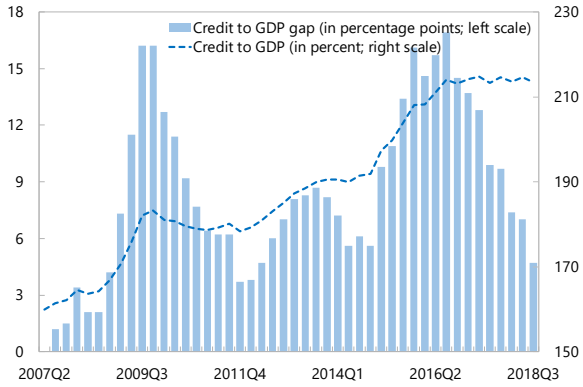
**Contribution to Credit Growth, 2007-19**

(In percentage points; year-on-year)




*… contributing to a smaller credit-to-GDP gap.*

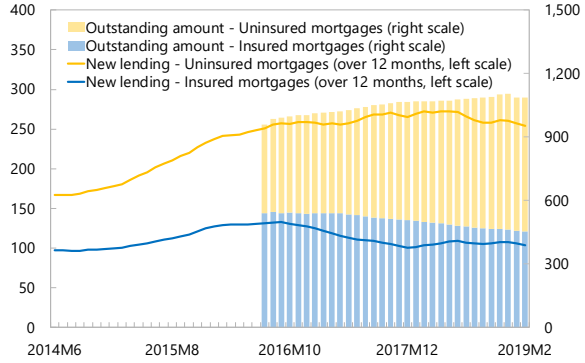
**Credit to Private Nonfinancial Sectors, 2007-18**




*The slowdown in residential mortgage lending is largely led by the decline in insured mortgages.*

**Banks' Residential Mortgage Lending, 2014-18**

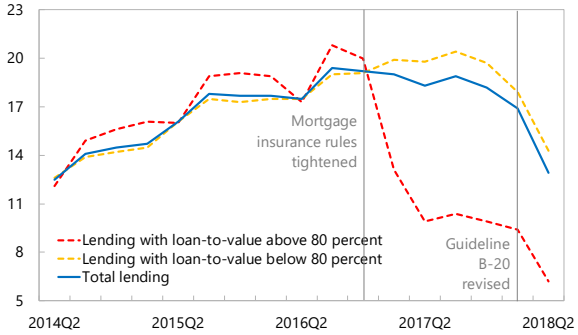
(In billions of Canadian dollar)




*Credit quality of mortgage lending has improved recently, with a lower share of highly indebted borrowers.*

**Share of Banks' New Residential Mortgage Lending to Highly Indebted Borrowers, 2014-18**

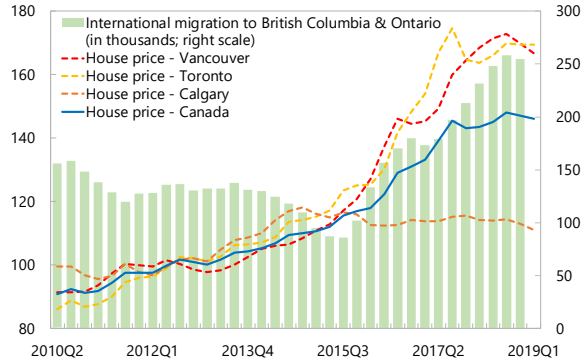
(In percent; highly indebted borrowers have loan-to-income above 450 percent)




*House prices became more stabilized in the past two years. Immigrations appear to be an important driver of rapidly rising housing prices in some regions.*

**Housing Market Development, 2010-19**

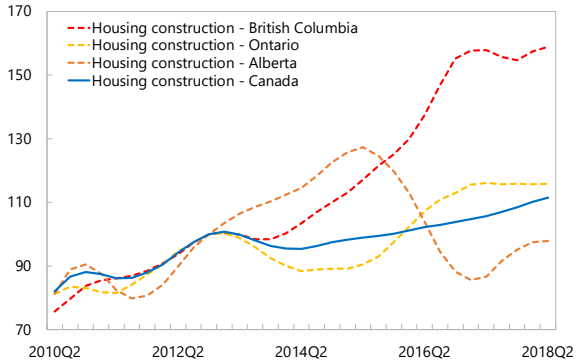
(2012=100)




*A construction boom is evident in British Columbia, while Alberta saw a boom-bust cycle driven by oil prices.*

**Construction Activity, 2010-18**

(2012=100)

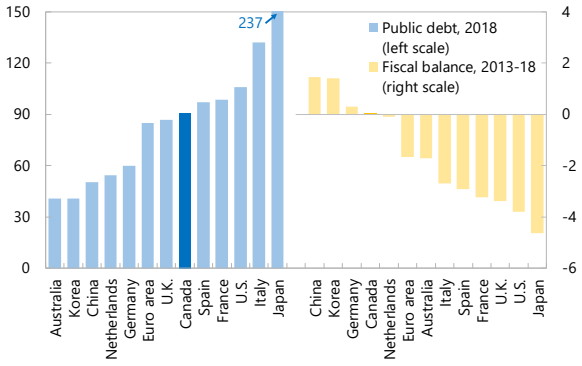



Sources: Bank of Canada, Staff Analytical Note 2018-35; Haver Analytics; and IMF staff calculations.

## Figure 3. Canada: External and Fiscal Vulnerabilities

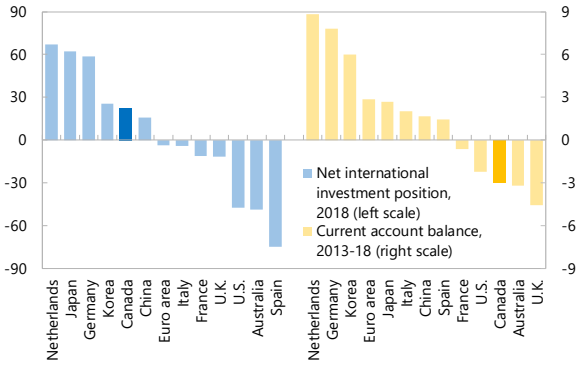
*The favorable macroeconomic outcome benefits from relatively strong public finance, …*

**Fiscal Vulnerabilities, 2013-18**
(In percent of GDP)



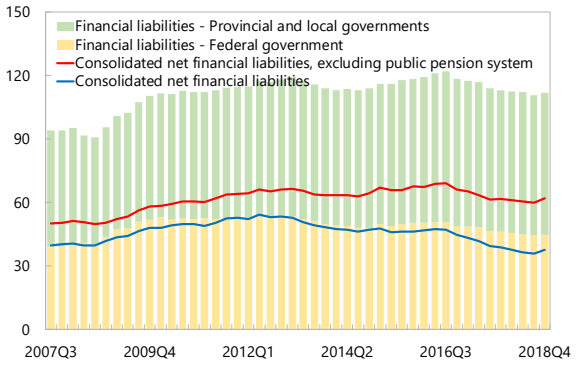

*… as well as an international net creditor status. However, the current account deficit indicates the reliance on foreign funding.*

**External Vulnerabilities, 2013-18**
(In percent of GDP)



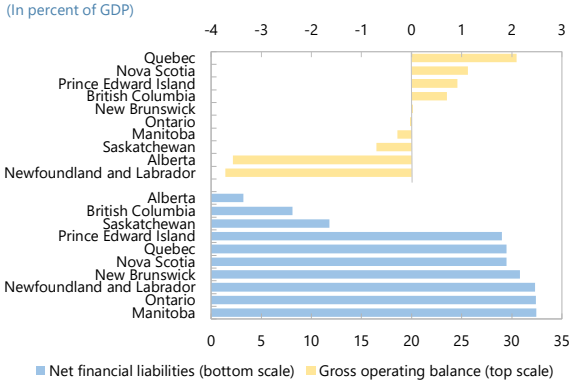

*Provincial governments have substantial financial liabilities, more than the federal government.*

**Consolidated Public Financial Liabilities, 2007-18**
(In percent of GDP)



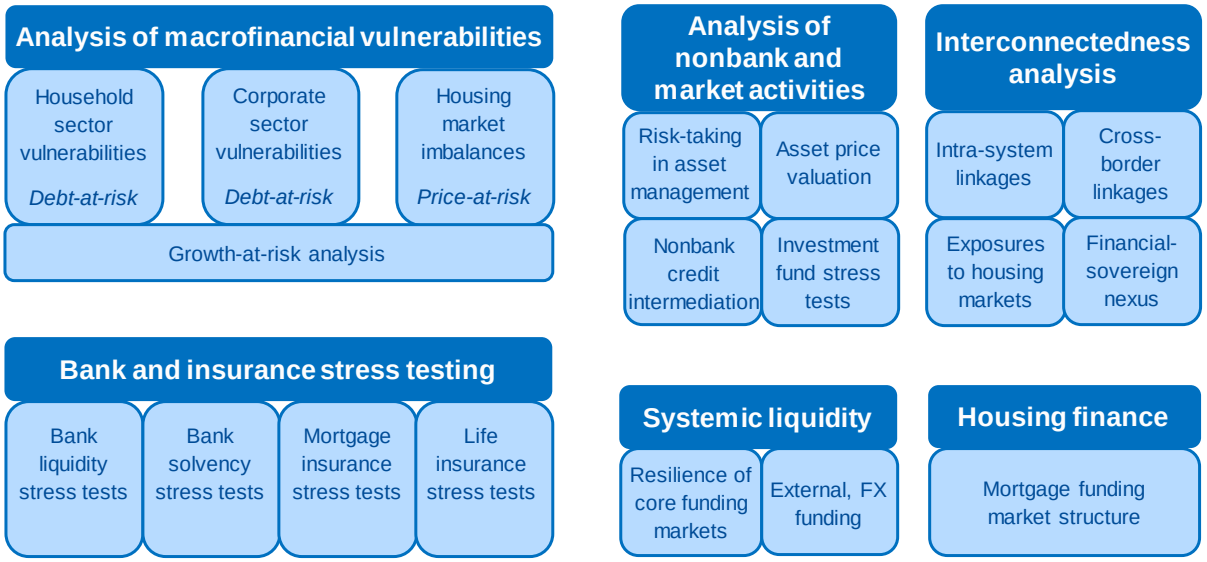

*Provincial governments' financial strength varies, potentially complicating the ability to backstop financial institutions in their respective jurisdictions.*

**Provincial Public Finance, 2017**
(In percent of GDP)




Sources: IMF, World Economic Outlook database and International Financial Statistics; and IMF staff calculations.

**Figure 4. Canada: FSAP's Approach to Financial Stability Analysis**




Source: IMF staff.

## Table 2. Canada: Financial System Structure

| | In billion Canadian dollars | | | | | In percent of GDP | | | | In percent of total assets | | | | Global ranking |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2008 | 2009 | 2013 | 2017 | 2018H1 | 2009 | 2013 | 2017 | 2018H1 | 2009 | 2013 | 2017 | 2018H1 | 2017 |
| **Financial institutions 1/** | | | | | | | | | | | | | | |
| Total assets | 7,572 | 8,198 | 10,709 | 13,737 | 13,962 | 522 | 563 | 641 | 630 | 100.0 | 100.0 | 100.0 | 100.0 | 9th |
| Depository institutions | 2,587 | 2,607 | 3,570 | 4,381 | 4,475 | 166 | 188 | 205 | 202 | 31.8 | 33.3 | 31.9 | 32.1 | 8th |
| Chartered banks | 2,283 | 2,289 | 3,159 | 3,872 | 3,939 | 146 | 166 | 181 | 178 | 27.9 | 29.5 | 28.2 | 28.2 | ... |
| Other depository institutions | 304 | 318 | 411 | 509 | 537 | 20 | 22 | 24 | 24 | 3.9 | 3.8 | 3.7 | 3.8 | ... |
| Insurance companies | 537 | 586 | 778 | 958 | 975 | 37 | 41 | 45 | 44 | 7.1 | 7.3 | 7.0 | 7.0 | 9th |
| Life insurance | 417 | 466 | 635 | 789 | 805 | 30 | 33 | 37 | 36 | 5.7 | 5.9 | 5.7 | 5.8 | ... |
| o/w: Segregated funds | 136 | 170 | 246 | 332 | 338 | 11 | 13 | 16 | 15 | 2.1 | 2.3 | 2.4 | 2.4 | ... |
| Property and casualty insurance | 121 | 120 | 142 | 169 | 170 | 8 | 7 | 8 | 8 | 1.5 | 1.3 | 1.2 | 1.2 | ... |
| Pension funds | 1,149 | 1,212 | 1,775 | 2,443 | 2,532 | 77 | 93 | 114 | 114 | 14.8 | 16.6 | 17.8 | 18.1 | 5th |
| o/w: Social security | 143 | 158 | 287 | 489 | 524 | 10 | 15 | 23 | 24 | 1.9 | 2.7 | 3.6 | 3.8 | ... |
| Public financial institutions | 304 | 402 | 431 | 480 | 495 | 26 | 23 | 22 | 22 | 4.9 | 4.0 | 3.5 | 3.5 | 5th |
| Other financial institutions | 3,139 | 3,550 | 4,443 | 5,965 | 6,008 | 226 | 234 | 279 | 271 | 43.3 | 41.5 | 43.4 | 43.0 | 6th |
| Mutual funds | 713 | 856 | 1,359 | 2,211 | 2,259 | 54 | 71 | 103 | 102 | 10.4 | 12.7 | 16.1 | 16.2 | ... |
| o/w: Money market funds | 78 | 61 | 32 | 30 | 31 | 4 | 2 | 1 | 1 | 0.7 | 0.3 | 0.2 | 0.2 | ... |
| Securities firms 2/ | 67 | 57 | 81 | 117 | 120 | 4 | 4 | 5 | 5 | 0.7 | 0.8 | 0.9 | 0.9 | ... |
| Finance companies | 111 | 96 | 95 | 144 | 151 | 6 | 5 | 7 | 7 | 1.2 | 0.9 | 1.0 | 1.1 | ... |
| Financial vehicle entities | 413 | 421 | 72 | 46 | 44 | 27 | 4 | 2 | 2 | 5.1 | 0.7 | 0.3 | 0.3 | ... |
| Other financial institutions 3/ | 1,835 | 2,120 | 2,835 | 3,448 | 3,434 | 135 | 149 | 161 | 155 | 25.9 | 26.5 | 25.1 | 24.6 | ... |
| **Nonbank financial intermediation 4/** | | | | | | | | | | | | | | |
| Total assets | ... | ... | 1,168 | 1,974 | ... | ... | 61 | 92 | ... | ... | 10.9 | 14.4 | ... | 9th |
| **Financial markets** | | | | | | | | | | | | | | |
| Outstanding debt securities | 1,282 | 1,371 | 1,813 | 2,883 | 2,935 | 87 | 95 | 135 | 132 | ... | ... | ... | ... | 8th |
| Government | 828 | 945 | 1,229 | 1,356 | 1,367 | 60 | 65 | 63 | 62 | ... | ... | ... | ... | 8th |
| Financial institutions | 312 | 266 | 337 | 1,112 | 1,138 | 17 | 18 | 52 | 51 | ... | ... | ... | ... | 13th |
| Others | 142 | 160 | 247 | 415 | 429 | 10 | 13 | 19 | 19 | ... | ... | ... | ... | 7th |
| Stock market capitalization | 1,256 | 1,758 | 2,246 | 2,971 | 2,989 | 112 | 118 | 139 | 135 | ... | ... | ... | ... | 9th |
| ***Memo items*** | | | | | | | | | | | | | | |
| Total assets 5/ | | | | | | | | | | | | | | |
| Deposit-taking sector 6/ | ... | ... | 4,278 | 5,799 | 6,047 | ... | ... | ... | ... | | 100.0 | 100.0 | 100.0 | ... |
| o/w: Six largest banks | ... | ... | 3,727 | 5,097 | 5,490 | ... | ... | ... | ... | ... | 87.1 | 87.9 | 90.8 | ... |
| o/w: Québec credit cooperative | ... | ... | 212 | 275 | 290 | ... | ... | ... | ... | ... | 5.0 | 4.7 | 4.8 | ... |
| Life insurance sector 6/ | ... | ... | 1,179 | 1,548 | 1,590 | ... | ... | ... | ... | | 100.0 | 100.0 | 100.0 | ... |
| o/w: Three largest life insurers | ... | ... | 1,039 | 1,418 | 1,456 | ... | ... | ... | ... | ... | 88.1 | 91.6 | 91.6 | ... |
| CMHC | ... | ... | 270 | 267 | 268 | ... | ... | ... | ... | ... | ... | ... | ... | ... |

Sources: FSB, Global Monitoring Report on Non-Bank Financial Intermediation 2018; IMF, World Economic Outlook database; Haver Analytics; SNL; and IMF staff estimates.

1/ Based on National Balance Sheet Accounts, thus not reflecting consolidated balance sheets of financial institutions that have overseas operations. This statistical concept is different from the above text chart, which is based on the consolidated balance sheet basis (a typical FSAP approach).

2/ Only including securities firms (e.g. brokers-dealers) that are not part of banking groups.

3/ Including captive financial institutions and money lenders (CFIMLs), which are largely set up for financial management, asset restructuring and fund-raising purposes to channel funds within corporations. In 2017, CFIMLs' total assets amounted to Can$3.3 trillion.

4/ Based on the FSB's definition. In 2017, 73 percent of nonbank financial intermediation was related to collective investment schemes with features that make them susceptible to runs, and 18 percent was related to credit provision that is dependent on short-term funding.

5/ Based on consolidated balance sheet basis.

6/ Only representing regulated entities in federal and Québec jurisdictions.

## Table 3. Canada: Selected Economic Indicators

(Percentage change, unless otherwise indicated)

Nominal GDP (2018): C$ 2,217 billion (US$ 1,711 billion) Quota: SDR 11,023.9 million
GDP per capita (2018): US$ 46,243 Population (2018): 37.0 million
Main exports: Oil and gas, autos and auto parts, gold, lumber, copper.

| | | | | | Projections | |
|---|---|---|---|---|---|---|
| | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
| **Output and Demand** | | | | | | |
| Real GDP | 0.7 | 1.1 | 3.0 | 1.8 | 1.5 | 1.9 |
| Total domestic demand | -0.1 | 0.7 | 3.9 | 1.7 | 0.6 | 1.8 |
| Private consumption | 2.3 | 2.2 | 3.5 | 2.1 | 0.8 | 1.4 |
| Total investment | -6.8 | -4.4 | 6.5 | -0.1 | 0.5 | 3.8 |
| Net exports, contribution to growth | 0.9 | 0.4 | -1.1 | 0.1 | 0.8 | 0.1 |
| **Unemployment and Inflation** | | | | | | |
| Unemployment rate (average, in percent) | 6.9 | 7.0 | 6.3 | 5.8 | 5.9 | 6.0 |
| CPI inflation (average) | 1.1 | 1.4 | 1.6 | 2.2 | 1.7 | 1.9 |
| **Saving and Investment (in percent of GDP)** | | | | | | |
| Gross national saving | 20.3 | 19.7 | 20.7 | 20.4 | 19.8 | 20.5 |
| General government | 3.8 | 3.7 | 3.8 | 3.5 | 3.2 | 3.1 |
| Private | 16.5 | 16.0 | 16.9 | 16.8 | 16.6 | 17.4 |
| Personal | 5.4 | 3.9 | 3.8 | 2.5 | 4.9 | 5.2 |
| Business | 11.0 | 12.1 | 13.1 | 14.3 | 11.7 | 12.3 |
| Gross domestic investment | 23.8 | 22.9 | 23.5 | 23.0 | 22.9 | 23.3 |
| **General Government Fiscal Indicators (in percent of GDP)** | | | | | | |
| Revenue | 40.0 | 40.1 | 39.9 | 40.1 | 39.8 | 39.9 |
| Expenditures | 40.0 | 40.6 | 40.3 | 40.6 | 40.6 | 40.7 |
| Overall balance | -0.1 | -0.4 | -0.3 | -0.4 | -0.8 | -0.8 |
| Gross debt | 91.3 | 91.8 | 90.1 | 89.7 | 87.5 | 84.9 |
| Net debt 1/ | 28.5 | 28.8 | 27.6 | 26.8 | 26.7 | 25.9 |
| **Money and Credit** (average, in percent)) | | | | | | |
| Household credit growth | 4.9 | 5.5 | 5.5 | 4.0 | 3.0 | 7.2 |
| Business credit growth | 9.3 | 5.3 | 8.2 | 6.5 | 3.6 | 4.2 |
| Three-months treasury bill | 0.5 | 0.5 | 0.7 | 1.4 | 1.7 | 1.9 |
| Ten-years government bond yield | 1.5 | 1.3 | 1.8 | 2.3 | 2.3 | 2.5 |
| **Balance of Payments** | | | | | | |
| Current account balance (in percent of GDP) | -3.5 | -3.2 | -2.8 | -2.6 | -3.1 | -2.9 |
| Merchandise trade balance (in percent of GDP) | -1.2 | -1.3 | -1.2 | -1.0 | -1.8 | -1.6 |
| Export volume (percentage change) | 3.4 | 0.6 | 0.7 | 3.1 | 2.5 | 2.6 |
| Import volume (percentage change) | 0.3 | -0.4 | 4.7 | 3.3 | 0.0 | 2.1 |
| Terms of trade | -7.1 | -1.2 | 3.3 | 0.3 | -4.6 | 0.4 |

Sources: Haver Analytics; and IMF staff estimates.
1/ Excludes equity (authorities' definition).

# MACROFINANCIAL RISKS UNDERPINNING STRESS TESTING AND FINANCIAL STABILITY ANALYSIS

## A. Overview of Key Risks

**15. Canada's financial system faces a confluence of domestic and external risk factors that could amplify existing financial sector vulnerabilities** (Table 4)**.** The key external risks are tighter global financial conditions, significant slowdowns in the euro area and China, and rising protectionism and retreat from multilateralism. On the domestic front, a sharp house price correction could occur on the back of rising unemployment and higher funding costs. Cyber-attacks could also pose significant risk to the financial system.

**Table 4. Canada: FSAP Risk Assessment Matrix (RAM)**

| Source of risks | Likelihood | Expected impact |
|---|---|---|
| **Sharp tightening of global financial conditions, with bouts of large market volatility**, against the backdrop of (i) monetary policy normalization in the U.S. and other major advanced economies, (ii) increasingly stretched valuations across asset classes, and (iii) aggressive risk-taking behavior that may not be sufficiently monitored given multiple authorities in charge | Low/ Medium | **Medium**<br>Decompression of risk premiums prompts a worldwide decline in asset prices, leading to:<br>• Tightening of liquidity conditions and increase in funding costs given Canada' strong financial linkages with the U.S. and the global financial system, affecting both financial institutions and borrowers<br>• Moderating economic activity in Canada and the U.S., contributing to deterioration in banks' asset quality<br>• Losses on investment portfolios, weakening solvency of some financial institutions, and triggering portfolio reallocations that affect asset prices |
| **Weaker-than-expected global growth**<br>• Structurally weak growth in key advanced economies due to failures to address crisis legacies and undertake structural reforms<br>• Significant China slowdown and its spillovers, stemming from disorderly deleveraging in the near term and insufficient progress in rebalancing that would further increase financial imbalances over the medium term<br>• Rising protectionism, retreat from multilateralism, and policy uncertainty, undermining trade, capital and labor flows, sentiment, and growth | High<br>Medium<br>High | **High**<br>Canada's economy is affected by weaker global growth and reduced cross-border activities, leading to:<br>• Impaired debt-servicing capacity of corporates and households, raising banks' nonperforming assets<br>• Financial difficulty faced by firms with cross-border operations, with spillovers to the financial system<br>Weaker global growth, especially together with spillovers from China, also depresses commodity prices, leading to:<br>• Growing vulnerabilities in the commodity-related sector<br>• Reduction in investment, jobs and real income, especially in resources-rich provinces, with knock-on effects on credit quality<br>• Spillovers to regional housing markets, resulting in negative macrofinancial feedback loops that heighten financial stability concerns and weaken provincial public finance. |

| Table 4. Canada: FSAP Risk Assessment Matrix (RAM) (concluded) | | |
|---|---|---|
| **Source of risks** | **Likelihood** | **Expected impact** |
| **Sharp house price correction** on the back of rising unemployment and higher funding costs, setting off negative feedback loops that weaken domestic demand and heighten financial stability concerns given high household debt | Medium | **High**<br>Adverse macrofinancial effects from housing market adjustments lead to:<br>• Deteriorating asset quality, particularly related to mortgage lending and real estate financing<br>• Rippled effects in financial markets that fund mortgage lending<br>• Increase in the government's contingent liabilities through claims on mortgage insurance |
| **Cyber-attacks on the interconnected financial system**, triggering systemic financial instability or disrupting socio-economic activities | Medium | **Medium**<br>Successful cyber-attacks on a key financial institution could spread widely, but the situation appears manageable given robust financial market infrastructures (FMIs) |
| The RAM shows events that could materially alter the baseline. The relative likelihood 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 between 30 and 50 percent). 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. | | |

## B. Macrofinancial Scenarios

**16. The financial stability analysis was conducted broadly based on two macrofinancial scenarios** (Figure 5, Table 5)**.** One is the baseline, which is based on the October 2018 World Economic Outlook projections. The baseline envisages a continued, stable macrofinancial environment, with economic growth of about 1.9 percent (annualized) over the three-year stress testing horizon (i.e., 2019–21). In the baseline, interest rates are expected to rise in line with monetary policy tightening. The other is the adverse scenario, which was designed based on key macrofinancial risks outlined in the RAM. The Global Macrofinancial Model—a structural macroeconometric model of the world economy, was used to simulate the adverse scenario.[3]

**17. The adverse scenario assumes a severe recession that would occur concurrently with significant financial stress and a sharp housing market correction.** The initial trigger would be disruptions in international trade and global production chains, followed by disorderly financial market adjustments and heightened policy uncertainty. As a result, global financial conditions would tighten significantly, setting off global housing market and credit cycle downturns. The impact of these negative external shocks would be amplified by existing macrofinancial vulnerabilities such as elevated household debt and housing market imbalances, resulting in a sharp housing market correction and deterioration in bank asset quality. Significant financial stress, together with large exchange rate depreciation, would also materialize in Canada. All these shocks would underpin a snapback of interest rates in Canada, driven by monetary tightening to stabilize inflation expectations (following rising inflation stemming from global supply shocks and Canadian dollar

[3] This estimated panel dynamic stochastic general equilibrium model features a range of nominal and real rigidities, extensive macrofinancial linkages with both bank and capital market based financial intermediation, and diverse spillover transmission channels. For more details, see Vitek (2018), "Global Macrofinancial Model," IMF WP/18/81.

depreciation at the initial phase of the adverse scenario). Accommodative monetary policy would follow in later years due to recession-induced significant deflationary effects. The scenario is severe but plausible, with cumulative real GDP growth of -2 percent (annualized) during 2019–21, equivalent to 3 standard deviations; based on growth-at-risk analysis, the likelihood of such a severe growth outcome is 3.8 percent.

# ANALYSIS OF MACROFINANCIAL VULNERABILITIES

## A. Overview

**18. Elevated household indebtedness and housing market imbalances continue to pose financial stability concerns.** During the decades-long credit upcycle, low interest rates and low capital charges for mortgage lending, together with policies promoting housing affordability, have fueled borrowing to finance home purchases in the face of rapidly rising house prices. Risk mispricing has contributed to debt accumulation among financially weak households, with problems more exacerbated in regions experiencing larger housing market imbalances. During severe downturns, Canada-specific housing finance characteristics may amplify procyclical effects of falling house prices, and the impact on growth could be protracted due to household balance sheet adjustments.[4]

**19. The FSAP examined vulnerabilities in the corporate and household sectors as well as those related to the housing market.** The FSAP employed the debt-at-risk approach to quantify the amount of debt owed by financially weak corporates and households. A set of sensitivity tests were conducted to assess how corporate and household balance sheets would be affected by macrofinancial shocks. The FSAP also performed house price-at-risk analysis to gauge downside risk to house prices.

## B. Household Sector Vulnerabilities

**20. Canadian households have substantially increased their debt obligations in the past decade, stretching their balance sheets** (Figure 5)**.** Household indebtedness peaked at 97 percent of GDP in 2016Q4 but has leveled off over the past two years. In the aggregate, households hold a sizeable amount of wealth, with net wealth of 489 percent of GDP as of 2018Q4. A bulk of household wealth is in the form of nonfinancial assets such as real estate.

**21. Canadian households are more indebted and have larger debt servicing obligations than advanced economy peers**. Only Australia and the Netherlands have higher household debt-to-GDP ratios and aggregated debt servicing-to-income ratios. Despite asset buffers, the average Canadian's debt servicing obligations are already large and could increase further as financial conditions tighten.

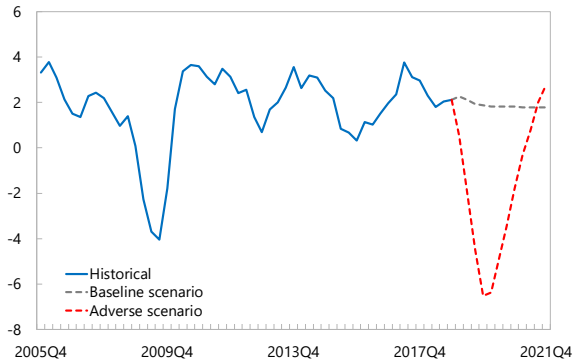
[4] See Technical Note on Housing Finance in the context of the 2019 Canada FSAP for more detailed discussion on housing finance issues.

## Figure 5. Canada: Key Macrofinancial Variables in the Baseline and Adverse Scenarios

*In an adverse scenario, Canada would experience a severe recession that occurs concurrently with significant financial stress and a sharp housing market correction.*

**Real GDP Growth, 2005-21**

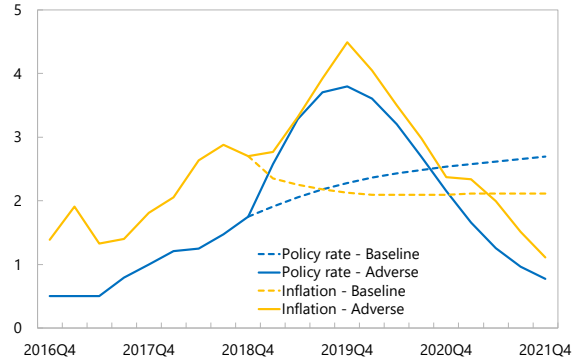
(In percent; year-on-year)




*The scenario would feature a snapback of interest rates, driven by monetary policy actions to first stabilize inflation expectations and then mitigate deflationary effects.*

**Policy Rate and Inflation, 2016-21**

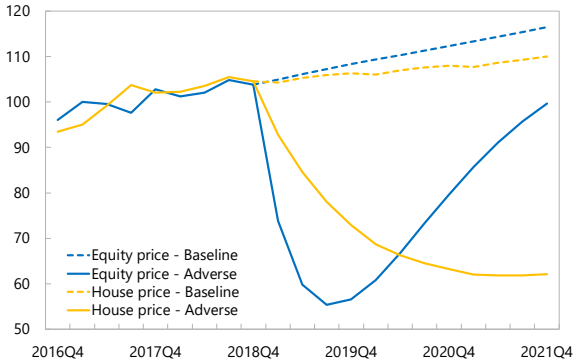
(In percent)




*The stock market would suffer a sizeable loss, while the housing market would witness a sustained decline in house prices by about 40 percent.*

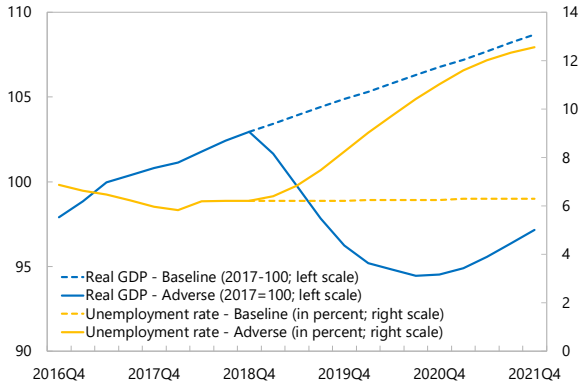
**Equity Price and House Price, 2016-21**

(2017=100)



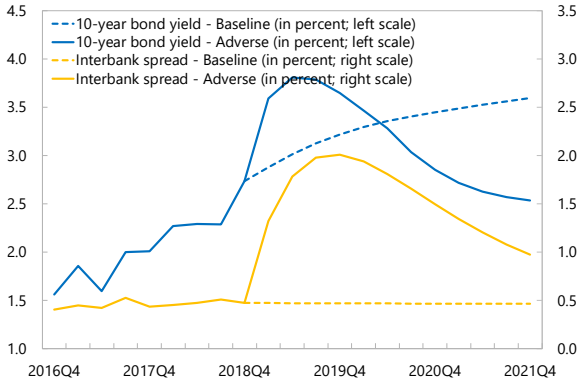

*Output would decline by 8 percent by end-2020, coupled with persistent, rising unemployment.*

**Real GDP and Unemployment Rate, 2016-21**




*Long-term bond yields would spike in 2019, while interbank spreads would widen over a more extended period.*

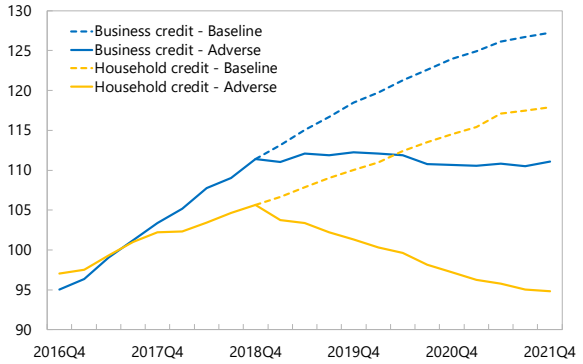
**10-year Bond Yield and Interbank Spread, 2016-21**




*Credit would contract, led by a significant decline in banks' mortgage lending.*

**Business Credit and Household Credit, 2016-21**

(2017=100)




Sources: Haver Analytics; IMF, World Economic Outlook database; and IMF staff estimates.

## Table 5. Key Macrofinancial Variables in the Baseline and Adverse Scenarios

(In percent; unless indicated otherwise)

| | Baseline | | | | | Adverse | | |
|---|---|---|---|---|---|---|---|---|
| | 2017 | 2018 | 2019 | 2020 | 2021 | 2019 | 2020 | 2021 |
| **Canada** | | | | | | | | |
| Real GDP growth | 3.0 | 2.1 | 2.0 | 1.8 | 1.8 | -3.1 | -4.2 | 1.3 |
| Inflation rate (CPI) | 1.6 | 2.6 | 2.2 | 2.1 | 2.1 | 3.6 | 3.2 | 1.7 |
| Unemployment rate | 6.3 | 6.1 | 6.2 | 6.2 | 6.3 | 7.2 | 10.1 | 12.1 |
| Exchange rate (CAD per USD) | 1.30 | 1.29 | 1.28 | 1.25 | 1.22 | 1.52 | 1.55 | 1.47 |
| Equity price (2017=100) | 100 | 103 | 107 | 111 | 115 | 61 | 70 | 93 |
| House price (2017=100) | 100 | 104 | 105 | 107 | 109 | 82 | 66 | 62 |
| Bank of Canada policy rate | 0.7 | 1.4 | 2.1 | 2.5 | 2.6 | 3.3 | 2.9 | 1.2 |
| 3-month government bond yield | 0.7 | 1.4 | 2.1 | 2.4 | 2.6 | 3.5 | 3.0 | 1.2 |
| 10-year government bond yield | 1.9 | 2.4 | 3.1 | 3.4 | 3.5 | 3.7 | 3.2 | 2.6 |
| Interbank spread (in percentage points) 1/ | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 1.8 | 1.7 | 1.2 |
| 5-year mortgage rate | 3.8 | 4.4 | 5.1 | 5.4 | 5.5 | 5.9 | 6.0 | 5.0 |
| Prime business lending rate | 2.9 | 3.6 | 4.3 | 4.6 | 4.8 | 5.2 | 5.3 | 4.2 |
| Business credit growth | 8.8 | 7.8 | 6.3 | 4.6 | 2.6 | 0.8 | -1.4 | 0.4 |
| Household credit growth | 5.3 | 3.4 | 4.1 | 4.1 | 3.0 | -4.1 | -4.2 | -2.5 |
| **United States** | | | | | | | | |
| Real GDP growth | 2.2 | 2.9 | 2.5 | 1.8 | 1.7 | -2.4 | -2.9 | 3.3 |
| Inflation rate | 2.1 | 2.4 | 2.1 | 2.3 | 2.2 | 2.6 | 1.5 | -0.3 |
| Unemployment rate | 4.4 | 3.8 | 3.5 | 3.4 | 3.6 | 4.6 | 7.3 | 8.8 |
| Equity price (2017=100) | 100 | 113 | 118 | 123 | 127 | 75 | 84 | 109 |
| House price (2017=100) | 100 | 107 | 114 | 120 | 125 | 103 | 103 | 105 |
| Federal Fund rate | 1.0 | 1.8 | 3.0 | 3.6 | 3.2 | 3.6 | 2.6 | 1.1 |
| Interbank spread (in percentage points) 1/ | 0.3 | 0.5 | 0.2 | 0.1 | 0.1 | 1.3 | 1.1 | 0.6 |
| 10-year government bond yield | 2.3 | 2.9 | 3.5 | 3.8 | 3.7 | 3.7 | 3.2 | 2.5 |
| **Euro Area** | | | | | | | | |
| Real GDP growth | 2.5 | 2.0 | 1.9 | 1.7 | 1.6 | -2.1 | -2.3 | 1.7 |
| Equity price (2017=100) | 100 | 102 | 105 | 109 | 113 | 67 | 75 | 97 |
| Interbank spread (in percentage points) 1/ | -0.3 | -0.3 | -0.2 | 0.0 | 0.0 | 1.1 | 1.2 | 0.6 |
| 10-year government bond yield | 1.2 | 1.3 | 1.5 | 1.9 | 2.2 | 2.1 | 1.8 | 1.5 |
| **Japan** | | | | | | | | |
| Real GDP growth | 1.7 | 1.1 | 0.9 | 0.3 | 0.7 | -2.9 | -3.3 | 0.9 |
| Equity price (2017=100) | 100 | 111 | 113 | 116 | 118 | 73 | 80 | 102 |
| Interbank spread (in percentage points) 1/ | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 1.1 | 1.0 | 0.5 |
| 10-year government bond yield | 0.1 | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.1 | -0.4 |
| **United Kingdom** | | | | | | | | |
| Real GDP growth | 1.7 | 1.4 | 1.5 | 1.5 | 1.6 | -3.0 | -2.8 | 2.5 |
| Equity price (2017=100) | 100 | 102 | 105 | 108 | 111 | 66 | 73 | 94 |
| Interbank spread (in percentage points) 1/ | 0.1 | 0.1 | 0.2 | 0.2 | 0.2 | 1.3 | 1.2 | 0.6 |
| 10-year government bond yield | 1.2 | 1.5 | 1.9 | 2.0 | 2.1 | 2.2 | 1.5 | 1.0 |
| **China** | | | | | | | | |
| Real GDP growth | 6.9 | 6.6 | 6.2 | 6.2 | 6.0 | 0.9 | 1.5 | 7.0 |
| **Global** | | | | | | | | |
| Real GDP growth | 3.2 | 3.2 | 3.0 | 2.9 | 2.9 | -1.5 | -1.4 | 3.9 |
| Commodity price - Energy (2017=100) | 100 | 131 | 128 | 122 | 117 | 133 | 87 | 55 |
| Commodity price - Non-energy (2017=100) | 100 | 103 | 102 | 102 | 103 | 101 | 85 | 71 |

Source: IMF staff estimates.

1/ Interbank spread is defined as the difference between interbank rate and policy rate.

**22. The household sector vulnerabilities index is close to its historical peak** (Figure 6)**.**[5] For instance, household debt-to-disposable income is roughly 30 percent higher compared to its historical average. At the same time, the average debt servicing ratio seems to be slightly below the historical trend, reflecting the protracted low interest rate environment. One of the main culprits explaining the elevated household sector vulnerability is the high level of household indebtedness combined with the recent deterioration of average debt service. The latter reflects relatively higher interest rates and tighter lending standards over the past one–two years.

**23. The portion of household debt held by financially weak borrowers increased substantially over the past two decades.**[6] Typically, financially weak households are defined as those households whose debt-to-income (DTI) ratio is above 4.5 or total debt service-to-income (TDS) is above 40 percent. The debt of these financially weak households is considered at risk. The share of debt held by households with DTI above 4.5 amounted to more than 30 percent of total household debt at end-2016, three times larger than the share in 1999. When other definitions of debt-at-risk are considered, the share of debt-at-risk ranges between 17 and 42 percent at end-2016. For instance, the share of debt-at-risk was about 17 percent when only borrowers with TDS above 40 percent were considered. At the same time, the share of debt-at-risk was about 42 percent when households with DTI above 350 percent were considered.

**24. The balance sheets of low-income borrowers (those below the 20$^{th}$ percentile of the income distribution) are more exposed to financial distress.** For instance, total debt service as share of income among low-income borrowers stood at about 55 percent in 2016, compared to 25 percent for the average borrower. In addition, the amount of debt accumulated by poorer borrowers climbed from about 3 times their annual income in 1999 to about 8 times in 2016.

**25. The assumptions of the household debt-at-risk analysis follow closely those of the stress testing adverse scenario**. However, this analysis only considers household income loss, house price declines, and interest rate shocks. On average, house prices in the adverse scenario are expected to decline by 40 percent over the next two years (i.e., by end-2020), in line with the adverse scenario. In addition, a decline in household disposable income of 15 percent and an increase in interest rates up to 230 basis points (bps) are considered. Depending on the renewal profile of borrowers, interest rates are adjusted upwards relative to 2016 level as follows: in 2017 by

[5] Household sector vulnerabilities index is the aggregated Z-score of several components: debt-to-disposable income, debt servicing ratio, debt-to-GDP ratio, and house prices.

[6] The household sector debt-at-risk analysis was based on representative households using data from the Survey of Financial Security. In the same vein, using the Canadian Financial Monitor (CFM) data, Peterson and Roberts (2016) employ a simulation-based model to determine household arrears and debt-at-risk (i.e., share of debt of households with debt service ratio higher than 40 percent). In terms of household income, disposable income (after tax) including government transfers is considered. Total debt service (TDS) refers to all mortgage payments plus credit card balances usually paid off every month. Some waves of the household survey allow for DTI measurement while others allow for both TDS and DTI measurement.

10 basis points, in 2018 by 70 basis points, in 2019 by 220 basis points, and in 2020 by 230 basis points.

**26. In the adverse scenario, house prices in Canada cumulatively decline, on average, by 40 percent by 2020.**[7] However, this analysis assumes heterogenous house price shocks across provinces, to better reflect valuation differences and other regional factors (e.g., supply constraints). The house price-at-risk analysis is used to inform the calibration of the housing shocks in each province or region. The decline in house prices in Ontario, British Columbia, Quebec, Alberta, and the rest of Canada ranges between 35 and 45 percent, reflecting regional differences (e.g., with Ontario and British Columbia most vulnerable).

**27. Some parts of the household sector look particularly vulnerable to severe macro-financial conditions.** Assessing households' financial strength based on debt servicing-to-income, the share of debt-at-risk would increase from 17 percent in 2016 to 29 percent in the 2020 in the adverse scenario. Debt-at-risk is disproportionally higher for households with low income, low net wealth, and no full-time job. For instance, the share of debt-at-risk held by the least wealthy borrowers (i.e., in the bottom 40 percent) increases from 16.2 percent in 2016 to 31 percent in 2020 in the adverse scenario (compared with 21 percent in the baseline). Households in British Columbia and Ontario are seemingly more financially vulnerable than those in Quebec and Alberta, in part reflecting higher indebtedness levels and housing market overvaluation in the former provinces.

**28. Financial stability implications of household sector vulnerabilities could be substantial given the ample share of debt-at-risk not covered by real estate assets in the adverse scenario.** The share of debt-at-risk not covered by real estate assets surges from less than 0.5 percent in 2016 to about 4.5 percent by 2020 in the adverse scenario.[8] The magnitude of the increase in debt-at-risk not covered by real estate assets is greatest for borrowers in Ontario and British Columbia, where the share rises by more than eight times.

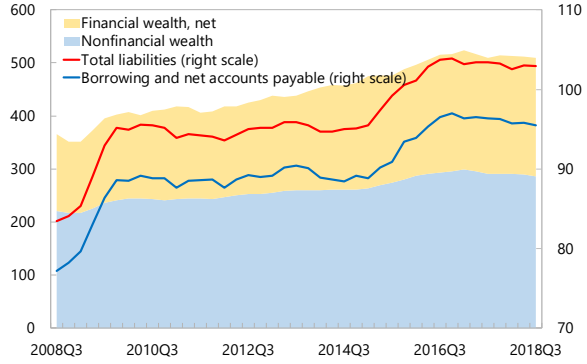
[7] Two sensitivity analyses were conducted. In the first one, house prices drop, on average, by only 25 percent, and in the second analysis the average decline in house prices is 40 percent, but with a higher dispersion across provinces (i.e., -15 to -65 percent).

[8] Two robustness checks entail a total share of debt-at-risk not covered by real estate assets of about 2 to 7 percent, when 25 percent and 40 percent average declines in house prices are considered, respectively.

## Figure 6. Canada: Household Indebtedness

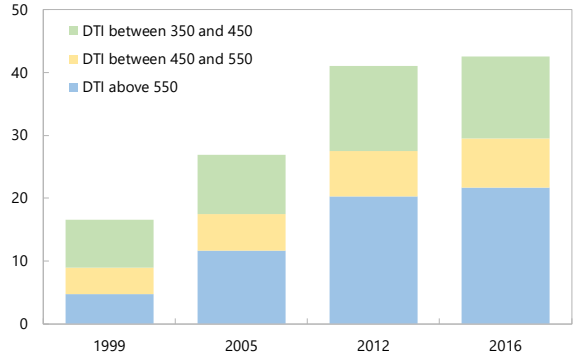
*The increase in household debt is significant, albeit concurrent with the increase in household wealth.*

**Household Indebtedness and Wealth, 2008-2018**
(In percent of GDP)



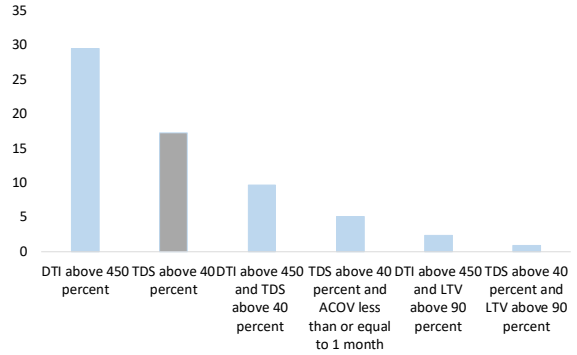

*Household debt at risk (based on debt-to-income) climbed to about 30 percent in 2016.*

**Household Debt at Risk, 1999-2016**
(In percent of total debt)



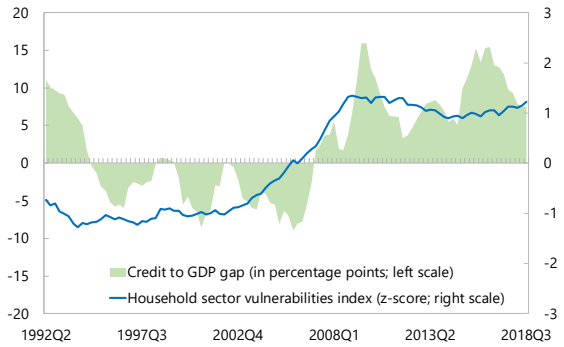

*The share of debt at risk was about 17 percent in 2016 for borrowers with total debt service-to-income (TDS) ratios above 40 percent.*

**Share of Household Debt at Risk**
(Percent of total mortgage debt; 2016)



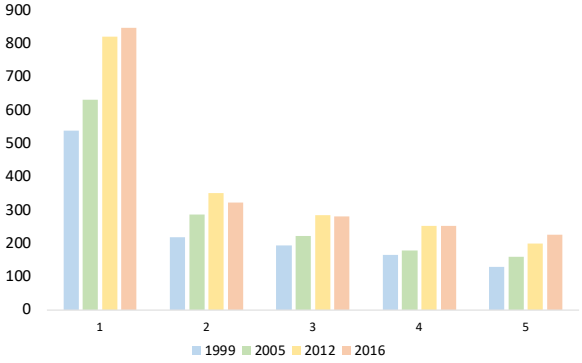

*The recent credit growth slowdown occurred amidst elevated household sector vulnerabilities.*

**Credit Cycles and Household Sector Vulnerabilities, 1992-2018**



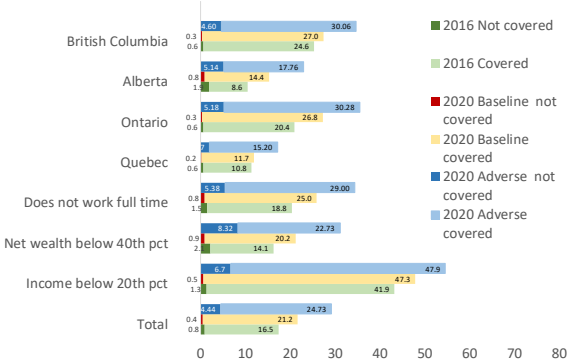

*Average DTI has significantly increased over the past two decades across all income quantiles.*

**Average Debt-to-Income (DTI)**
(By income quantile)




*The share of debt at risk increases substantially by 2020 in the adverse scenario, especially for the least wealthy borrowers.*

**Share of Household Debt at Risk**
(Percent of total)




Sources: Statistics Canada's Survey of Financial Security; IMF staff calculations.
Note: DTI ratio is calculated as total amount of debt divided by household disposable income, including government transfers. TDS is the ratio of mortgage payments plus credit card payments divided by disposable income, including government transfers. LTV is the ratio of mortgage loan (final value) to the value of the principal residence. The household sector vulnerabilities index incorporates household indebtedness information such as leverage, debt servicing, and debt repayment capacity.

## C. Housing Market Imbalances

**29. Alongside the household debt buildup, Canada has experienced a surge in house prices across a broad spectrum of cities.** Canada-wide house prices have trended upward over the past five years, increasing by more than 40 percent. After a housing boom between 2011 and 2017, the housing market started to cool off in 2018, reflecting tighter monetary policy, stricter lending standards, and other housing market measures.[9] Over the past year, certain housing-related activities have slowed substantially, including construction activity, sales, and mortgage lending. The general slowdown partially reflects the use of macroprudential measures to safeguard financial stability and other measures to mitigate speculative activity and improve affordability in regional markets.

**30. House price-to-income and house price-to-rent ratios in major cities (e.g., Toronto and Vancouver) show persistently overstretched valuations.** While house prices have largely stabilized over the past year, imbalances continue to persist in major metropolitan areas such as the Greater Toronto Area (GTA) and Greater Vancouver Area (GVA). For the Canada-wide housing market, the house price-to-income ratio is about 1.3 times the long-term average, with GTA being the most expensive.

**31. House price-at-risk analysis shows significant downside risks to house prices in Canada.** The analysis was based on individual cities, using quarterly data from 1980 to 2018. Downside risks to house prices in Canada appear to have substantially increased over the past decade, partially reflecting higher house price overvaluations.[10] Supply-side drivers such as residential investment play an important mitigating role to forward-looking house price risks. In addition, capital flows are found to be associated with downside risks to key residential housing markets, but the net effect depends on the type of flows and varies across cities. Financial conditions, which reflect both domestic and external factors, are an additional relevant factor to housing market risks in Canada.

**32. Downside risks to house prices across Canadian cities have changed substantially over time, with housing markets in GTA and GVA currently the most at risk.** Over the past four decades, downside risks across main metropolitan areas in Canada show several cycles, suggesting that housing markets are susceptible to booms and busts (Figure 7). Additionally, there is considerable dispersion in downside risks to house prices across cities, as reflected by the volatility of the lower bound (tenth percentile of the cross-sectional distribution). At longer horizons such as three years ahead, it is evident that Canadian downside risks have substantially increased in the past

[9] Apart from the tightening of mortgage insurance rules at end-2016 and the revised B-20 guidelines in January 2018, CMHC and provincial governments used a few other housing-related tools. For instance, provincial governments in British Columbia and Ontario have implemented housing market measures including foreign buyers stamp duties and vacant home taxes. At the same time, 5-year mortgage rates increased by about 60–80 bps over the past two years.

[10] Downside risks are defined as the 5 percent value-at-risk for the one-year-ahead horizon (see Appendix I for details). Similar analysis has been conducted for the three-years ahead horizon. As part of the sensitivity analysis, the 10 percent value-at-risk is also depicted in Figure 6, which tracks well the 5 percent house price-at-risk.

two decades, surpassing levels seen around the GFC. The average three years-ahead house price-at-risk across Canada stood at about -12 percent (annualized) at end-2018 Q3. In other words, there is a 5 percent likelihood that Canada-wide real house prices will decline by 12 percentage points or more three years from now. However, the magnitude varies substantially across cities, with tail risks to Toronto and Vancouver housing markets being close to -24 percent and -25 percent, respectively, over the same period.

**33. Overvaluation (relative to fundamentals, such as disposable income) continues to represent a key determinant for downside risks to house prices, albeit with variations between regional markets.** City-level house price valuations, proxied by the house price-to-income ratio, appear to be associated with higher one-year ahead house price-at-risk. Compared to long-term averages, housing market valuations in Canada have become more stretched over the past five years, especially in GVA and GTA.[11] At the same time, tail risks to Canadian house prices have generally increased, reflecting tighter financial conditions and speculative capital inflows (see below).

**34. The dynamics of housing market risks in major cities are partially correlated with capital inflows and financial conditions which seem to both amplify and mitigate downside risks to house prices across Canadian cities.**[12] More specifically, the sensitivity to these factors seems to differ across cities:

- Foreign direct investment (FDI), which is typically long-term investment, is generally associated with lower future downside risks to several Canadian housing markets. For example, a one percentage point increase in Canada's FDI inflows is significantly associated with a reduction of about 0.5–1 percentage point in house price-at-risk of cities such as Calgary, Quebec City, Ottawa, and Toronto. At the same time, other capital inflows (i.e., not FDI or portfolio flows), which are generally attributed to foreign bank transactions, are found to amplify downside risks to house prices in cities such as Toronto, Vancouver, and Calgary. The largest effects are seen in Vancouver, where speculative capital inflows might have partially contributed to the recent housing boom.

- Tighter financial conditions, which encompass monetary policy, macroprudential measures and other factors, are negatively associated with downside risks to house prices. These effects are typically channeled through lending standards and mortgage costs. Although sensitivities to financial conditions are statistically significant for most cities, their economic magnitude is marginal. The most sensitive cities to financial conditions are Toronto, Ottawa, and Calgary.

**35. Contributions to housing downside risks vary substantially across Canadian cities (Figure 8).** For instance, house price-at-risk has substantially deteriorated in GTA over the past year

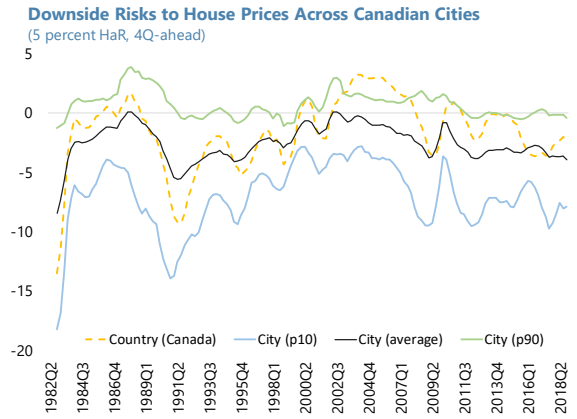
[11] The 2019 Canada Article IV Report (forthcoming) reaches similar conclusions about overvaluation in GVA and GTA, using two complementary approaches—one based on the borrowing capacity of households and the other focused on the net present value of rental income.

[12] Recent studies found compelling evidence that housing markets in global cities such as London and New York may be affected by foreign capital inflows (Alter, Dokko, and Seneviratne 2018; Badarinza and Ramadorai 2018; Sá 2016; Sá and Wieladek, 2015).

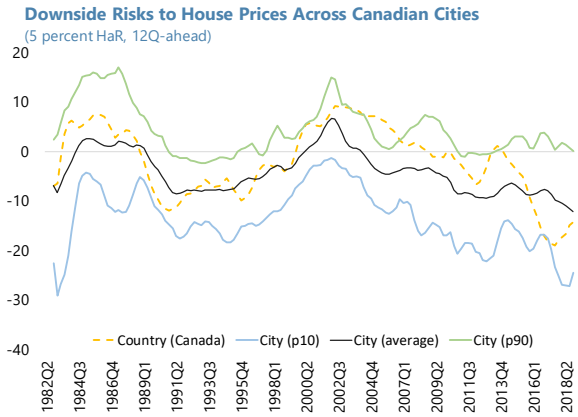
largely due to city-specific factors such as higher valuations and constrained supply. In contrast, Ottawa's house price at risk appears to have improved in the past five years, with loose financial conditions and balanced valuations playing important roles. At the same time, downside risks in GVA have steeply risen over the past five years, partially reflecting higher price valuations but also the negative role of other capital inflows. However, the latter contributions seem to be ameliorating over the past two years, likely reflecting the housing-related measures taken by the local government. For Canada-wide house prices, valuation net of supply-side factors such as residential investments seem to amplify downside risks, while loose financial conditions are a mitigating factor.

## Figure 7. Canada: City-Level House Prices at Risk

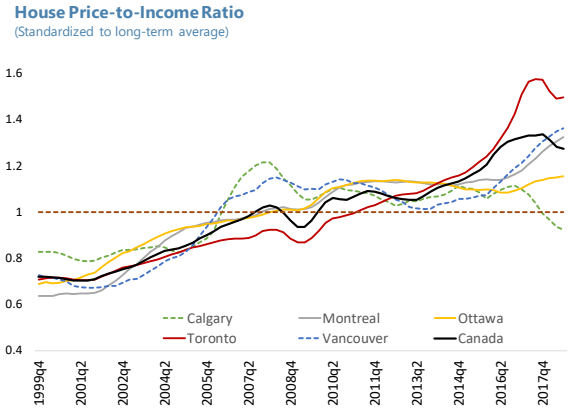
*Downside risks (1year-ahead) across Canadian cities have deteriorated in recent years, approaching 2008 levels.*



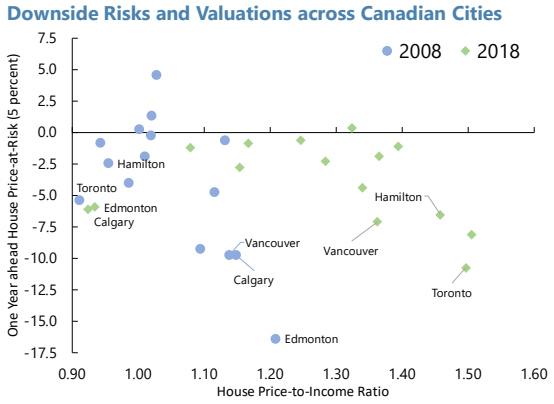

*However, risks to house prices at longer horizons, have substantially worsened over the past decade.*



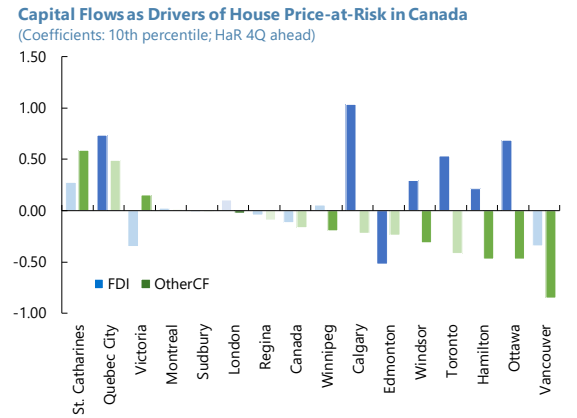

*Overall, Canada-wide house-price-to-income ratio declined in 2017-18. Toronto is found about one and a half times overvalued compared to its long-term average.*



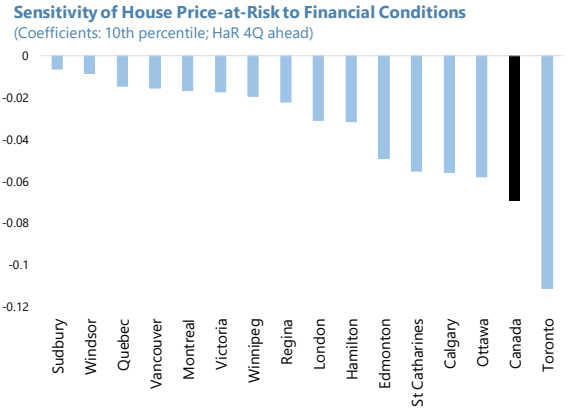

*Amid stretched valuations, several Canadian cities look more vulnerable to downside risks in 2018 compared to 2008.*




*FDIs are associated with lower downside risks to several cities, while other capital inflows can amplify them.*




*Tighter financial conditions are associated with higher downside risks to house prices.*

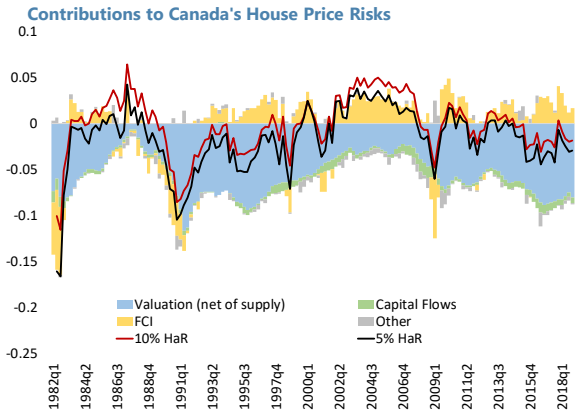



Source: CREA; Statistics Canada; Haver; IMF staff calculations.

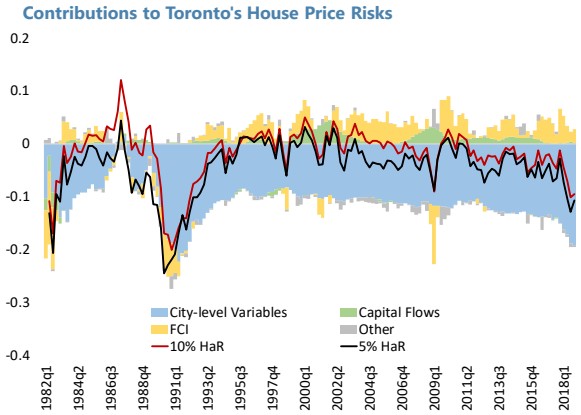
Notes: In panels 1 and 2, p10 and p90 refer to tenth and ninetieth percentile of the cross-sectional city house prices-at-risk (HaR) distribution at each period. In panels 4, one-year ahead estimates of 5 percent HaR refer to end 2018 and 2008, respectively. In panel 5, FDI and OtherCF (other capital flows) refer to incoming foreign direct investments and capital flows other than FDI and portfolio investment, respectively.

## Figure 8. Canada: Decomposition of House Price-at-Risk

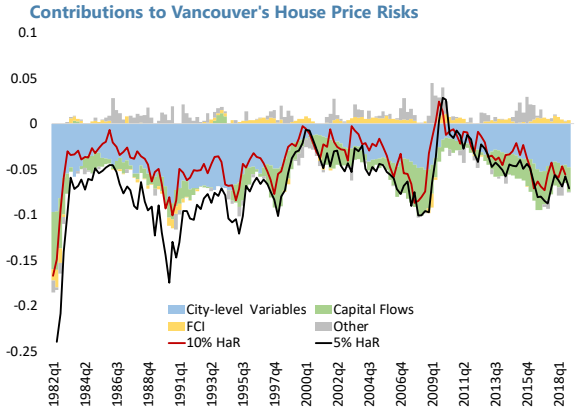
*House price valuation (net of supply factors) is the main driver of downside risks to Canada's real house prices.*



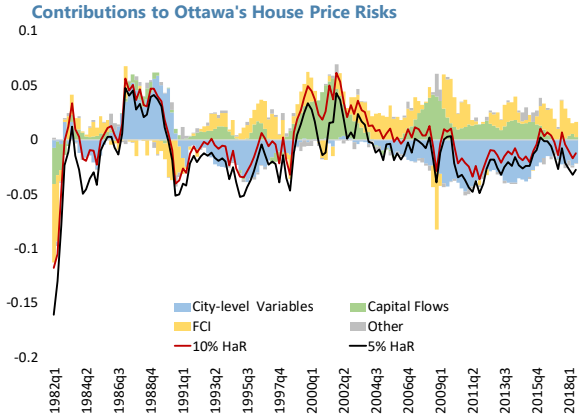

*House price-at-risk measure has substantially worsened in the Toronto metropolitan area over the past year, mostly explained by higher valuations.*



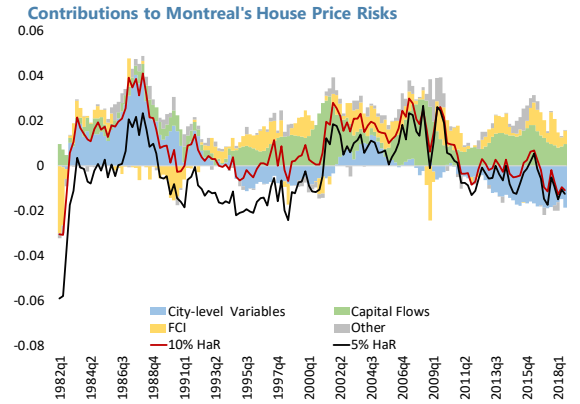

*Downside risks in Vancouver have risen sharply over the past seven years, partially reflecting higher price valuations but also the negative role of capital inflows.*



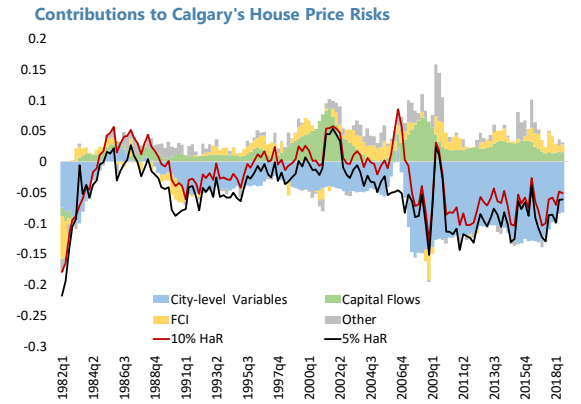

*Ottawa's house price at risk appear to have improved in the past five years, with loose financial conditions and balanced valuations playing important roles.*




*FDI inflows and financial conditions seem to be important mitigating factors to downside risks to house prices in Montreal.*




*Calgary's housing market risks are driven by excess supply and overvaluation, with downside risks recently improving.*




Source: Canadian Real Estate Association; Statistics Canada; Haver; and IMF staff calculations.

Notes: In the top-left panel, valuation is net of residential investment, which has a positive (mitigating) contribution to Canada-wide house price risks. In panels 2–6, city-level variables include house price-to-income ratio and residential investment in each city/province. FCI refers to financial conditions, which is an aggregated factor based on interest rates, volatility, and other price-based financial factors (see also IMF2017a, Chapter 3). Capital flows include foreign investment inflows and other capital inflows. Other includes oil prices and household debt. The intercept and auto-regressive term are not depicted. All contributions refer to the quantile regression at the 10th percentile HaR (house price at risk).

## D. Corporate Sector Vulnerabilities

**36. Corporate sector vulnerabilities have risen in recent years.** Nonfinancial corporate debt-to-GDP in Canada has grown by 22 percentage points since end-2014, to 111 percent, faster than all other G20 economies in this period except Turkey.[13] Roughly two-thirds of this debt growth has been in the form of loans, with the remainder corporate debt issuance. Debt growth was fastest in 2015 and 2016, in part reflecting the impact of currency depreciation on foreign-currency borrowing; subsequently, nonfinancial corporate debt-to-GDP has largely stabilized.[14] Canadian corporates also have the highest estimated aggregate corporate debt-servicing ratio (DSR) among advanced economies, according to BIS data, although this calculation likely overstates Canadian firms' vulnerability.[15]

**37. Debt-servicing capacity appears nonetheless to be broadly resilient for Canadian nonfinancial firms in aggregate.** According to Statistics Canada data, which uses a consolidated residence-based balance sheet approach, cumulative debt growth for all nonfinancial firms has only been slightly faster than annual earnings before interest, taxes, depreciation and amortization (EBITDA) since end-2014 (16 percent versus 13 percent).[16] As of 2018Q3, debt was 4.7 times EBITDA, up from 4.5 times in 2014, and 3.8 times on a net-of-cash basis. The interest coverage ratio was largely unchanged over this period, at 6.85 times.[17]

**38. Oil-and-gas and mining firms have however seen vulnerabilities increase due to commodity price volatility.** Petroleum and mining firms were particularly hard hit by the collapse in commodity prices in 2014–2015. Statistics Canada data shows these sectors saw earnings declines of 27 and 6 percent, respectively, from end-2014 to the four quarters ending in 2018Q3. Oil-and-gas firms saw debt-to-EBITDA rise to 7.4 times as of 2018Q3, from 5.8 times in 2014, and interest coverage fall to 3.4 times. Despite the recovery in oil prices, these firms may be exposed to Canada-specific oil price declines due to challenges in economically transporting oil out of Western Canada and backlogs in U.S.-based oil transportation due to problems in storage infrastructure.

[13] This figure includes affiliate borrowing and thus may overstate the level of vulnerability, however measures of nonfinancial corporate debt without intercompany debt estimated by the BOC have shown similarly rapid growth relative to GDP over this period. For details, see Grieder and Schaffter (2019).

[14] Some of the debt growth in 2016 may reflect the Canadian dollar's 19 percent depreciation against the U.S. dollar in 2015. According to the BIS, there was approximately US$200 billion in Canadian-resident U.S. dollar-denominated nonfinancial bond issuance as of 2014Q4.

[15] Nearly one-third of the debt stock used in this calculation for Canadian corporates is inter-affiliate lending, which is typically not included in such transactions. This means the DSR is likely to be substantially higher. The BIS numbers also assume corporate debt is amortizing, which is typically not the case for bond market borrowing. This may also bias the DSR higher for all countries.

[16] Based on Statistics Canada's Quarterly Financial Statements dataset. Debt is measured as liabilities less inter-affiliate borrowing; earnings are defined as earnings before interest, taxes, depreciation, and amortization.

[17] The interest coverage ratio is EBITDA divided by interest payments.

**39. Increasing leverage in the construction, utilities and real estate sectors merit further attention.** Firms in these sectors saw relatively large increases in debt relative to earnings. Utilities firms typically operate with high leverage, reflecting highly regulated business models with predictable and steady income flows; however, firm-level data suggests that debt-servicing challenges could be rising in parts of the sector. Construction firms, which are largely unaccounted for in firm-level data, accounted for about nine percent of the increase in nonfinancial debt from end-2014 to 2018Q3. Construction firms' nonfinancial debt also grew four times as fast as earnings, although interest coverage ratios remained high (above 6 times). Real estate, rental, and leasing firms, including real estate investment trusts and other de facto investment fund structures, are typically excluded from nonfinancial firm debt-servicing analyses but are classified as nonfinancial firms in Statistics Canada data. Notably, these firms account for 24 percent of the overall growth in nonfinancial corporate debt in this period (see Section on Risk-taking in Nonbanks and Financial Markets). Excluding these firms, nonfinancial firms' aggregate interest coverage ratios actually improved slightly from end-2014 to 2018Q3, and the aggregate debt-to-EBITDA was unchanged.

**40. Firm-level data shows the share of financially weak firms is fairly small, consistent with the aggregate data**. In a sample of 314 nonfinancial, non-real-estate corporations accessed through S&P's Capital IQ database, debt of firms with interest coverage ratios less than one—considered "debt-at-risk"—accounted for 4.9 percent of the Can$980 billion in outstanding debt across the sample.[18] These financially weak firms were largely in the energy and materials (including mining) sectors. The total share of debt-at-risk was roughly unchanged from around five percent in 2016, reflecting the impact of previous years' oil shock on corporate earnings. In 2018, several utilities firms saw debt-servicing risks increase, although some of these firms have public sector backstops. Notably, the sample does not include construction, property development and real estate firms.

**41. A shock consistent with the FSAP's adverse macrofinancial scenario would increase debt-at-risk only modestly.** Simple sensitivity analyses can illustrate how the share of financially weak firms might rise in an economic downturn.[19] The first element of a hypothetical shock is a sample-wide decline in EBITDA by 35 percent, which would be roughly consistent with the year-on-year GDP decline in the adverse scenario of -6.5 percent, based on the sensitivity between GDP and EBITDA observed during the GFC.[20] The second element of the shock is an increase in funding costs of about 3.5 percent for all debt coming due within one year, meant to reflect the 1.7 percentage point increase in the prime lending rate and an additional increase in the interbank spread of

[18] Interest coverage ratios are calculated as interest expense (including capitalized interest) divided by EBITDA. An interest coverage ratio below one indicates that a firm must repay its interest costs using firm assets, rather than income. Debt reported by this data sample is equivalent to about 71 percent of total firm-level borrowing reported by Statistics Canada, as of end-2017; that said, the degree of overlap between the two samples is difficult to estimate.

[19] One key drawback of this type of analysis for gauging the impact on a weak tail of firms is that declines in profitability are assumed to be consistent and proportional across all firms. This means that firms with weak but positive profitability will see smaller absolute declines in profit margins relative to more profitable firms.

[20] For Canadian-incorporated nonfinancial corporations with data on Capital IQ, the decline in aggregate EBITDA during the largest four quarter GDP decline during the GFC (-4.3 percent, for the period ending in Q3 2009) was 24 percent. This implies a sensitivity of 5.6 times, which is used here.

1.5 percentage point (a proxy for potential funding strains). The earnings shock on its own would generate an increase in debt-at-risk of about 3.6 percentage points. The interest rate shock generates an increase of 2.6 percentage points. Together, they generate an increase of 3.6 percentage points in debt-at-risk, the same size as from the earnings shock alone.

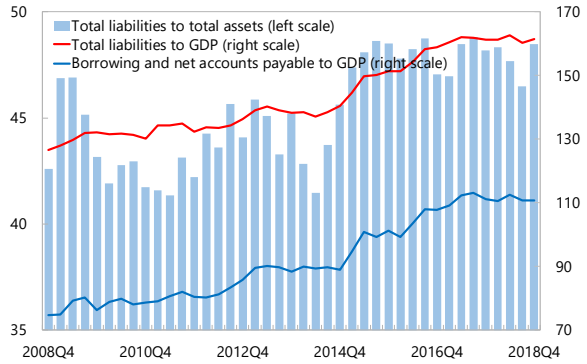
**42. A standalone oil price shock would have a limited effect on energy sector debt-servicing capacity, however the analysis may underestimate potential vulnerabilities.** During the oil price shock of 2014–15, when oil prices fell 75 percent, aggregate trailing 4-quarters EBITDA of Canadian energy-sector firms in the Capital IQ sample reported a decline of about 45 percent peak-to-trough (over six quarters). If energy firms faced a similar 45 percent decline in EBITDA, the share of sector debt-at-risk would only rise from about 0.6 percent to 2.0 percent, reflecting the fact that 89 percent of sector debt is owed by firms with interest coverage ratios above 3. This may however underestimate the potential rise in weak firms; an even higher percentage of energy sector debt was owed by firms with interest coverage ratios above 3 in 2014 (93 percent), but sector debt-at-risk still rose from 1.6 percent in 2014 to 7.3 percent in 2016.

**43. Data limitations mean that corporate debt vulnerabilities could be underestimated.** Statistics Canada data shows private nonfinancial firms have very large inter-affiliate debt liabilities, equivalent to about 50 percent of all other borrowings. While much of this may be related to genuine cross-border inter-affiliate lending relationships, it may also capture debt financing arrangements that meet the definition of inter-affiliate but are nonetheless arms-length in nature (e.g., private equity and debt funds), or are linked to arms-length obligations issued outside the statistical perimeter. This would mean the overall level of arms-length debt captured in the national balance sheet accounts is understated. There are also challenges in understanding the amount of foreign currency borrowing, and to what degree these exposures are hedged via revenue streams or in derivatives markets. Finally, the firm-level dataset is based on the globally consolidated operations of firms that report data to securities regulators, whereas Statistics Canada data may not capture the foreign activities and debt of certain non-resident Canada-incorporated firms. Thus the degree of overlap between the two data sources is unknown.

## Figure 9. Canada: Corporate Financial Soundness

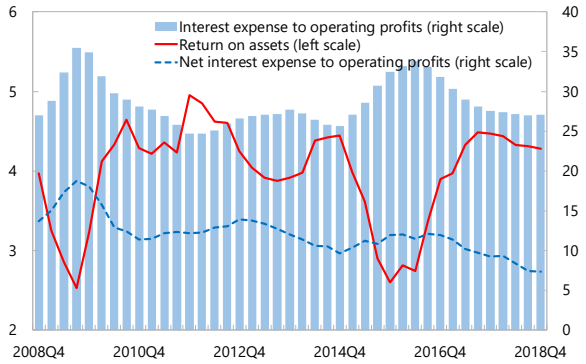
*Corporates have become more indebted and leveraged.*

**Corporate Indebtedness and Leverage, 2008-18**
(In percent)



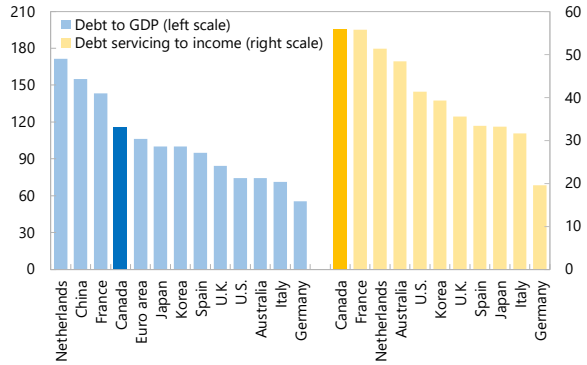

*Corporate profitability has improved from the economic slowdown, with stronger debt-servicing capacity.*

**Profitability and Debt-Servicing, 2008-18**
(In percent)



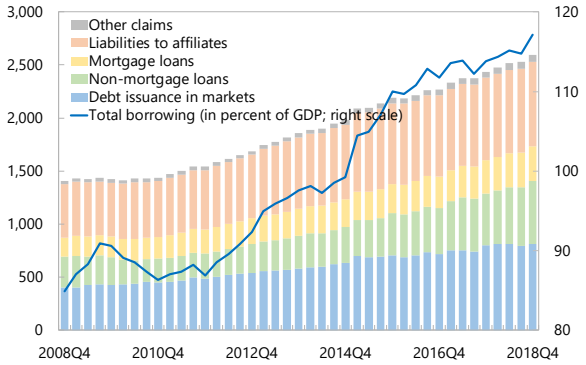

*Canadian firms' servicing obligations are relatively high.*

**Corporate Indebtedness and Debt Servicing, 2018Q2**
(In percent)



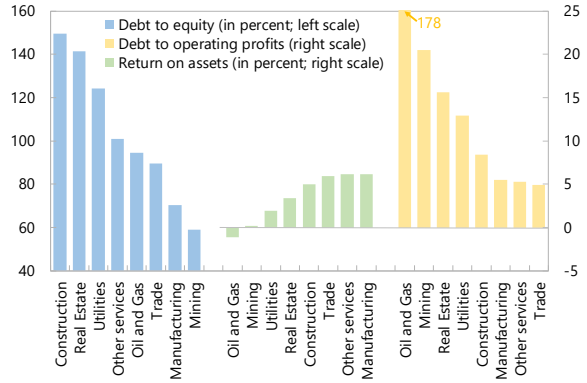

*Two-fifths of corporate borrowing is in the form of liabilities to affiliates.*

**Corporate Borrowing, 2008-18**
(In billions of Canadian dollar)



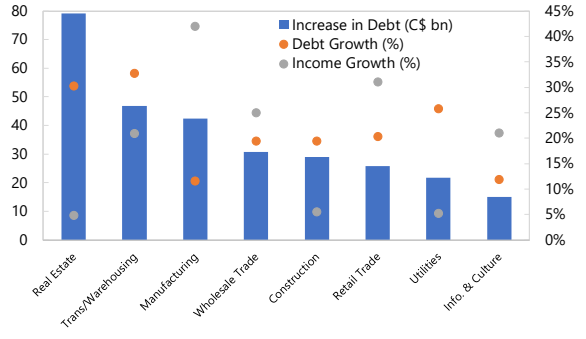

*Construction and real estate firms are relatively leveraged. Meanwhile, oil and gas, and mining firms have weak earnings, aggravating their debt burden.*

**Corporate Leverage, Indebtedness and Profitability, 2018Q3**




*Real estate-related firms account for the largest share of growth in firm debt*

**Corporate Leverage: Debt and Income Growth for Selected Industries: 2014-2018Q3**
(In billions of Canadian dollars and percent)



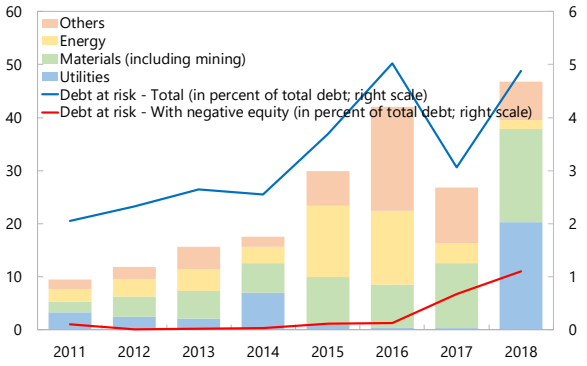

Sources: Capital IQ; Haver Analytics; and IMF staff estimates.
Note: The sixth panel is based on Statistics Canada's Quarterly Financial Statements data. Income is calculated as profits plus interest expense and depreciation expenses.

**Figure 9. Canada: Corporate Financial Soundness (concluded)**

*Corporate debt-at-risk, though rising, remains small, with firms in the utilities and materials sectors among the most vulnerable.*

**Corporate Debt-at-Risk, 2011-18** [1]

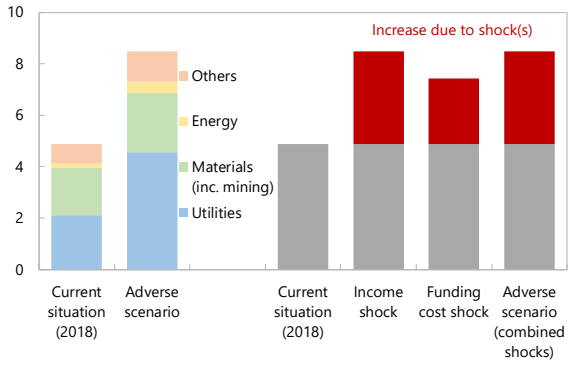
(In billions of Canadian dollar)




*A severe shock consistent with the FSAP adverse scenario would likely double the share of corporate debt-at-risk*

**Corporate Debt-at-Risk, 2018** [1,2]

(In percent of total debt; based on firms with publicly available financial statements)




Sources: Capital IQ; Haver Analytics; and IMF staff estimates.

[1/] Financially weak firms are defined as firms whose earnings before interest, tax, depreciation and amortization (EBITA) is less than interest expense (including capitalized interest). Debt of these financially weak firms is considered at risk.

[2/] The sensitivity analysis assumes income shock (i.e., 35 percent decline in EBITDA) and funding cost shock (i.e., 3.5 percentage points increase).

# BANK SOLVENCY STRESS TESTS

## A. Overview

**44. The FSAP, in cooperation with the BOC, the Office of the Superintendent of Financial Institutions (OSFI) and Autorité des marchés financiers (AMF), assessed the banking sector's resilience to macrofinancial risks.** The analysis included solvency stress testing for all six domestic systemically important banks (D-SIBs) and Quebec's domestic systemically important financial institution (D-SIFI), which account for more than 90 percent of deposit-taking institutions' total assets.[21] The BOC carried out a similar top-down exercise in parallel but used its own methodologies and infrastructure, which also account for contagion effects, including interaction between solvency and liquidity conditions. Both exercises were conducted based on 2018Q3 data and assumed a three-year stress testing horizon.

**45. The FSAP top-down solvency stress test accounted for a comprehensive set of risks.** The FSAP team used IMF's internally developed solvency stress testing framework to capture credit risk (covering both credit impairments and scenario impact on risk-weighted assets, funding, and interest rate risk), market risk (covering repricing and spread risks for interest rate sensitive assets, as well as equity and commodity risks), and non-interest income risks.

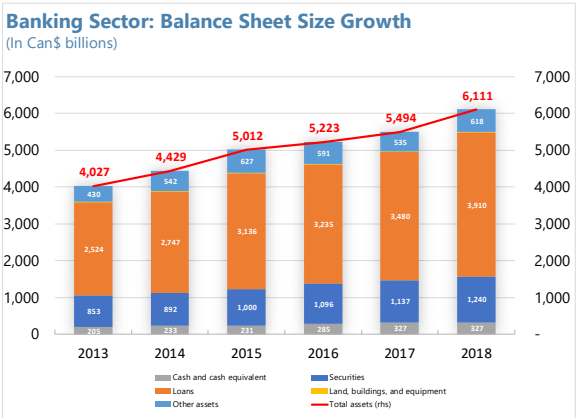
[21] In this particular section, the term "banks" encompasses all entities in the bank stress testing exercises, including Quebec's D-SIFI.

## B. Recent Performance of the Banking Sector

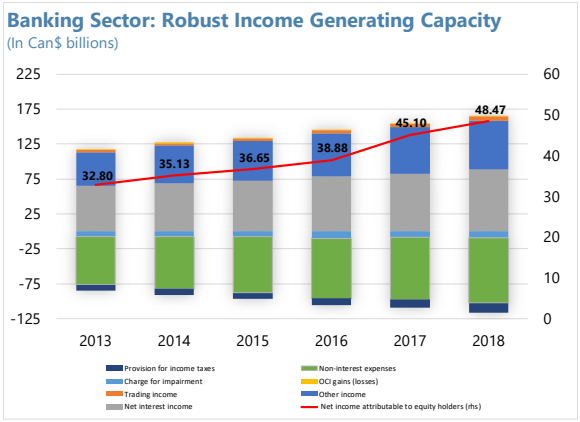
**46. The financial system has enjoyed solid overall growth and remarkable international expansion since the 2014 FSAP.** The combined size of Canadian banks' balance sheets has increased by 52 percent since end-2013, underpinned by robust loan book growth. Banking sector growth is partly driven by the expansion of U.S. operations, with total claims on nonresidents increasing to 39 percent of banking sector assets (from 31 percent). With a targeted expansion in the U.S. being the obvious choice, each major Canadian bank has followed a different implementation plan to achieve its enlarged footprint. While it may take some time to assess the effectiveness of each strategy, the aggregate level the growth of the sector has clearly been steady in terms of balance sheet growth rates and robust in terms of aggregate profitability (Figure 10).

### Figure 10. Canada: Banking Sector Recent Performance

*The sector's balance sheet has expanded by about 50 percent during the last five years, …*




*… with robust income streams and generous internal capital generation capacity.*




Sources: OSFI data on federally regulated entities; and IMF staff estimates.

**47. Internal income generation remains robust, partly due to the exceptional non-interest stream of revenues and the contained increase of operational expenses.** The favorable economic conditions have further supported growth strategies. Credit-linked impairments have been extremely low, and dividend distribution has remained at reasonable levels. As a result, retained earnings could fully finance the implementation of bank expansion plans while at the same time support the build-up of significant capital buffers above the minimum ratios.

**48. Going forward, the ability of the sector to maintain a decent net interest margin might need to be reconfirmed.** Growth of non-domestic asset classes might be more expensive in terms of funding and capital charges faced by banks. On the domestic front, rising competition and market maturation effects[22] might create some strong challenges for the sector. Potential downside risks on the credit portfolio, related to either credit losses or higher risk weights, could have a sizeable impact on overall sector profitability. Nevertheless, the solid current capital ratios of

[22] Especially in the domestic mortgage market in a potential cooling-off scenario.

Canadian banks could provide a mitigating feature, if such adverse developments were to materialize in an economic downturn.

## C. IMF Top-Down Stress Tests: Methodology

**49. A granular solvency stress test for banks was conducted using the two macrofinancial scenarios (baseline and adverse) presented in paragraphs 16 and 17**. The exercise was of an accounting nature, based on the latest available regulatory reports (calendar 2018Q3). It mainly focused on system-wide projections and targeted the assessment of risks and vulnerabilities identified in the FSAP RAM that are relevant to the banking sector. An outline of the overall methodological features, the modelling focus and approach, and the main assumptions are presented below.

### Balance Sheet, Income Projections, and Hurdle Rates

**50. Balance sheet growth followed a quasi-static allocation assumption.** The allocation of assets and the composition of funding sources remained constant as of the cut-off date. Credit exposures in bank balance sheets were projected to grow in line with the baseline and adverse macroeconomic scenario projections for retail and business credit growth. The interest sensitive liability segments were proportionally adjusted to fully reflect the changes in the asset side. Any exchange rate adjustments from the scenario were also incorporated in the balance sheet projections. Maturing capital instruments were not assumed to be rolled over under the adverse scenario, reflecting stressed conditions for banks to raise capital or renew capital instruments directly from the market.

**51. The FSAP stress testing approach also accounted for the recently introduced IFRS 9 accounting standard.** Accounting provisions under both scenarios were projected using stressed stage transition probability matrices for each asset segment. Starting point stage transition probabilities were used based on bank-level reported data, and a fully-fledged methodology was implemented to project lifetime Expected Credit Losses for Stage 2 assets. As a result, the solvency exercise also projected the relative size of IFRS 9 staging volumes by credit segments and accounted for both accounting impairments and regulatory expected losses. Excess credit accounting provisions over regulatory expected losses were added back to tier-2 capital up to the cap of 0.6 percent of credit RWAs. Furthermore, regulatory expected losses in excess of accounting provisions were deducted from common equity tier-1 (CET1) capital to fully recognize the treatment of internal ratings-based (IRB) shortfall or excess.

**52. Projection of RWAs accounted for balance sheet growth, defaulted credit exposures formation, and changes in the exchange rate.** RWAs changed due to balance sheet growth (positive or negative), adjustment in the credit quality of the performing exposures, additional formation of nonperforming exposures based on the scenario, and exchange rate fluctuations. Additional impairments attributed to credit risk were also considered for the RWAs calculation both under the standardized (STA) and advanced IRB (AIRB) approach. For market risk, the value-at-risk (VaR) RWA charge was replaced with the stressed VaR RWA charge in the adverse scenario. RWAs

for operational risk and any residual RWA charge were kept constant at the level of the cut-off date for both baseline and adverse.

**53. Income (profit or loss) was projected based on the impact of all risk factors considered in the stress test.** Specifically, total net income reflected projections for net interest income, non-interest income and expenses, trading income, profit and loss or other comprehensive income changes due to the revaluation of the "fair value through other comprehensive income" (FVOCI) and "fair value through profit or loss" (FVTPL) portfolios, credit loss provisions, and tax charges and dividend distributions.

**54. Minimum capital requirements were based on actual supervisory requirements during the stress testing horizon (2019–2021).** The stress testing results were benchmarked against the regulatory minimum and target values for CET1, T1, and total capital that also includes a capital conservation buffer (CCB) of 2.5 percent (fully phased in 2019) and a D-SIB surcharge of 1 percent for all 7 banks within the scope of the exercise. An additional domestic stability buffer (DSB) of 1.75 percent[23] is required for the six federally regulated D-SIBs. Table 6 summarizes the regulatory minimum and target capital requirements. Under the baseline scenario, banks are expected to maintain capital ratios that are above the total target requirements (including minimum, CCB, D-SIB surcharge, and DSB, if applicable). In the adverse scenario, the requirement on preserving the CCB and the DSB are relaxed.

**Table 6. Canada: Minimum and Target Capital Requirements for Solvency Stress Tests (effective 2019)**

(In percent)

| | Minimum requirement | Capital conservation buffer (CCB) | D-SIB surcharge | Domestic stability buffer (DSB) | Total minimum |
|---|---|---|---|---|---|
| Common equity tier-1 (CET1) capital | 4.50 | 2.50 | 1.00 | 1.75 | 8.00 + DSB |
| Tier-1 capital | 6.00 | 2.50 | 1.00 | 1.75 | 9.50 + DSB |
| Total capital | 8.00 | 2.50 | 1.00 | 1.75 | 11.50 + DSB |

Note: See Chapter 1, Section 1.5 of "OSFI Capital Adequacy Requirements (OSFI 2018).

**55. Banks were assumed to comply with the regulatory dividend distribution policy and applicable restrictions under both scenarios.** Dividends were assumed to be constant, anchored to the distribution of the last fiscal year; distributions were only restricted if the ending capital ratios during the scenario years was below the regulatory thresholds that are used to restrict distribution, as per Table 7.

[23] The calibration of the DSB is reviewed semi-annually. The DSB was increased to 2.0 percent on June 4, 2019.

**Table 7. Canada: Dividend Distribution Restrictions**

| CET1 capital ratio (in percent) | Maximum of profits that cannot be distributed (in percent) |
|---|---|
| 5.5–6.125 | 100 |
| >6.125–6.75 | 80 |
| >6.75–7.375 | 60 |
| >7.375–8.0 | 40 |
| >8.0 | 0 |

Note: The 1 percent D-SIB surcharge extends the capital conservation buffer for the purpose of capital conservation. Dividend restrictions depend on the quartile of the shortfall, i.e., full restriction applies when the ending CET1 capital ratio is below 6.125 percent, a restriction of 20 percent of earnings is imposed when the CET1 capital ratio falls into the range of 6.125–6.75, and no restriction applies when the CET1 capital ratio is above 8 percent.

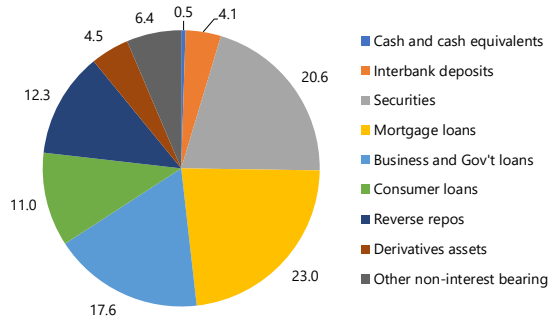
## Credit Risk Analysis and Estimation

**56. Credit risk is the most important risk factor for the Canadian system given that credit exposures correspond to almost 51.6 percent of total assets (Figure 11).** By type, retail real estate-linked products account for about 40 percent of the total exposures at default (EAD) and almost 50 percent of the total drawn lines. Corporate loans correspond to 32 percent of credit exposures and consumer credit (including credit cards) to 15.8 percent. By geography, 68.3 percent of total exposures are domestic and another 21 percent in the United States. However, individual banks appear to be quite diverse in terms of their geographical footprint. The relative importance of credit risk is also confirmed by the substantial proportion of total RWAs that are attributed to credit risk versus residual risk types (which is almost 83 percent, including charges for securitizations and counterparty credit risk). Finally, market aggregate data indicate that AIRB is the predominant regulatory approach; approximately 88 percent of exposures are reported under IRB and only 12 percent under STA.

## Figure 11. Canada: Asset Side Analysis

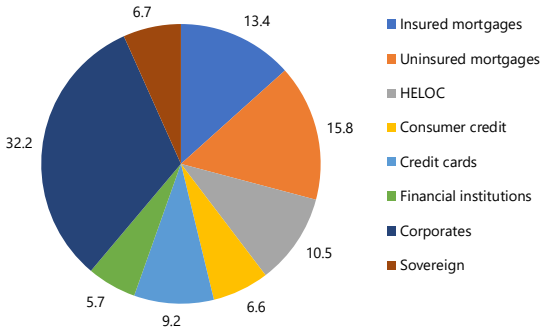
*Loans account for more than half of the aggregate asset side of the balance sheet, with securities holdings and reverse repos at the second and third place, respectively.*

**Aggregate Market: Asset Side Analysis**
(In percentage points)



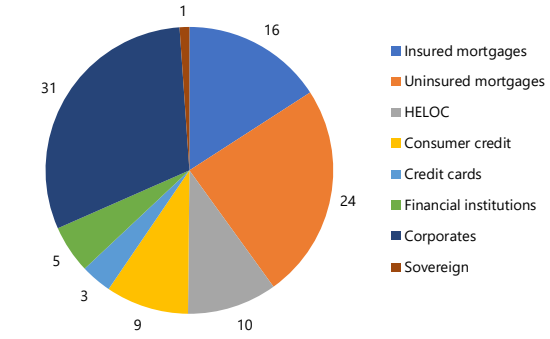

*In terms of exposures, retail real estate-related segments (insured and uninsured mortgages and HELOCs) make up almost 40 percent of the total…*

**Exposure at Default (EAD): Breakdown by Type**
(In percentage points)



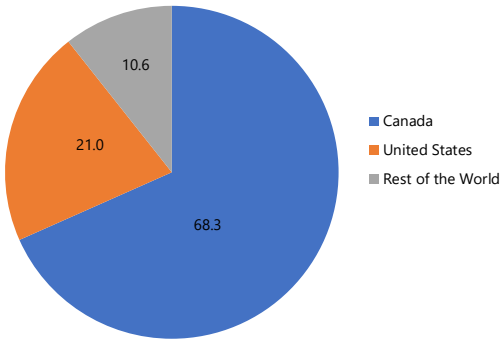

*… and almost half of the drawn notional amounts. This fact identifies mortgage-linked exposures as the main risk in terms of the relative magnitude in the balance sheet.*

**Drawn Notional: Breakdown by Exposure Type**
(In percentage points)



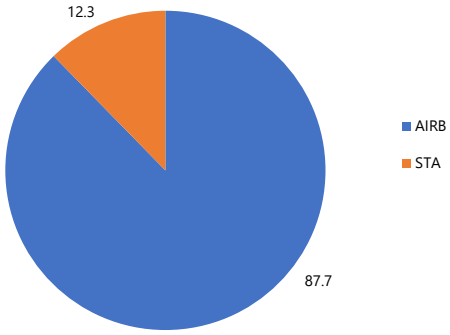

*In terms of geographical breakdown, Canadian and U.S. exposures account for almost 90 percent of the exposure in aggregate terms…*

**Geographical Concentration of Credit Exposures**
(Market aggregates in percenatge points)



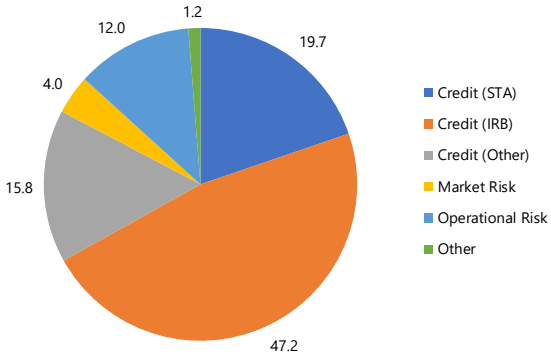

*…with almost 90 percent of the exposures under the advanced internal ratings based (AIRB) approach.*

**Credit Exposures (EAD) by Regulatory Approach**
(In percenatge points)




*The importance of credit risk is further confirmed by the relative size of credit-related RWAs compared to market and operational risk charges.*

**Risk Weighted Assets (RWA): Decomposition by Type**
(Market aggregate figures as a percentage of total RWAs)




Sources: IMF staff estimates.

**57. A variety of modelling approaches were used to model credit parameters under the two scenarios.** Exposures were initially allocated to asset types based on an exposure segmentation scheme that included retail real-estate related classes (insured and uninsured mortgages and HELOCs), consumer retail classes (consumer credit and credit cards), and corporate exposure classes. Corporate exposures were further broken down by industry into 11 industrial asset classes. Additional segmentation layers included a breakdown by geography—Canada, United States, and Rest of the World (ROW)—and by regulatory approach (AIRB and STA). Credit parameters starting points were collected for all asset types and segments, and a suite of models were estimated for the scenario dependent projection-of-credit parameters—probability of default (PD), point-in-time (PiT), and loss given default (LGD) PiT.[24] Table 8 illustrates the entire segmentation scheme, with 16 asset exposure classes for 3 geographies (Canada, United States, and ROW) and 2 regulatory approaches (AIRB and STA). This results in a total of 96 asset-class segments.

**Table 8. Canada: Credit Risk Exposure Segments**

Geographies: Canada, United States, Rest of World
Regulatory approach: AIRB, STA

| |
|---|
| Residential mortgages (insured) |
| Residential mortgages (uninsured) |
| HELOCs |
| Consumer credit |
| Credit cards |
| Corporates |
| Financial institutions |
| Agriculture, logging, forestry, fishing, and trapping |
| Mining, quarrying, and oil wells |
| Manufacturing |
| Construction and real estate |
| Transportations, communications, and other utilities |
| Wholesale trade |
| Retail trade |
| Services |
| Non-residential mortgages |
| Other business loans |
| Sovereign |

[24] Given that no historical LGD data could be collected from the regulatory returns, a simplified approach was followed for all segments except the retail real-estate related segments. Under this approach, for segments for which there is no explicit model for PiT LGDs, the regulatory downturn LGDs was used as the basis to provide adjusted estimates for both adverse and baseline scenarios.

**58. For the projections of PDs, the stress test approach made use of satellite models to project scenario-dependent forward paths.** Bayesian Model Averaging (BMA) was used as the core modelling approach in the estimation of econometric models for the projection of default probabilities under both scenarios. This framework was used for all 11 corporate segments, and the consumer and credit card segments for both Canada and the United States. For corporate PD PiT satellite models, historical default rates by industry were used. The historical default rates by industry were obtained by third party data providers.[25] For credit cards, the aggregate for the market historical delinquency and loss statistics time series was provided by the Canadian Bankers Association statistical data warehouse.[26] These time series were used to drive the calibration of a regression model with reasonable response. Based on the estimated econometric models, a PD path for each scenario and asset segment/class was generated. Details of the BMA PD PiT satellite models and the estimation approach can be found in Appendix III.

**59. The satellite models also informed the IFRS 9 calculation engine that was used to account for the accounting layer.** PiT stage transition rates were collected from the regulatory returns for all banks and all segments for the first three quarters of 2018. Based on the PiT PD paths for each scenario, a stressed transition rate matrix was produced for each year of the stress testing horizon. The estimation of stressed transition matrices facilitated the projection of exposure transitions across stages through the horizon. An additional calculation layer was used to estimate lifetime losses for Stage II assets. The accounting layer was developed to enable a full projection of accounting impairments for each asset type/segment. Under the baseline scenario, macroeconomic variables were assumed to remain constant after year 3 of the scenario; under the adverse scenario, macroeconomic variables were assumed to gradually converge back to the baseline path within a period of six years. Perfect scenario foresight was also assumed to simplify provisioning projections.

**60. A structural model was used to project loss rates for mortgage and real estate-related retail portfolios.** Major loss events in residential housing loan portfolios are practically non-observable in the history of the Canadian market; furthermore, the currently observable default rates are particularly small. For these reasons, a satellite model calibrated on conventional econometric approaches was not feasible for fully capturing the dynamics of a major economic downturn like the one captured in the adverse scenario. A structural model, on the other hand, can fully incorporate features that mimic how defaults in residential mortgage markets may be masked by a housing market boom. Therefore, it can perfectly explain the bimodal dynamics of smaller loss rates during rising housing markets (like those observed in the Canadian market) and also provide some valuable insights on how defaults and non-performing loan (NPL) formations may drastically evolve under severely adverse macrofinancial conditions. In that context, the model can be consistent with economic realities under both scenarios.

[25] Moody's CreditEdge historical default rates for Canadian and U.S. industrial segments were used to estimate the corporate segments satellite models of Canada and United States, respectively. For ROW, the U.S. models were used as a proxy.

[26] The time series can be found under the following link: https://cba.ca/credit-card-delinquency-and-loss-statistics.

**61. The model uses borrower affordability metrics (i.e., DSR) and how they get affected under a specific scenario to infer default probabilities.** House price shocks are used to estimate losses in the default event. Scenario shocks are linked to household microdata sources in order to also simulate behavioral elements for the borrowers under distress. This allows a joint distribution of the DSR, the loan-to-value (LTV) ratio of the mortgage, and the liquid wealth of the borrower to fully represent the credit quality of the portfolio. The scenario shocks (on interest rates, unemployment, and house prices) determine how the borrowers' population is affected, how defaults are triggered, and how potential losses can be linked to such defaults. A detailed presentation of the approach underpinning the implementation and use of the structural model for mortgage portfolios can be found in Appendix IV.

**62. The structural model proved to be particularly flexible and was used to assess several aspects of the mortgage market.** More specifically, in the FSAP overall approach, the mortgage structural model served the following tasks. First, it was used as the primary model for the purpose of projecting PD PiTs and LGD PiTs. Second, it facilitated the task of disentangling the two-layer architecture of coexistence of banks and mortgage insurers and provided estimates for the credit parameters of both insured and uninsured mortgage portfolios. Third, it provided bank specific starting points and projections after adjusting for bank specific portfolio quality characteristics. Fourth, it provided valuable guidance in assessing the adequacy of capital requirements for both market layers, both under current and post-stress conditions. Fifth, it enabled the team to perform some sensitivity or impact attribution analysis under different set of assumptions for the interest rate, unemployment, and house price shocks.

### Market Risk Analysis

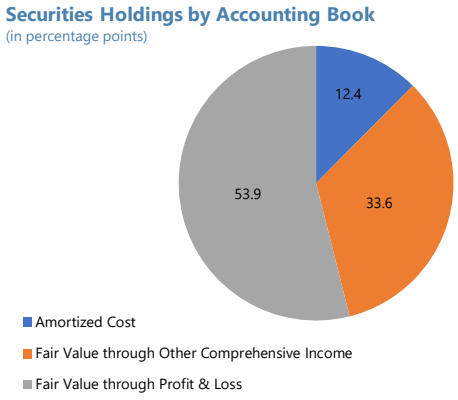
**63. The analysis for market risk captured the valuation risks of the securities portfolio due to changes in risk-free interest rates and credit spreads for interest sensitive instruments, as well as equity and commodity risks.** An ad-hoc data collection request was made to banks which they reported their debt, equity, commodity and fund portfolios by accounting category and maturity bucket (where applicable). The macrofinancial scenario was extrapolated to produce financial variable shocks (mainly interest rate spread shocks by security type). Interest rate and spread shocks were applied to debt portfolios using the modified duration approach by debt portfolio type (CAN sovereign, other sovereign issuers, provincial and municipal governments, MBSs. corporate bonds and paper, and ABSs and ABCPs).

**64. The analysis covered the impact of interest rate risks and spread risks on sovereign and corporate debt securities in all accounting portfolios: amortized cost (AC), FVOCI, and FVPL.** Losses from AC and FVPL portfolios was assumed to have an impact on regulatory capital through net profits, while those for FVOCI portfolios affected capital through other comprehensive income. For interest rate sensitive positions in the AC portfolio, only the impact of credit spread changes was accounted for. For conservatism, existing hedges were assumed to be ineffective during the scenario horizon.[27]

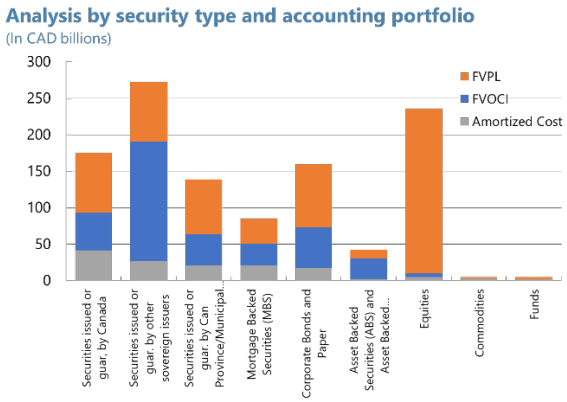
**65. Debt securities are primarily held in the FVOCI book and are largely dominated by domestic and international sovereign debt.** Sovereign debt accounted for 57 percent of the FVOCI portfolio and 40 percent of the total securities portfolio, with provincial government debt adding an additional 12 percent in the total general government securities share. Corporate debt stood at 14 percent, with an additional 12 percent of asset-backed securities (ABS) and mortgage-backed securities (MBS). In terms of portfolio allocation, 12.4 percent of securities are in the AC portfolio, 33.6 percent in the FVOCI portfolio, and the residual in the FVPL book. Figure 12 illustrates the composition of the three accounting portfolios and a breakdown by asset/security type.

## Figure 12. Canada: Securities Holdings Analysis

*Banks hold significant securities positions in all accounting portfolios, ...*




*... with high-quality sovereign debt being the most dominant asset type.*




Source: IMF staff estimates.
Note: FVOCI = Fair-value Through Other Comprehensive Income; FVTPL = Fair-value Through Profit or Loss.

[27] A notable exception was the significant FVTPL equity exposures for several banks in the sample. Based on discussion with authorities, these exposures are either back-to-back transactions with pension funds or hedging equity-linked structured notes that are widely marketed as a term deposit alternative. Based on the discussions and the documentation provided by OSFI, the overall approach was to exclude these exposures from the application of market shocks to avoid producing extreme profit-and-loss impact from the specific exposures. A proper assessment of these positions would have included a complete set of exposure sensitivities, including the overall hedging approach and the assessment thereof of any hedging inefficiencies. An analysis of this type would require a much more granular dataset that is not captured by the standard regulatory return that was available for the FSAP.

**66. Market valuation losses from interest rate risks in the debt portfolios were derived using a modified duration approach.** First, the analysis captured the re-pricing losses in the FVOCI and the FVTPL books due to shocks to sovereign yield curves. Second, it also accounted for the valuation impact in all accounting books due to shocks to the spread of debt securities. Spread projections on provincial government debt, corporate bonds, and ABS/MBS debt were computed based on average yield per maturity tenor of the relevant type of security from Bloomberg and was anchored to reflect the macrofinancial conditions described by the two scenarios.

**67. Commodity price risks and mutual fund exposure risks were also accounted for using the shocks provided in the scenarios.** The banking sector's exposure to these types of risks is relatively limited when compared to interest rate and spread risks (Figure 2).

### Net Interest Income

**68. Econometric models were estimated to project the scenario impact on a set of interest sensitive liability and asset segments.** Given that historical price series of effective interest rates were available for six asset and six liability interest bearing segments (Table 9), the FSAP approach was to implement econometric models to project effective interest rates under the two scenarios. First, a system-wide historical time series of effective interest rates was estimated for all twelve segments using quarterly historical data on effective balances and interest rates. Second, an econometric model for each segment was calibrated using BMA techniques. The BMA approach operates with a pool of equations (several hundreds or thousands) per dependent variable, to which weights are assigned that reflect their relative predictive performance, which then results in a "posterior model" equation. The pool of equations contains a large number of equations for every single interest rate risk indicator (per portfolio segment), by considering all possible combinations of predictors from a pool of potential predictor variables, including variables such as real GDP, investment, consumption, price inflation, short- and long-term interest rates, and credit spreads. Detailed satellite estimations on effective interest rates can be found in Appendix V.

**Table 9. Canada: Net Interest Income Segments**

| | |
|---|---|
| **A** | **Assets** |
| A1 | Interbank deposits |
| A2 | Securities |
| A3 | Mortgage loans |
| A4 | Business and government loans |
| A5 | Consumer loans |
| A6 | Reverse repos |
| | |
| **L** | **Liabilities** |
| L1 | Personal demand deposits |
| L2 | Personal term deposits |
| L3 | Other demand deposits |
| L4 | Other term deposits (wholesale) |
| L5 | Subordinated debt |
| L6 | Other interest-bearing liabilities |

**69. The distance of bank specific starting points by segments informs the projection for the bank-specific interest rate forward paths.** Bank-specific interest rate percentage deltas from the system-wide composite interest rate per segment at the starting point were used to adjust composite interest rate projections (from the BMA satellite model output) and produce bank-specific interest rate projection paths for both scenarios and across all segments.

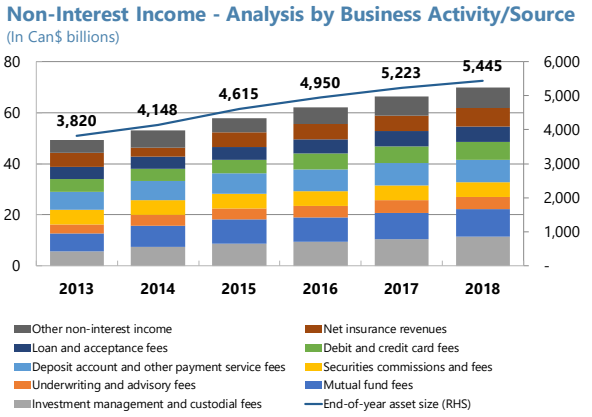
**70. Maturity gap analysis was also used to reflect pass-through constraints for mortgages and consumer credit.** The short-term maturity profile of most liability segments implies a fast repricing of most segments, with no significant pass-through constraints. For these segments a direct net interest income/expense projection was based on the effective interest rate projected by the satellite model. For mortgages and consumer credit, after a thorough analysis of the repricing profile in both the domestic and non-domestic dimension, it was decided to also employ an additional constraint to account for the imperfect pass-through conditions (due to the longer-term nature of the repricing gap). Therefore, new mortgage origination rates, as projected in the two macrofinancial scenarios, were used in combination with the repricing gap to derive bank-specific effective interest rate paths. An additional cap of 330 basis points for the spread of the mortgage rate over the personal demand deposit rate was used to ensure conservatism and reflect structural competition factors that would not allow the two segments to reprice independently. For consumer credit, the effective interest rate projected by the econometric model was used as a proxy of the effective rate to be used for the part of the portfolio that is repriced during this period (with no additional constraints). After enforcing these two pass-through constraints, tighter interest margins are observed in the adverse scenario during the first two years of the horizon.

### Non-Interest Income Analysis

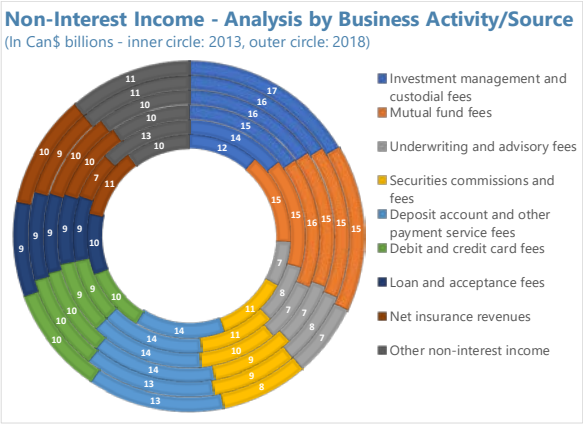
**71. Non-interest income is a significant component of Canadian banks' overall profitability and internal capital generation capacity.** Non-interest total income reached a level of almost 75 percent compared to the sector's net interest income in 2018 and has been a particularly stable source of profitability over the past seven years. Growth of non-interest income has followed in magnitude the growth of the sector in terms of total asset size and geographical concentration, and the composition of non-interest income by business lines has been broadly stable (Figure 13).

## Figure 13. Canada: Non-interest Income Analysis

*Non-interest income has experienced solid growth as balance sheets expanded…*




*This segment is well diversified and balanced in terms of originating activity or business line.*




Source: IMF staff estimates.

**72. In the adverse scenario, non-interest income was stressed using a relatively simplified approach based on the historical variance of the non-interest income components by income activity.** Historical data were collected on total non-interest income and then broken down by specific activity for the last five years. A conservative estimate of projected bank-specific income was produced by adjusting yearly profit by activity: under the adverse scenario, profits from each business activity were projected to be equal to the latest income minus one standard deviation of the historical variability of the income. This approach ensures that projections for banks with higher levels of dispersion in terms of activity income (as a percentage of total assets) would be more negatively impacted. As an additional constraint, a minimum drop in yearly income was introduced for each activity to account for its sensitivity to adverse macrofinancial conditions. To reduce balance sheet sensitivity, and to fully account for the non-domestic expansion of Canadian banks, bank-specific standard deviations were calculated after dividing historical profits by bank total assets each year.

**73. The approach allows for different sub-components to be stressed in accordance with the degree of their market sensitivity or to the level of historical variability.** Income breakdown across activities serves as the starting point that generates different projections for each bank. The foreign-currency composition of each revenue stream in both scenarios is also accounted for by considering the exchange rate appreciation/depreciation in the scenario and the currency breakdown at the cut-off date. Operating expenses are assumed to remain constant through the scenario, allowing only for the impact of exchange rate appreciation/depreciation. Additional information on the business activity lines that were considered, and the minimum scaling factors used, can be found in Appendix VI.

## D. IMF Top-Down Stress Tests: Results

### Main Results

**74. Banks appear resilient to severe macrofinancial shocks, with all banks meeting the hurdle rates by the end of the stress testing horizon** (Figure 14)**.**

- In the baseline, the system-wide aggregate CET1 capital ratio would be on an upward trajectory due to banks' solid revenue-generating capacity.
- In the adverse scenario, the aggregate CET1 capital ratio would decline by 4.8 percentage points to 7.4 percent in 2020 before recovering to 9.6 percent in 2021. During the stress testing horizon, most banks would run down conservation capital buffers, subjecting them to dividend restrictions (partially or fully).
- The worst outcome in 2020 largely reflects the dynamics of the adverse scenario that features a strong recovery with a more favorable interest rate environment in 2021. During 2019–20, in the adverse scenario, cumulative pre-loss income would amount to 2.9 percent of RWAs, compared with losses due to credit and market risks of 3.9 and 1.8 percent of RWAs, respectively. Deteriorating credit quality of loan portfolios, as reflected in higher RWAs, would also have an impact of 1.2 percentage points in the final CET1 ratio.
- The key factors behind the larger capital depletion in the adverse scenario (relative to the baseline) are substantially larger credit impairments, lower net interest income and non-interest income, and increased RWAs. The difference between the baseline and adverse aggregate CET1 capital ratio at the end of the stress testing horizon is 5.6 percentage points.

**75. Stress test results highlight the importance of properly capturing accounting considerations, particularly related to IFRS 9.** In the adverse scenario, and when compared to the baseline, credit impairments could increase significantly under IFRS 9, which introduced lifetime expected credit losses for Stage 2 assets (i.e., non-defaulted exposures showing deteriorating credit quality). In particular, aggregate Stage 2 assets and Stage 3 assets (i.e., defaulted exposures) would account for 13.6 and 8.3 percent of total exposures, respectively. Overall, accounting impairment charges in the adverse scenario would exceed regulatory provisions for most banks, which further underpins the importance of also considering the accounting layer in the stress testing exercise. As a result, excess provisions are added back to tier-2 capital, up to the cap of 0.6 percent of credit RWAs, to derive a more accurate projection of realistic CET1 projections.

**76. Credit losses are the main driver of the stress test solvency result.** Impairments in the adverse scenario are significant across all asset classes. The cumulative default rate at the end of the stress testing horizon stands at 6.4 percent for uninsured mortgages and HELOCs, 13.3 percent for consumer retail exposures, and 8 percent for corporate exposures. The respective figures for the baseline scenario are 0.7, 8.3, and 3.8 percent. Additional cumulative impairment flow under the adverse scenario reaches approximately Can$90 billion, with 37 percent of them corresponding to

corporates, 34 percent to consumer credit asset classes, and 29 percent to uninsured mortgages and HELOCs (Figure 14).[28]

**77. Net interest income experiences a significant drop in the adverse scenario due to the imperfect pass-through.** The snapback nature of the interest rate path in the adverse scenario is a particularly challenging scenario for the system in terms of pass-through efficiency. The short-term nature of the funding mix tends to reprice faster than the asset side when interest rates are on the rise, leading to a higher increase of the interest expense component versus the interest income component (Figure 14). This translates into compressed net margin for all years. Average yearly net interest income is approximately 24 percent lower when compared to the year preceding the cut-off date (2018) and the average net interest income in the baseline. It is important to point out that the aggregate net interest income reaches the lowest value during Year 2 when net interest expense reaches the maximum value. At this point net interest income is 34 percent below the cut-off year level, and broadly recovers after that, following the favorable adjustment of interest rates.

**78. In the adverse scenario the impact for non-interest income is considerable.** Non-interest income projections are approximately 20 percent lower for the system aggregate in the adverse scenario relative to the baseline. Banks still manage to generate Can$168 billion of non-interest profits during the three years, or an average of Can$56 billion per year (Figure 14), versus a yearly starting point of Can$70 billion. This decline could be attributed to the conservative estimates across the various business lines and, to a lesser extent, the slowly decreasing size of interest-bearing assets and the exchange rate adjustments in accordance with the scenario. In contrast, foreign-currency related effects on non-operational expenses do not to seem to play an important role in the overall result.

**79. While pre-loss income is substantially stressed it remains positive throughout the entire stress testing horizon of the adverse scenario.** This is because the starting points for bank net interest income (high net interest margin in absolute terms) and non-interest income are very high compared to operational expenses. The significant level of diversification observed in the break-down of non-interest income and the concentration on business lines that are not market sensitive also have a positive contribution to the observed resiliency of the pre-loss income. Such resiliency supports the capital position of banks through positive earnings under stressed conditions.

**80. The total market risk impact largely depends on the scenario path and more specifically on the interest rate path of the scenario.** FVOCI and FVTPL portfolios contain significant positions of interest rate sensitive instruments. As a result, the end-horizon losses under the baseline are larger compared to the losses incurred under the adverse scenario due to the higher interest rates shock experienced. In the adverse scenario, profit-and-loss and other

[28] Under the FSAP approach, no additional impairments for banks were associated with the insured mortgage portfolios. Nevertheless, the application of the credit satellite models on the insured segments was used to inform the analysis of the mortgage insurers' stress testing, thereby ensuring that losses projected for these segments were consistent with the uninsured mortgages.

comprehensive income losses are not substantial (less than Can$10 billion, or approximately 0.5 percent of RWAs), but the timing of losses (and profits) is important. Given the material shock to interest rates during Year 1 in the adverse scenario, revaluation market risk losses reach Can$43 billion. Most of it is partly recovered during Years 2 and 3, as yields gradually converge to lower levels following accommodative policy changes. In the baseline, interest rate losses are more protracted: at the end of the stress testing horizon market risk losses account for Can$32.4 billion, or 1.6 percent of RWAs. Exposures on other asset types (equity risk, post recognition of current hedging relationships; commodity risks; and fund participation risks) do not seem to have a material impact on profit and loss or capital. Derivatives exposures, though significant in terms of notional amounts, were not explicitly stressed due to unavailability of sensitivity data. Data limitations made it impossible to include counterparty credit risk and credit valuation adjustment (CVA) risk in the scope of the market risk analysis.

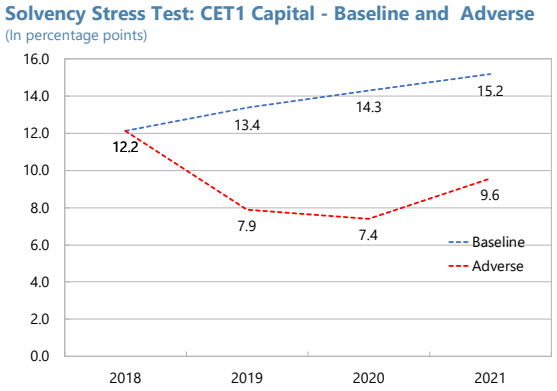
**81. Unfavorable macrofinancial conditions and the resulting deterioration of credit quality for the credit exposures have a material impact on RWAs in the adverse scenario.** Overall, credit risk RWAs increase to Can$1.66 trillion in Year 2 of the adverse scenario versus a starting level of Can$1.29 trillion, reflecting the significant increase in the through-the-cycle PDs for all asset classes (Figure 15). Improving macrofinancial conditions during Year 3 have some positive impact on corporate PDs and, therefore, total RWAs are lower in the later year. If compared with the starting point (cut-off date), credit RWAs increase by 29 percent by Year 2 and 17 percent by Year 3 and have a negative contribution to the CET1 depletion of 1.2 percent and 0.8 percent of total RWAs, respectively. The impact of market risk RWA changes in the adverse is immaterial given the small relative size of market risk RWAs.

**82. When compared with the respective values of the baseline case, incurred losses under the adverse scenario are (partially) offset by the lower provisions for tax and the assumed restrictions on dividend distribution.** Taxes are generally lower because banks may be loss making or experience significantly lower profitability in the adverse scenario than in the baseline. Dividend distribution is also restricted as a result of the regulatory restrictions regarding CCB maintenance. These are illustrated in Table 7.[29] As a result, tax-linked outflows are lower by 0.9 percent of starting RWAs and dividend distributions are lower by 0.7 percent of RWAs, partially compensating for the more severe CET1 depletion in the adverse scenario.

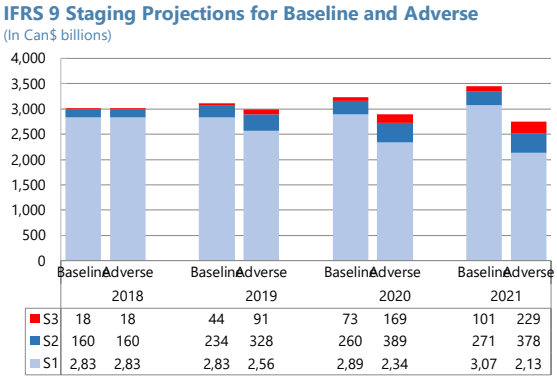
[29] Although the restriction in dividend distribution is effectively applied on a quarterly basis, the FSAP approach could only use an annual proxy to simulate the impact. Therefore, the impact of lower dividends may be slower to kick in or underestimated during the first years.

## Figure 14. Canada: Bank Solvency Stress Test Results

*Banks are resilient to the adverse macro scenario, but at the trough of Year 2 most banks would have to restrict dividend payments.*

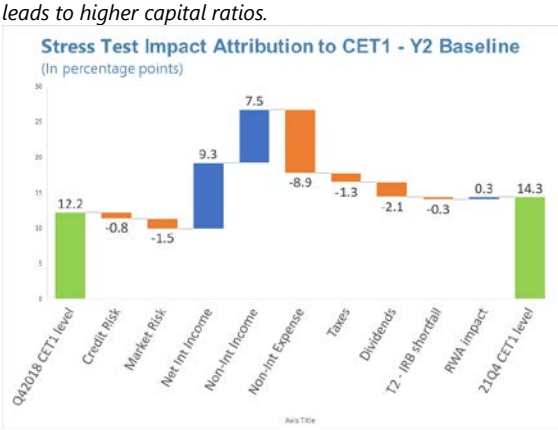



*IFRS 9 Stage 3 and Stage 2 exposures account for 8.3 percent and 13.8 percent, respectively, of total credit exposures in the adverse scenario.*

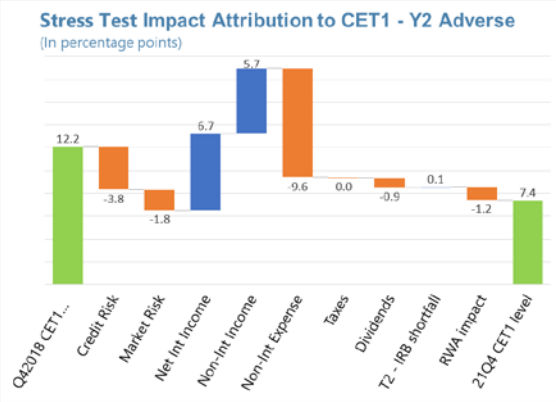



Exposure Volumes of IFRS 9 Stages under Baseline and Adverse

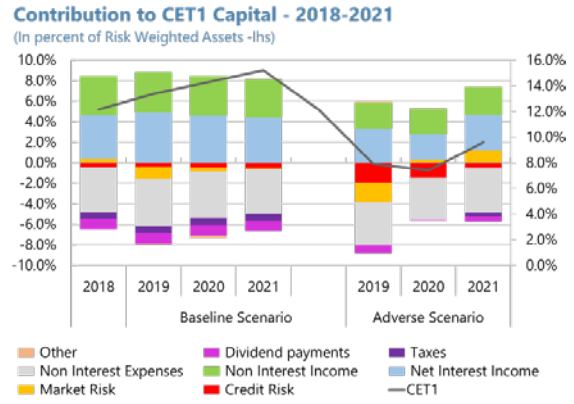
*Solid internal capital generation capacity in the baseline—due to elevated levels of net interest and non-interest income—leads to higher capital ratios.*



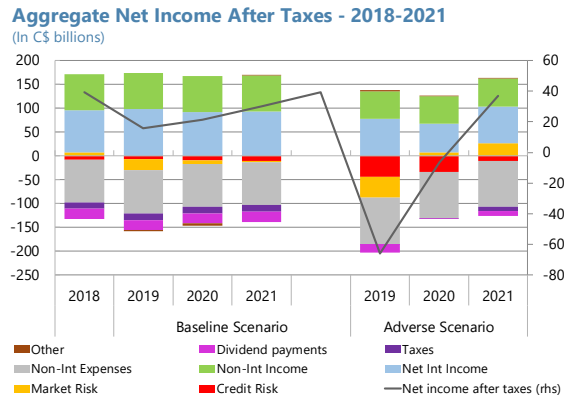

*Credit impairment and market risk losses, combined with stress to net interest income, drives the negative result in Year 2 of the adverse scenario.*




*The effects of stressed interest and non-interest income and significant credit impairments in the adverse scenario are only partially offset by lower effective taxes and restrictions on dividend payouts.*



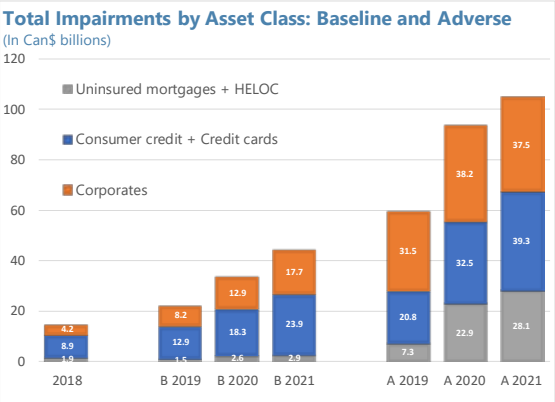

*Net income after taxes would only recover under Year 3 of the adverse scenario on the back of a favorable interest rate environment and contained credit impairments.*



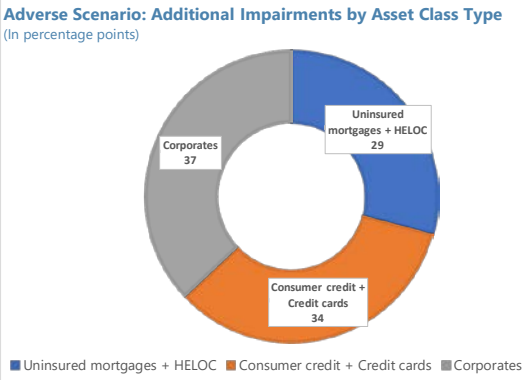

Source: IMF staff estimates.

## Figure 15. Canada: Stress Test Results—Credit Risk Impairments and RWA Projections

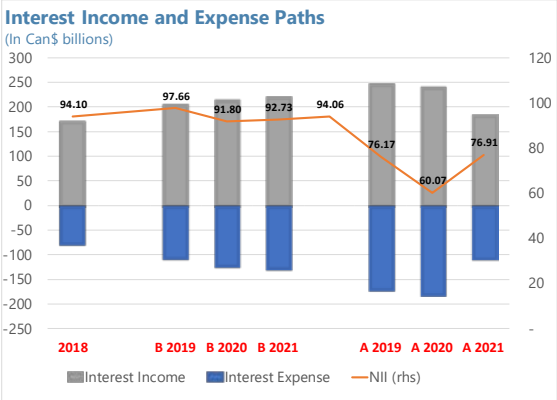
*In the adverse scenario, almost Can$90 billion of additional provisions are projected.*



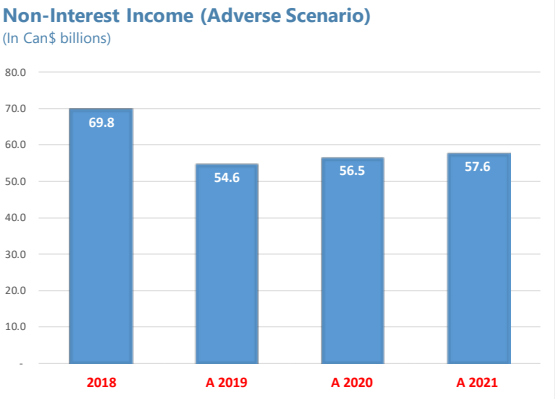

*New impairments are evenly distributed across asset classes.*



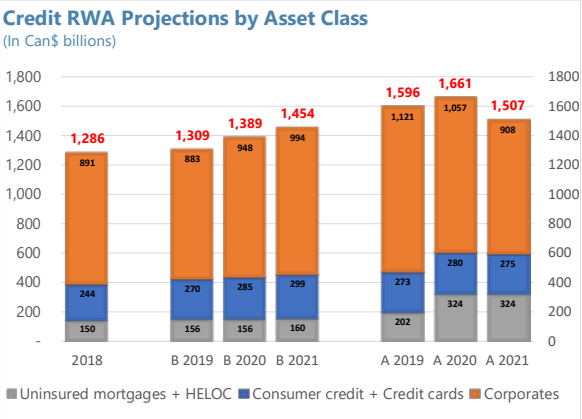

*In the adverse scenario, average net-interest income is almost 25 percent lower than the baseline.*




*In the adverse scenario, non-interest income is 19 percent lower, on average.*




*Total RWAs increase, despite the contraction of the balance sheets in the adverse scenario, but by varying degrees across exposure classes.*




Source: IMF staff estimates.

## Sensitivity Analysis

**83. There are a number of Canada-specific features that cannot be fully captured in the abovementioned set of stress test results that are based on standard assumptions, for which further sensitivity analysis was performed by the FSAP team.** In agreement with the BOC, the FSAP team conducted some additional tests to quantify the impact of the following elements: (i) sizeable undrawn exposures related to HELOCs and consumer credit (not captured under a quasi-static balance sheet assumption); (ii) mortgage exposures where lifetime expected credit losses (for Stage II assets under IFRS 9) are calculated based on remaining contractual maturity, which is far shorter than the residual amortization period; and (iii) more dynamic risk-based pricing of mortgage spreads, which would be more likely to adversely affect financially vulnerable households.

### *Stressing Undrawn Exposures*

**84. The quasi-static balance sheet assumption does not fully assess the impact of undrawn off-balance sheet exposures in the banking book.** A more rigorous assessment would assume that part of the undrawn committed lines of credit are utilized during the stress testing horizon. This assumption can only be explored under a fully dynamic balance sheet assumption where behavioral reactions are captured for borrowers and creditors. Given that significantly sized undrawn exposures were observed in Canada, the FSAP approach was to evaluate the impact of such exposures in the context of sensitivity analysis and compare it with the results obtained under the constrained balance sheet presented in the previous section.

**85. In the above context, a certain percentage of the undrawn credit line is assumed to be utilized during each year of the horizon, and the appropriate loss rates are applied for the assumed additional drawn exposures.** The analysis assumed that 19 percent of the starting undrawn notional credit line for uninsured mortgages, 13 percent for HELOCs, 3 percent for consumer credit, 6 percent for credit cards, and 9 percent for corporate is drawn each year on top of the drawn exposure path under the core solvency stress testing approach.[30] Second-round effects, such as the impact on RWAs and the impacts linked to the quality of the portfolios under this "blending," are ignored. Based on the above assumptions, total impairments in the adverse scenario were found to be Can$18.5 billion higher than the main results with constrained balance sheets. This corresponds to an additional CET1 impact of 91 basis points in the adverse scenario by the end of Year 3.

**86. Sensitivity analysis results suggest that the potential impact of undrawn exposures is substantial, especially in the adverse scenario.** The growing importance of segments with substantial undrawn parts has constrained creditors' ability to proactively deleverage (mainly HELOCs but also consumer lines of credit). This potential risk needs to be monitored. Large undrawn credit lines may also make it more difficult for lenders to identify emerging credit problems. This is

[30] The drawdown rates were anchored to the respective rates that the BOC used in its approach to facilitate a direct comparison of the results. Given that all second-round effects are ignored, calculating the impact of a different drawdown rate is a relatively straightforward process.

because borrowers can utilize available lines to mask high debt loads by consolidating high-interest loans into a secured credit line that charges a lower interest rate. As a result, lenders may not observe the initial phases of a borrower's financial distress if borrowers use their HELOC products to make regular payments on their other loans. The interaction of the rising popularity of HELOC-type products with rising household balance sheet vulnerabilities has an amplifying effect, and close monitoring (or preventive action) may be required.

***Stressing the Residual Amortization Tenor for IFRS 9-Expected Credit Loss***

**87. Under IFRS 9 the contractual tenor of mortgage exposures is used to calculate lifetime expected credit losses.** The term contractual tenor refers to the average portfolio maturity until renewal, which is significantly shorter than the average portfolio amortization period given the five-year standard renewal cycle that prevails in the Canadian mortgage market. As part of the sensitivity analysis, the residual impact on credit losses was measured in the hypothetical case were the contractual maturity matches the residual amortization period. Under this assumption,[31] Stage II mortgages would incur higher losses since the average lifetime would be significantly longer than the one considered under the contractual assumption.

**88. The average lifetime for mortgages was set at 15 years as opposed to the 2.5 years used in the primary stress test approach.** The yearly portfolio maturation rate was assumed to be 4 percent (corresponding to a 25-year amortization period). Due to the adjusted maturation rate, flows between IFRS 9 stages are also affected. Under these alternative assumptions the relative size of Stage II loan assets in the adverse scenario increases to 16.4 percent from 13.6 percent in the primary approach, and the average coverage ratio across all asset segments almost doubles to 3.4 percent (Figure 16). However, the impact on total credit impairment flows is not substantial since they only increase by Can$5.2 billion to Can$94.8 for Year 3 of the adverse scenario. This increase in impairments flows corresponds to an additional decline of the CET1 capital ratio by 26 basis points at the end of the stress testing horizon.

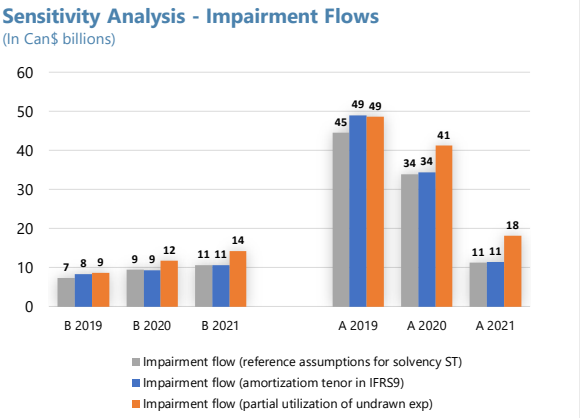
**89. The results of this analysis should be interpreted with some caution.** Given that there is no data to support a proper differentiation between the quality of the exposures that flow into Stage II (a single PD PiT is used for all performing exposures in Stage I and Stage II), the lifetime expected credit losses might be underestimated when compared with bottom-up projections.[32] (The latter are obtained using a higher level of granularity in terms of credit quality of exposures that flow into Stage II.) In relative terms, the increase in provisioning does not appear to be that critical.

[31] This is clearly a sensitivity analysis working assumption and should not be seen as challenging the way that the accounting regime is applied by banks.

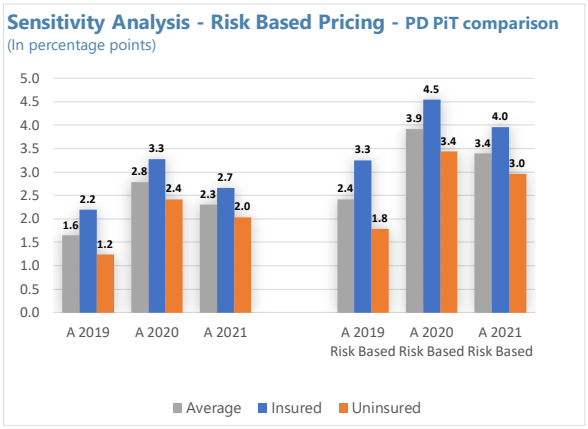
[32] The inverse argument applies for Stage I exposures.

**Figure 16. Canada: Sensitivity Analysis Results**

*The additional impact of assuming the amortization tenor as the exposure lifetime under IFRS9 and from utilizing a part of the undrawn exposure is not very material, ...*




*...while risk-based pricing might have a more substantial effect on mortgage default rates under the adverse scenario.*




Source: IMF staff estimates.
Notes: A=adverse scenario; B=baseline.

### *Risk-based Pricing for Mortgages*

**90. Risk-based pricing analysis examines the impact that additional capital charge costs (attributed to the costs arising from elevated RWAs) have on borrower affordability.** Hence, borrowers of lower credit quality (as captured by a lower affordability ratio) face higher spreads over the benchmark lending rate. Concurrently, the analysis assumes that competition forces may drive spreads lower for the high-quality (prime) segments in a downturn. The FSAP performed a simulation where the same satellite model (structural model for mortgage defaults) was modified to account for an additional variable that reflects the assumed risk-based sensitive spread over the lending rate. Borrowers in the riskier DSR band (DSR ratios higher than 0.4) were offered renewals with an additional spread of 100 basis points, and borrowers in the next band (DSR>0.3) were offered a contract with an adjusted higher spread of 50 basis points. On the prime side, the highest quality borrowers (DSR<0.15) were offered a spread that was tighter by 50 basis points to the applied benchmark interest rate change. Effective interest rates for the other DSR bands were not changed and the spread add-ons were applied to all borrowers in the distribution, irrespective of their LTV bucket.

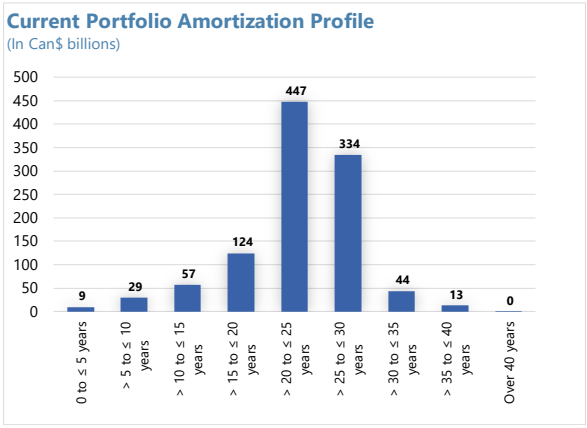
**91. There is a significant impact on model projected default and loss rates under the risk-based pricing assumption.** PD PiTs for both insured and uninsured segments increase by 40 to 50 percent, and the increase gets translated into loss rates that are also higher by a similar magnitude (Figure 16). Several model simulations with different risk-based pricing spreads confirm an increase in loss rates by some magnitude.

**92. This result underpins the importance of having mechanisms in place that would prevent "wrong-way" risks for the system.** For example, building capital buffers during good

times could be used to mitigate amplifying correlation risks during an economic downturn (i.e., when house price developments and affordability concerns are contributing to credit quality deterioration of the portfolio). Shaping the institutional landscape toward a direction that favors countercyclical risk-based pricing for all mortgages would probably be a first step in this direction.

**93. The Canadian mortgage market is vulnerable to the long-dated amortization profile of the entire portfolio.** There is currently a significant concentration of exposures with average remaining amortization tenors between 20 and 30 years (Figure 17). This remarkably skewed profile appears to be more persistent than the impact of longer amortization periods at origination for some vintages and may also infer that the amortization period has been extended during regular contractual renewals for some parts of the existing stock of exposures. The remaining amortization tenor profile should be closely monitored by authorities as it may be used to mask increased household balance sheet vulnerabilities. In addition, it may pose significant impediments during a severe housing market shock because the system's ability to offer the most efficient measure of temporary forbearance—the extension of the amortization period—may have already been used for most borrowers. Furthermore, it endogenously contributes to the amplification of systemic risks associated with renewal risk, especially under a scenario where banks are forced to deleverage.

**Figure 17. Canada: Mortgage Portfolio Amortization Profile**




Source: IMF staff estimates based on data provided by OSFI, AMF, BOC.

## Concentration Risk Analysis

**94. Concentration risk was also part of the FSAP analysis.** The analysis used large credit exposures data to non-financial corporations for all banks and assessed the impact of simultaneous defaults for the largest one, five, and ten credit exposures. Assuming an aggregate LGD of 50 percent, the default of the single largest exposure would have an impact of 38 basis points in the average CET1 capital ratio. A concurrent default of the five largest exposures would reduce the CET1 capital ratio by 1.2 percentage points, and a simultaneous default of the ten largest exposures would lead to a decline in the CET1 capital ratio by 1.8 percentage points. In each of these theoretical counterparty default cases, no individual bank would fall below any regulatory CET1 capital minimum. A more thorough review of name-specific exposures also revealed that the most significant exposures are toward well-established domestic and global corporate entities.

**95. A complementary concentration analysis was conducted on interbank unsecured counterparty exposures, based on the available data from regulatory returns.** At the interbank level, scattered concentrations are noted. However, exposure analysis finds that these are at the

operational level (e.g., exposures with custodian banks, clearing houses, and central counterparties). In that context, the review did not find elevated or unexpected concentration risks for the Canadian banking sector.

## E. Top-Down Stress Tests by Authorities

**96. The BOC stress test results are largely aligned with the FSAP stress test results in terms of overall impact on capital and relative performance of individual banks.** Although the approaches might be different in several aspects, projections are comparable in key segments—PDs and loss rates for credit exposures, slowdown in net interest income, and dynamics of non-interest income and operating expenses. Most of the differences can be attributed to the specific assumptions or modelling approach of either exercise. A summary of the BOC stress test results was presented in the May 2019 Staff Analytical Note 2019-16[33] after the conclusion of both exercises.

## F. Assessment of the Bank of Canada's Solvency Stress Testing Framework

**97. The BOC solvency stress test framework has significantly evolved in recent years.** The BOC stress testing and analytical framework has its origin in the robust analysis of second-round effects at the system-wide level. It has a specific focus on contagion and spillover effects from the propagation of solvency and liquidity shocks within the stressed macroeconomic environment (MacroFinancial Risk Assessment Framework module). Recently, the BOC has developed the core layer of a unified top-down macro stress testing framework (Macro Stress Testing module) that accounts for a full top-down macroprudential stress test and can be naturally combined with the second-round analysis module.

**98. Although the pace of developing a fully-fledged macroprudential stress testing capacity has been rapid, some further enhancements are yet to be implemented.** More specifically, there are two major areas that need to be developed:

- Most of the satellite models should be adjusted or further developed in a direction that can accommodate bank-specific characteristics. The framework should (i) combine the estimated satellite models and the use of bank-specific starting points to better capture idiosyncratic attributes of bank portfolios; (ii) collect a wider set of bank specific historical data points; (iii) and extend the use of models or estimation techniques that can fully capture bank specificities would be a major step in this direction.
- The approach should become more granular so that data attributes that are really important for the domestic banking system are fully captured. Examples of potential dimensions to be explored are geographies of exposures or significant currencies. Credit and interest rate parameters are important to be tracked by geography or by significant currency. A single "blended" mix across all geographies or currencies may simply not be good enough as the baseline option going forward.

[33] See Gaa et al. (2019).

- A direct consequence of such enhancements would be the adaptation of satellite models to produce bank-specific projections that are anchored to bank-specific parameters and not system-wide averages. This process may be further supported by ensuring that the required data are also reported by banks on a regular basis.

**99. A wider coverage of risks would also be required.** This might include segments that are not currently covered (for example market risk or operational risk) but it would ensure that the framework becomes more comprehensive and granular on how the overall stress test impact is projected. This direction could include more scenario-consistent projections on balance sheet evolution (quasi-static or dynamic balance sheet), a more granular coverage of RWA tracking for performing and nonperforming portfolios, a full coverage of nonperforming exposures, and the development of an accounting layer to distinguish economic losses from accounting reality (fully fledged IFRS 9 accounting layer).

## G. Policy Recommendations

**100. Additional required capital for mortgage exposures are desirable.** While banks' overall capital buffers are adequate, lenders' risk weights for mortgage exposures should be higher. In particular, authorities should develop and communicate to the industry a minimum set of attributes that would be sufficient to characterize a historical period as a full economic cycle. In the absence of historical episodes of economic downturns, a representative proxy might be required; authorities should enforce the use of such downturn proxies, given that historical data may provide little or no use. Avoiding extreme procyclicality by incorporating buffers in the system (including those for banks and mortgage insurers) during good times may prove to be critical to surpass any cliff effects during an adverse macrofinancial shock. Enforcing higher levels of RWA densities for mortgage portfolios and to ensure that risk amplifications during a downturn are (at least partially) mitigated is recommended.

**101. The use of "challenger" models that are conceptually orthogonal to typical econometric techniques based on historical data may be useful in this direction.** Challenger models provide a reasonable alternative to classical econometric techniques when the later fail to produce rational scenario projections. They could potentially provide some end-state visibility on how portfolios would look like after a simulated shock and support the concept of artificially enlarging the available data space using simulation. Banks may be guided to use similar approaches in their internal models to ensure that significant parts of stressed history is included in their calibrations.

**102. Stress testing infrastructure should be further developed but, most importantly, this should also be complemented by a fully-fledged analysis and redesign of the relevant data needs.** The existing regulatory reporting framework, though relatively modern and sophisticated, may need to be revamped to better capture (at least) the following emerging needs:

- As geographies outside Canada gradually become more important for some institutions, reporting requirements should be adjusted to better capture country-specific attributes (including foreign-currency linked dependencies).[34]

- System-wide risks should also be accounted for, and additional bank-specific reporting that captures vulnerabilities (post aggregation) at the system level may also be needed.[35]

**103. An elevated level of monitoring and additional reporting would be required on issues that are linked with the size and the complexity of the Canadian banking system.** Potential areas of focus include large derivatives exposures (mainly potential foreign-currency exposure mismatches, but also interest rates exposures), significant counterparty risks, the impact of existing hedging strategies and their potential inefficiencies, and risks originating from funding or currency mix concentration. Due to the systemic nature of some of these vulnerabilities, and their potential impact on market confidence, it is recommended that the BOC, OSFI, and AMF discuss and agree on a common monitoring and reporting framework that would provide a "bird's eye view" on the entire system. Building additional capacity to selectively include some of these themes in the regular top-down or bottom-up stress testing exercises would be the natural step to follow.

# BANK LIQUIDITY STRESS TESTS

## A. Overview

**104. This FSAP assessed liquidity risks that could arise from volatility in bank funding sources.** The team used two approaches to evaluate liquidity risks—the LCR-based test and the cash-flow analysis.[36] For both types of stress tests a set of scenarios reflecting a systemic liquidity stress event were derived, liquidity conditions for all banks were simulated, and the relevant liquidity metrics calculated after the application of the scenario. Scenario shocks were developed based on historical liquidity crisis episodes and were calibrated in such a way that they would target specific vulnerabilities of the domestic market.

[34] Credit parameters should be monitored at the country of exposure level. Effective interest rates should be monitored by significant currency.

[35] A typical use case can be the use of bank-specific DSR and LTV data to reconstruct a precise DSR/LTV joint distribution for the system on a frequent basis, in order to measure trends in household affordability and leverage.

[36] NSFR liquidity monitoring is currently in a phase in stage; therefore, available regulatory data on NSFR monitoring are not of sufficient quality to be used for a NSFR liquidity stress test.

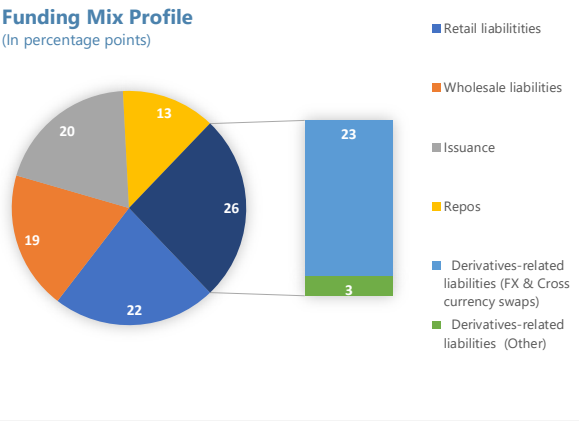
## B. Current Liquidity Conditions and Bank Liquidity Profiles

**105. Canadian banks appear to be well diversified in terms of funding mix.** In addition to the bulk of retail and wholesale deposits, banks also appear to depend on significantly sized repo and derivative-linked segments (Figure 18). The significant size of derivatives-related liabilities raises some concerns on the foreign-currency funding mix and its sustainability under a potential market disruption. However, if the asset side is also taken into account, there are no major mismatches to be reported. The notional size of the FX and cross-currency swaps suggests that a thorough monitoring of cross-currency funding is warranted.

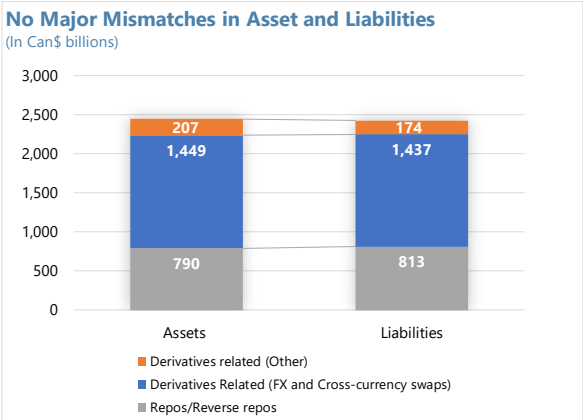
**106. Consolidated regulatory reporting for liquidity monitoring purposes served as the data layer for FSAP liquidity stress tests.** The existing set of liquidity monitoring regulatory returns provides a very granular and rich dataset on several liquidity monitoring metrics that facilitates the monitoring and analysis of liquidity related vulnerabilities. This data set includes information on contractual maturities for all funding segments, a granular picture of the asset side in terms of counterbalancing capacity, and a comprehensive analysis of the use of collateral by security type for repo/reverse repo/securities financing positions.

### Figure 18. Canada: Stress Test Results—Liquidity Analysis

*The Canadian banking sector appears to have a well-diversified funding mix profile.*




*Large derivatives-related liabilities (and repo segments) are balanced by similarly sized derivatives-linked assets (and reverse repo segments).*




Sources: IMF staff estimates.

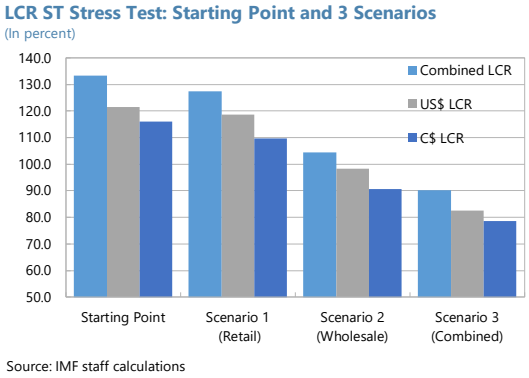
## C. LCR-based Tests

**107. The LCR metric measures the ability of banks to meet liquidity needs in a 30-day liquidity stress scenario by using a stock of unencumbered high-quality liquid assets (HQLA).** With a regulatory standard of 100 percent, three scenarios were calibrated to measure banks' ability to withstand a 30-day stressed run-off rate versus the run-off rate prescribed by the regulator for the standard LCR calculation.

**108. Three scenarios were considered for the LCR-based tests**. The first scenario draws on some stressed run-offs on retail deposits, assuming some increased retail withdrawal and measuring the relative impact on the LCR. The second scenario uses increased run-offs on wholesale sources of funding and especially on wholesale/corporate demand deposits. The third scenario, which combines the stressed run-off parameters of the first two tests, was also evaluated; however, it is not considered to have a similar level of plausibility, given that stress factors are applied in parallel for most funding segments across all banks. A full set of the stressed values that were used and their deviation from the regulatory LCR calculation parameters can be found in the first part of Appendix VII.

**Figure 19. Canada: Liquidity Stress Test Results—LCR Analysis**

*The retail and wholesale stress test scenarios surpassed the LCR regulatory threshold; the extreme combined scenario fell slightly below the 100 percent level.*




Source: IMF staff estimates.

**109. The LCR-based tests were performed per significant currency and for the combined aggregated LCR.**[37] The average LCR remains above the required minimum threshold for both retail and wholesale funding outflows scenarios (**Error! Reference source not found.**19), with an aggregate average LCR of 127.6 percent under the scenario with retail funding outflows and 104.4 percent under the scenario with wholesale funding outflows, declining from a starting point of 133.3 percent. With respect to stressed LCRs by significant currency, the U.S. dollar LCR decreases from 121.5 percent to 118.7 percent under the retail funding outflows scenario and 98.3 percent under the wholesale funding outflow scenario. Meanwhile, the Canadian dollar LCR decreases from 116 percent to 109.8 percent and 90.7 percent, respectively. Under the combined scenario, the aggregate LCR falls to 90.3 percent; however, this is not regarded as a scenario the severity of which may warrant the binding nature of LCR from a prudential angle. Overall, there appears to be ample

[37] Assessing the LCR performance by individual currency provides some significant insight into the foreign-currency composition of existing liquidity buffers. Nevertheless, it should be treated with caution, since some of the inflows are constrained by the 75 percent outflow cap, which might not be binding in the consolidated LCR calculation. In that context, single-currency LCRs might not add up to the consolidated LCR; therefore, the later should be used as a more consistent proxy of the overall liquidity position.

space for banks to accommodate outflows given the solid buffers in security holdings and the significant short-term inflows from the loan book.

## D. Cash-Flow Analysis

**110. The cash-flow analysis is based on the assessment of banks' ability to withstand liquidity outflows using their counterbalancing capacity.** The analysis used information from the contractual maturity ladder for assets and liabilities.[38] Assuming a liquidity stress duration of three months, the contractual maturity ladder is used to identify the highest levels of roll-over needs by segment during a forward looking 3-month period.

**111. A granular set of severity scenarios are defined, and each severity level is associated with a different set of run-off rates and liquid asset haircuts.** The scenario severity is used to define run-off rates on the liability side and fair value and discount haircuts associated with liquid assets. As the scenario severity increases, higher run-offs are applied to the respective estimates of roll-over needs, and an overall funding shortfall is estimated. Utilization of liquidity and credit off-balance sheet commitments is also accounted for. Counterbalancing capacity is then measured by estimating the ability to generate additional liquidity across all liquid asset classes after applying the scenario-specific fair value and collateral haircuts. Counterbalancing capacity is compared to funding needs and a liquidity surplus or shortfall is established for the specific scenario. For each scenario a full collateral revaluation is performed, including also collateral that is used for repo and reverse repo transactions. A full description of the ranges employed for run-off parameters and market and discount haircuts for liquid assets for the range of severity levels considered is available in Appendix VIII.[39]

**112. Reduced valuations can lead to margin calls for existing collateralized funding positions.**[40] For eligible collateral, and to extent that this is possible to segregate, collateral haircuts are anchored to standing liquidity facilities haircuts of the BOC. This calibration assumes that these haircuts will be maintained at a constant level during a liquidity stress period. Second-round effects capturing the need to provide additional collateral for existing funding or other collateralized positions are also estimated. The analysis also ignores (by assumption) any positive inflows from the loan portfolio under the constraint that banks are not allowed to reduce credit intermediation during the liquidity episode.

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[38] For the purposes of cash-flow analysis, the Net Cumulative Cash Flow (NCCF) regulatory template was used at a bank consolidated level. For conservatism, and assuming some significant liquidity ring-fencing from host authorities, the NCCF returns for U.S. subsidiaries were not incorporated into the calculations.

[39] Under this approach (and contrary to what is commonly used in regulatory metrics focusing on idiosyncratic shocks; e.g., LCR) roll-over rates of maturing assets are assumed to be 100 percent, i.e., banks are not allowed to counterbalance outflows on the funding side by deleveraging or by not extending new credit facilities to the real economy during the liquidity stress episode.

[40] The purpose of this process is to estimate the impact from the additional collateral required to compensate for the falling collateral valuations, and not to account for a full repricing of derivatives positions due to underlying price adjustments. The latter task would require far more granular data on the derivatives positions and their sensitivities and was not within the scope of the FSAP liquidity stress test.

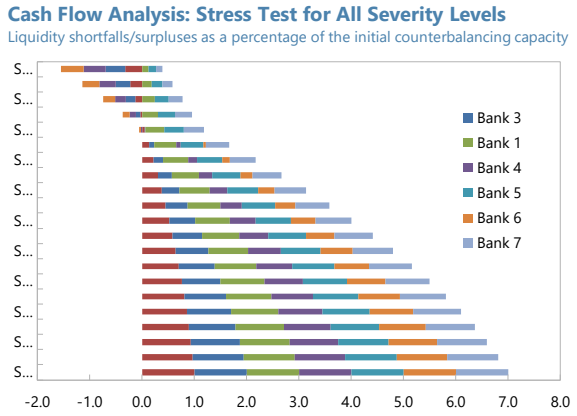
**113. The cash-flow analysis identifies small liquidity shortfalls for several banks under some severity levels that are close to the severely adverse case** (Figure 20)**.** The combined liquidity shortfall (if only banks with a shortfall are included) in the severely adverse scenario reaches Can$91 billion**.** The highest shortfall for an individual bank stands at Can$26 billion. The results suggest that a large outflow shock would be needed to generate liquidity shortfalls for some Canadian banks. Even in such extreme cases the shortfalls are of a manageable magnitude given the ample space of the BOC to provide liquidity through standard facilities and extraordinary measures.

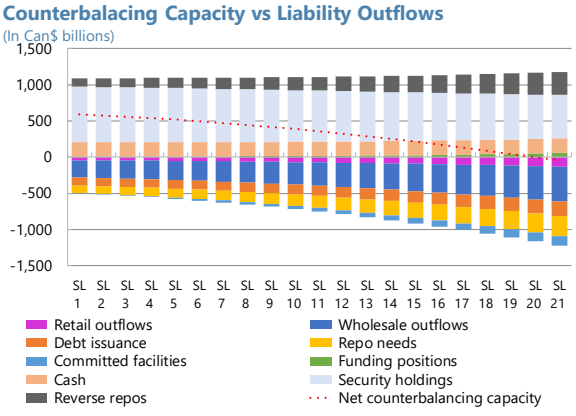
**114. Banks' ability to withstand liquidity shocks can be attributed to the elevated level of securities holding (a significant part of which is currently or could become eligible for BOC liquidity facilities) and the absence of significant mismatches in the repo books of banks.** This balanced picture does not generate significant knock-on effects under the assumption that repo and reverse-repo run-offs are matched. On the downside, some significant concentrations on wholesale or corporate deposits should be closely monitored due to their unstable nature. Some data gaps related to better identifying the eligibility of encumbered and unencumbered collateral could also be filled. Due to limitations on data availability, the liquidity impact of the high derivatives exposures (e.g. currency swap liquidity risks and total return swaps) were not possible to assess. Going forward, authorities should be closely involved with establishing a framework for the monitoring of such risks given that they appear to be material.

## Figure 20. Canada: Liquidity Stress Test Cash Flow Analysis Results

*Cash-flow analysis reveals some shortfalls for four banks at stress levels that are close to the severely adverse scenario (SL 21).*

*The overall shortfall for the banks with negative counterbalancing capacity is Can$91 billion. This is considered manageable given the severity of the stress and the ample space of the BOC to provide additional liquidity support, if needed.*




Source: IMF staff estimates.

## E. Assessment of OSFI's Liquidity Monitoring

**115. Current liquidity templates used by both competent authorities are very rich and granular in terms of the amount of data they capture.** Some additional and more sophisticated pre-validation effort is needed, since there were several instances where the submitted liquidity templates did not match basic validation checks. This rich information repository can be further utilized by ensuring that all past submissions are cross-checked before being accepted. With respect to content, contractual cash flow reporting should be complemented with a behavioral flow add-on. Also, Net Cumulative Cash Flow (NCCF) reporting can be enhanced with better information on collateral that is eligible for BOC liquidity facilities. This will ensure that some measure on utilization of eligible collateral per individual bank and across the system is readily available.

**116. Behavioral flows on the utilization of off-balance sheet credit and liquidity commitments should be integrated into the NCCF calculation.** Although credit and liquidity commitments are already reported, they are not really associated with specific outflows. Including these elements would further enhance the relevance of liquidity monitoring metrics for supervisory purposes. Furthermore, authorities should also ensure that the classification and reporting of outstanding balances by liability segment follow strict guidelines, thus, minimizing the leeway for subjective interpretation on how things should be reported.

## F. Policy Recommendations

**117. The substantial notional amounts of both liability and asset-related derivatives should be very closely monitored.** Current liquidity monitoring reporting does not provide any additional insight into the nature of such notional exposures, the relevant sensitivities, and how dysfunctional markets might impact the overall liquidity profile of banks. Additional reporting and monitoring efforts, focusing on (first and second order) sensitivities of those positions to different risk factor shocks, would help identify potential risks residing on both sides of the balance sheet. This additional reporting would also help authorities establish a system-wide view on the use of such products and on the balance sheet mismatches that they are called to bridge. Some type of regular benchmarking exercise is needed to identify outliers and enhance risk-based supervision of relevant risks.

**118. Risks arising from the proper functioning of repo markets should also be monitored.** Canadian banks are also very active in repo markets, with a large proportion of their securities holdings being used actively as collateral in repo or reverse-repo transactions. The proper functioning of these markets, and the quality of unencumbered collateral, should be monitored constantly by relevant authorities. This will help identify early warning signals of liquidity or financial distress for individual institutions that could potentially further impair confidence in the market.

# LIFE INSURANCE SOLVENCY STRESS TESTS

## A. Overview

**119. The FSAP, in collaboration with OSFI and AMF, conducted the life insurance solvency stress test.** The exercise covered the five largest life insurers, including three globally active federally regulated entities and two domestically oriented, provincially regulated entities in Québec. These correspond to 90 percent of life insurers' total assets and approximately 80 percent of life insurers' total net premiums. The exercise, using regulatory and supervisory data, assessed the instantaneous impact of macrofinancial shocks (consistent with the adverse scenario) on the solvency position of life insurers. The stress test assessed the sensitivity of life insurers solvency—using an estimate of the Life Insurance Capital Adequacy Test (LICAT) ratio—to macrofinancial conditions in 2019Q3 (most severe financial market stress) and 2021Q4 (lowest interest rates) in the adverse scenario.

## B. Recent Performance of the Life Insurance Sector

**120. Life insurers have maintained high profitability in a low interest rate environment (Figure 21).** Return on equity has remained stable. While the investment yield has varied markedly over time, it has generally contributed positively to the performance of life insurers. Life insurers maintain strong solvency positions, holding capital buffers in excess of supervisory targets. While the Canadian market accounts for over 40 percent of net premiums, life insurers have significantly expanded their overseas operations, particularly in Asia and Europe.

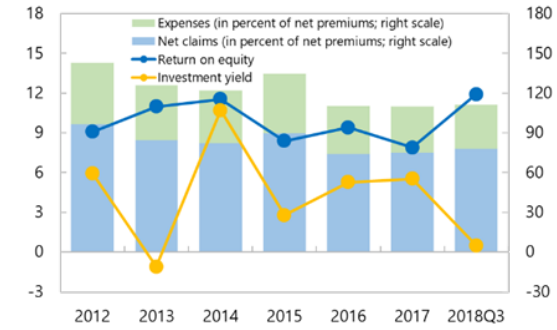
**121. Life insurers' investment assets predominantly consist of bonds.** Equity, mortgages, and properties account for less than a quarter of the investment portfolios of the five largest life insurers. While Canada is the largest investment destination, over 60 percent of assets are invested abroad, with 26 percent of assets invested in the United States. The geographical allocation of the investment portfolio largely matches life insurers liabilities.

**122. A significant proportion of bond holdings are unrated or of lower ratings.** While two-thirds of bonds are rated A or higher, 16 percent of bonds are either unrated or have a rating below B. These exposures could make life insurers vulnerable to increases in bond yield spreads. Canadian bonds account for approximately 41 percent of the aggregate bond portfolio and 55 percent of AAA bonds (including bonds eligible for 0 percent LICAT factor). Nearly half of the bonds with a lower rating than B or unrated are held in Canada and about 30 percent in the United States.

## Figure 21. Canada: Insurance Sector Performance

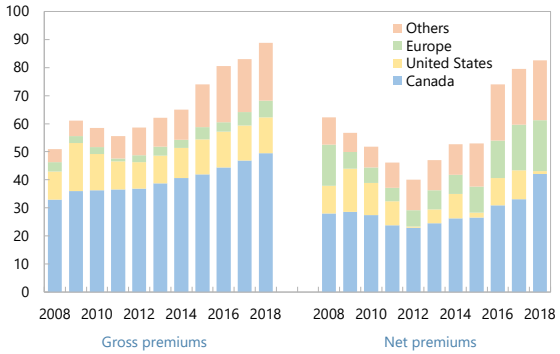
*Life insurers have remained highly profitable in a low interest rate environment.*

**Life Insurers' Profitability and Earnings, 2012-18**
(In percent)



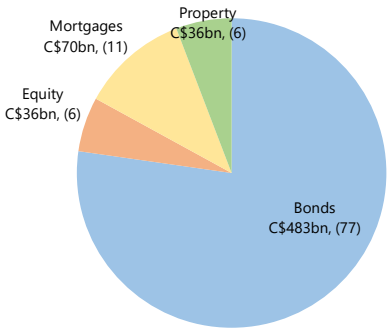

*Overseas operations have increased in recent years.*

**Life Insurers' Premiums by Regions, 2008-18** [1]
(In billions of Canadian dollar)



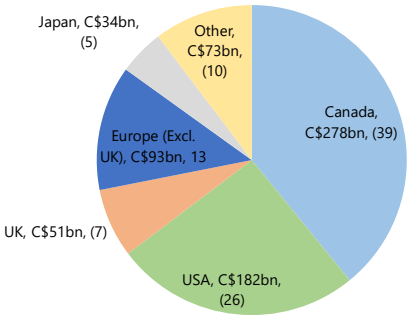

*The investment portfolio largely consists of bonds.*

**Life Insurers' Investment Portfolio Assets by Category**
(In billions of Canadian dollar and percent, based on five largest life insurers)



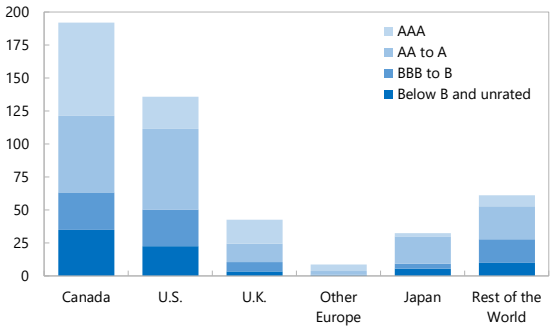

*Canadian and U.S. assets account for nearly two thirds of total assets.*

**Life Insurers' Assets by Region**
(In billions of Canadian dollar and percent, based on five largest life insurers)




*Life insurers hold a large portion of unrated and low-rated bonds.*

**Life Insurers' Holding of Debt Securities, 2018**
(In billions of Canadina dollar; based on five largest life insurers)




Sources: AMF; OSFI; and IMF staff calculations.

Sources: AMF; OSFI, and IMF staff calculations.

## C. IMF Top-Down Stress Tests: Methodology

**123. Capital ratios of life insurers are affected through three different channels in the adverse scenario of the stress test.** Shocks to risk-free rates has a direct effect on the present value of the liability cash-flow; asset price shocks affect the value of the investment portfolio and hence on the capital requirement for market risk. Assets, liabilities and capital requirements are calculated for each region and are aggregated in Canadian dollars. The six regions specified in LICAT are Canada, the United States, the United Kingdom, Europe (excluding the United Kingdom), Japan and "other regions."

**124. The supervisory minimum requirements of 90 percent for the total capital ratio and 50 percent for the core capital ratio are used as hurdle rates.** This is in accordance with LICAT where the total capital ratio is defined as the sum of available capital (including both tier-1 and tier-2 capital), the surplus allowance and eligible deposits, divided by the base solvency buffer. The core capital ratio is based on the sum of tier-1 capital, the surplus allowance (only 70 percent), and eligible deposits (only 70 percent), divided by the base solvency buffer. An insurer's base solvency buffer is equal to the sum of the aggregate capital requirement net of credits, for each of the six geographical regions multiplied by a scalar of 1.05. The aggregate capital requirement within a geography includes requirements for credit risk, market risk, insurance risk, segregated funds guarantee risk and operational risk. The surplus allowance is based on provisions for adverse deviations (PfADs), which is assumed to be a fixed proportion of liabilities in the exercise.

**125. The present value of liabilities is directly affected by the change in the risk-free component of the discount factor.** The discount factor for life insurers' assets and liabilities consists of a risk-free and a spread component. The deviation in government bond yields in the adverse scenario compared to the baseline was used to calculate the shock to the risk-free component of the discount rate for liabilities (Figure 22). The spread component of the liability discount rate is assumed to remain constant since the characteristics of the liability cash-flow do not change in the adverse scenario. Hence, the exercise assumes that any changes in bond yield spreads are entirely due to changes in the level and pricing of credit risk. This differs from the current regulatory framework, Canadian Asset Liability Method (CALM), under which appointed actuaries assess the extent to which bond yield spreads are due to liquidity risk versus credit risk (expected defaults plus a margin for adverse deviations).

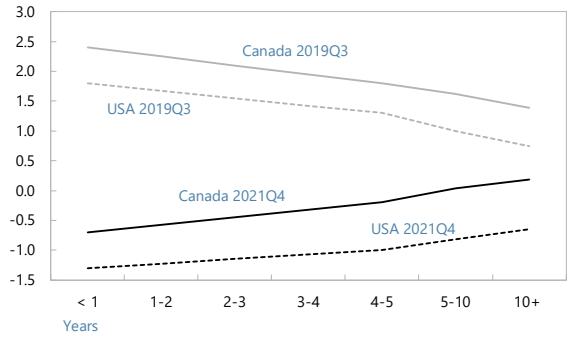
**126. The value of fixed income assets is affected by both shocks to risk-free rates and to credit spreads.** Shocks to the value of the bond portfolio therefore vary based on years to maturity, credit rating and geographical location. The shocks to bond credit spreads are assumed to be due to increased default risk and the pricing of this risk.

**127. As an alternative assumption to the primary approach, life insurers' solvency is assessed using the same discount rate for assets and liabilities.** In contrast to the primary approach outlined in paragraphs 125 and 126, the change in the value of life insurers' fixed income portfolios is calculated by applying the liability discount rate to the asset cash-flow. This

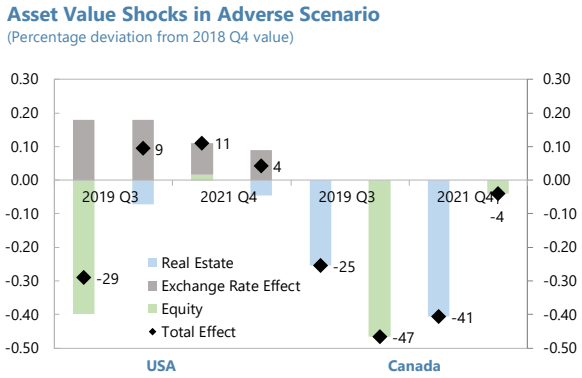
methodology is more similar to CALM and assumes no changes in bond yield spreads as the level and pricing of credit risk is assumed to be unchanged.

**Figure 22. Canada: Shocks in Adverse Scenario of Life Insurance Stress Test**

*Risk-free rates are higher than baseline in 2019Q3, but lower than baseline in 2021Q4.*




*Asset price shocks are larger in 2019Q3 than in 2021Q4. The exchange rate effect offsets some of the asset price effect in the United States.*




Sources: IMF staff calculations.

**128. Bilateral spot rates are used to calculate the exchange rate effects on assets and liabilities.** The liability discount rates for regions other than Canada are adjusted using the prevailing bilateral spot exchange rates in the adverse scenario relative to the baseline scenario. The percentage change in the U.S. dollar/Canadian dollar spot rate is used as a proxy for exchange rate movements of "other regions." Similarly, asset values are converted to Canadian dollar using the prevailing exchange rates.

**129. The mark-to-market approach is used to evaluate the impact on equity and real estate assets.** The value of the equity portfolio is calculated using the national equity price indices at 2019Q3 and 2021Q4. In addition to equity holdings in the investment portfolio, several life insurers have substantial equity holdings registered as "other loans and invested assets." Hence, in these cases "other loans and invested assets" are shocked similarly to equity held in the investment portfolio. The value of real estate assets is assumed to follow the development in the national house price indices.

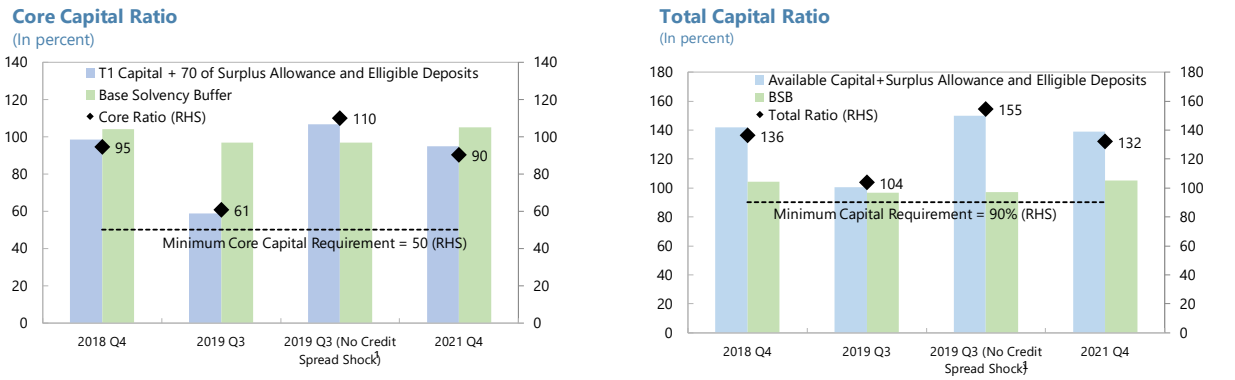
**130. Changes in capital requirements only reflect changes in market risk due to changes in exposures.** Life insurers are required to hold capital in each of the regions in which they operate. This includes capital for credit risk, market risk, insurance risk, segregated funds guarantee risk and operational risk. For market risk, the capital requirements for interest rate risk, equity risk and real estate are assumed to remain a constant proportion of the values of the corresponding asset holdings. All other capital requirements are unaffected by the shocks considered in our scenario except the exchange rate effect. The capital requirement for credit risk is unaffected by the local currency market value of fixed income assets, since bonds are assumed to keep the same credit rating.

## D. IMF Top-Down Stress Tests: Results

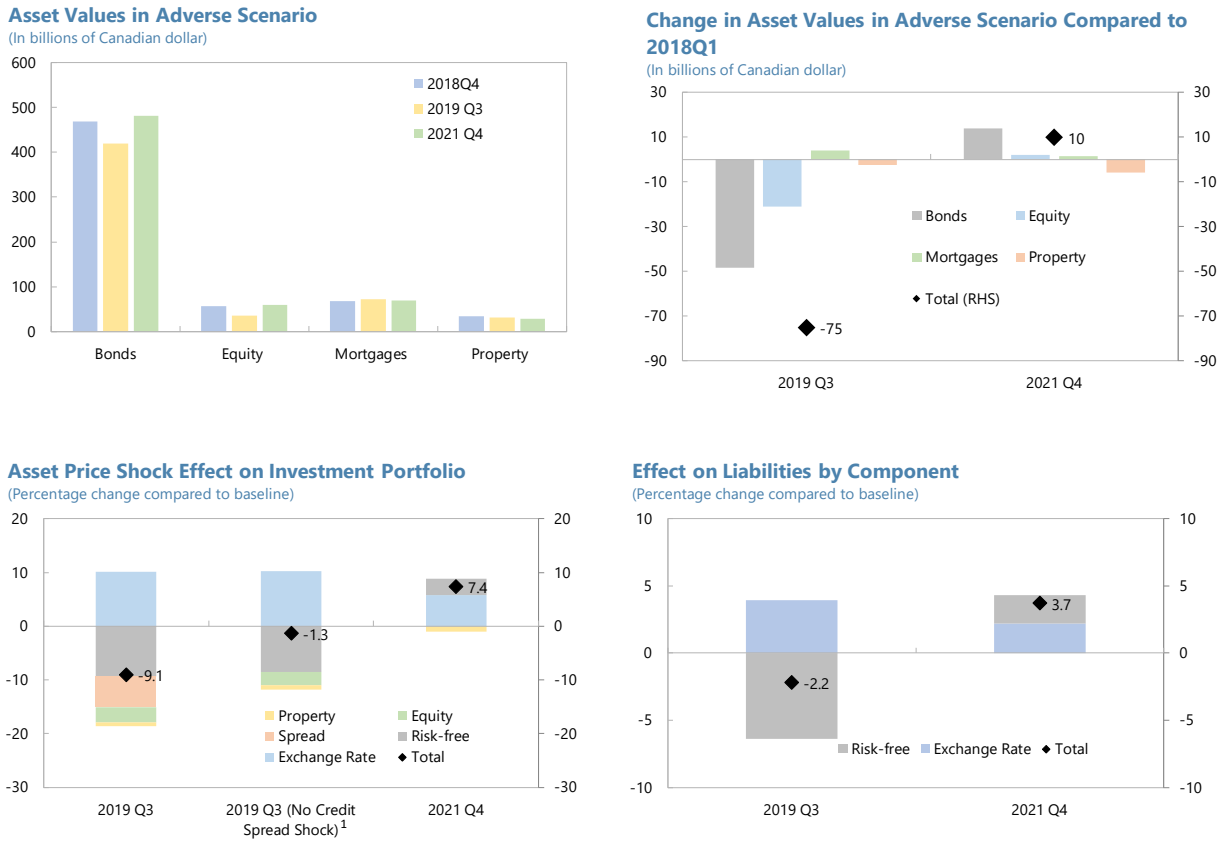
**131. Large life insurers are somewhat vulnerable to macrofinancial shocks (Figure 23).** In the adverse scenario, the aggregate core capital ratio of the five largest life insurers would decline by 34 percentage points to 61 percent by 2019Q3, largely driven by the impact of widening credit spreads and falling equity prices. Some entities would have capital falling below the 50 percent regulatory minimum. The aggregate total capital ratio would similarly fall by 32 percentage points to 104 percent, with total capital ratios of some life insurers falling below the 90 percent hurdle rate. By 2021Q4, the aggregate core ratio would reach 90 percent and the aggregate total capital ratio would reach 132 percent, with all life insurers maintaining their capital ratios above regulatory minimums.

**132. When applying the same discount rate to assets and liabilities, all large life insurers maintain capital requirements above minimum requirements.** Using the liability discount rate to calculate the change in the present value of fixed income assets, which is similar to the CALM, the aggregate core capital ratio would increase to 110 percent and the aggregate total capital ratio would increase to 155 percent in 2019Q3. However, this alternative assumption does not consider the widening of bond credit spreads. Since the shocks to credit spreads are assumed to have fully dissipated by 2021Q4, the results for 2021Q4 are the same for both methodologies.

**Figure 23. Canada: Results of Top-Down Life Insurance Stress Test**



## Figure 23. Canada: Results of Top-Down Life Insurance Stress Test (concluded)



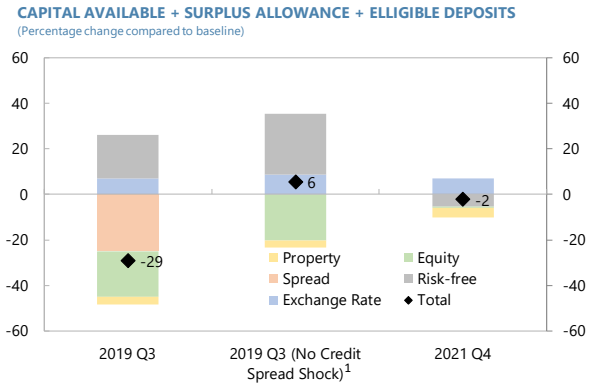

Sources: AMF; OSFI; IMF staff calculations.
1/Results under the assumption of the same discount rate for asset and liability cash-flow and hence does not account for increase in bond spreads due to credit risk.

**133. Life insurers are exposed to market risk.** Asset values fall by Can$75 billion largely due to a decrease in the bond portfolio value in 2019Q3 of the adverse scenario. The aggregate bond portfolio falls by Can$50 billion, both due to the increase in the risk-free rate and widening credit spreads. The value of aggregate equity holdings would fall by over Can$20 billion, considering both the equity in the investment portfolio and "other loans and invested assets." While the value of mortgages falls in domestic currency, the Canadian dollar depreciation against the U.S. dollar implies a moderate increase in the Canadian dollar value of U.S. mortgages. By 2021Q4, asset values will have increased by Can$10 billion compared to 2018Q4, largely due to the bond portfolio. With credit spreads having abated and risk-free rates having declined in response to the crisis, the value of the bond portfolio will have increased by Can$14 billion. Equity prices have almost recovered to their 2018Q4 levels in local currency and the exchange rate effect implies an increase in the Canadian dollar value of the equity portfolio.

**134. Life insurers are sensitive to falling risk-free interest rates** (Figure 24)**.** The increases in risk-free rates by 2019Q3 of the adverse scenario causes the value of liabilities and PfADs in the surplus allowance to fall. This more than offsets the direct negative effect of rising risk-free rates on the fixed income portfolio. The exchange rate also has a positive effect on the numerator of the capital ratio, while the credit spread and equity price shocks both have a negative effect. The lower risk-free yield curve in 2021Q4 affect the capital ratio negatively. In fact, assuming the same discount rate for assets and liabilities, a parallel downward shift in the discount yield curve by one percentage point would reduce the core capital ratio by 40 percentage points.

**Figure 24. Canada: Numerator of Capital Ratio**

*Higher risk-free rates in 2019Q3 has a larger effect on liabilities than on the fixed income portfolio, making its total effect on the numerator of the capital ratio positive.*




Sources: IMF staff calculations.
[1/]Results under the assumption of the same discount rate for asset and liability cash-flow and hence does not account for increase in bond spreads due to credit risk.

## E. Policy Recommendations

**135. The insurance supervisors should continue to monitor life insurers' portfolios of low-rated and unrated bonds.** Search for yields during a prolonged period of low interest rates has resulted in large exposures to lower quality and unrated fixed income assets. These relatively large holdings make life insurers particularly vulnerable to credit spread shocks.

**136. In preparation for the new accounting standards (IFRS 17), OSFI and AMF should carefully consider how risk margins interact with the regulatory solvency framework for life insurers**. Under the current framework (i.e., the CALM), liability cash-flows are discounted using the asset discount rates, minus an allowance for expected defaults, a market shock and a margin for adverse deviation in the expected default assumption. However, the fixed income portfolios of life insurers imply credit risk and sensitivity to macrofinancial conditions, while the liability cash-flows are largely independent of such factors. A framework taking this into consideration would allow for more accurate estimates of the present value of cash-flows during periods of elevated credit risk.

# MORTGAGE INSURANCE SOLVENCY STRESS TESTS

## A. Overview

**137. The FSAP, in collaboration with OSFI, conducted the mortgage insurance stress tests.** The exercise covered all three mortgage insurers. The exercise was based on the balance sheet approach, using regulatory data. The exercise was carried out in a manner consistent with the bank solvency stress test to assess system-wide capital buffers for mortgage lending. Hence, the exercise considers two scenarios—a baseline based on the October 2018 WEO and the adverse scenario, both over the 3-year horizon 2019Q1-2021Q4. The supervisory target capital ratio in accordance with the Mortgage Insurance Capital Adequacy Test (MICAT) of 150 percent is used as the hurdle rate.

## B. Recent Performance of the Mortgage Insurance Sector

**138. Approximately 57 percent of total mortgage loans outstanding were insured as of 2018Q3.** This corresponds to a value of Can$670 billion, with CMHC capturing a 58 percent market share, while the two private mortgage insurers made up the remainder. Similarly, private mortgage insurers accounted for about 40 percent of new premiums over the past five years.

**139. Mortgage insurers remain highly profitable.** Return on equity exceeded 12 percent for private mortgage insurers but was somewhat lower for CMHC at 7.5 percent in 2018Q3 (Figure 25). Private mortgage insurers have improved profitability over time and their share of total market profits have increased from 22 percent in 2013 to nearly 40 percent in 2018Q3. The underwriting business accounted for nearly two thirds of the pre-tax net income, and investment income accounted for approximately one third.

**140. As of 2018Q3, private mortgage insurers accounted for 42 percent of insured mortgages, but their assets only accounted for 31 percent of the sector's total assets.** Similarly, private mortgage insurers only held 30 percent of the sector's available capital. This is partly due to CMHC having larger capital buffers with a capital ratio of 182.5 percent compared to private mortgage insurer's 170.4 percent. But it is also due to CMHC having a higher capital requirement for insurance risk on their mortgage portfolio than the private mortgage insurers did; for CMHC this corresponds to 2 percent of its insurance in-force-outstanding, compared to 1.4 percent for the private mortgage insurers.

## C. IMF Top-Down Stress Tests: Methodology

**141. The adverse scenario affects mortgage insurers through three different channels.** Deteriorating economic conditions increase the default rate of mortgage holders and the fall in house prices leads to a higher loss given default; both contribute to an increase in total claims. Lower credit growth negatively affects net premiums written, while the shock to asset prices impacts the value of the investment portfolio and investment income. Capital requirements for market risk

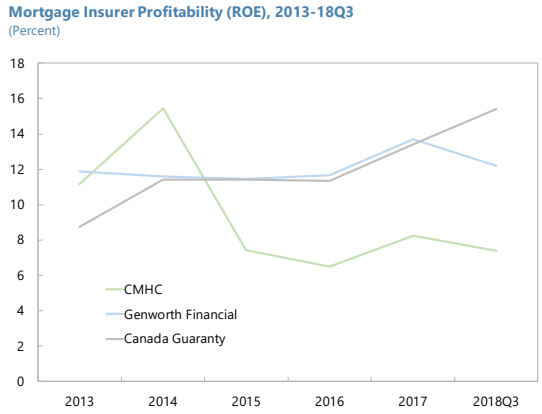
and credit risk are directly affected by the size of the investment portfolio and the capital requirement for insurance risk is proportionate to total mortgage insurance outstanding.

**142. Total claims are projected to mirror banks' potential losses on mortgage exposures.** The PD and LGD parameters for insured mortgage loans are assumed to coincide with the bank solvency stress test (see paragraphs 60–62).

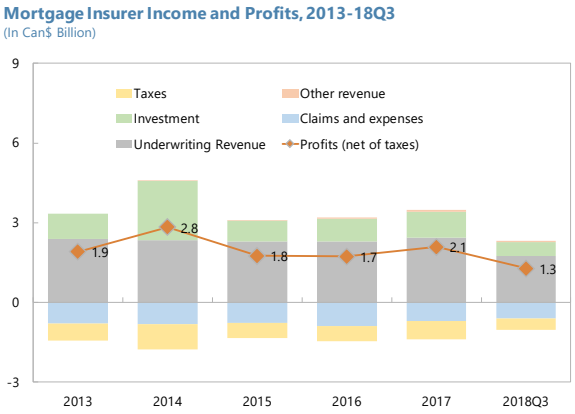
**143. Unearned premiums are assumed to be proportionate to mortgage insurance-in-force.** This implies that no provisions are held for mortgages that have been defaulted on and that the expected profits in the unearned premiums of these mortgages is used to cover losses.

## Figure 25. Canada: Performance of Mortgage Insurers

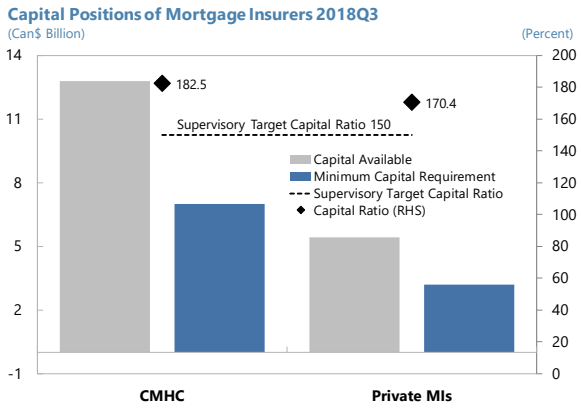
*Mortgage insurers are highly profitable and private mortgage insurers have improved their profitability over time.*




*Underwriting revenue account for over two thirds of total revenue.*




*Private mortgage insurers held less capital than CMHC relative to the size of their insured mortgage portfolios, both due to a lower capital requirement per insurance in-force outstanding and a lower capital ratio.*




Sources: OSFI and IMF staff calculations.

**144. The mark-to-market approach is used to evaluate the impact of asset price shocks on the investment portfolio.** The investment portfolios of mortgage insurers mainly consist of domestic interest sensitive assets (above 90 percent for all mortgage insurers). The change in the yields of these assets is assumed equal to the change in government bond yields with corresponding maturity. The price of common shares is assumed to evolve in line with the equity price index.

**145. Investment income is modeled based on the size of the investment portfolio.** Quarterly investment income is projected based on simple regression models using the size of the investment portfolio as the explanatory variables.

**146. Mortgage insurers are assumed to obtain tax refunds from reported operating losses.** Taxes paid within the previous three years to a reported loss are eligible for a refund.

**147. Capital requirements for credit and market risks are assumed to be proportionate to asset values.** The capital requirement for market risk per asset type is assumed to be proportional to the corresponding asset market value. The capital requirement for credit default risk is assumed to be proportionate to the portfolio of interest sensitive assets. Finally, the capital requirement for operational risk is 20 percent of the sum of the capital requirements for insurance risk, market risk and credit risk.

**148. As a sensitivity analysis, the capital requirement for insurance risk is calculated using both constant LTVs and allowing it to vary with house prices.** Under MICAT, the base capital requirements for insurance risk is calculated as a function of credit scores, LTVs and the remaining amortization period. For mortgage insurance originating before 2016, LTVs are calculated using the December 2015 Teranet house price index; for mortgage insurance originating in 2016 and after, LTVs are calculated using house prices at date of issuance. The stress testing exercise used two alternative methodologies for calculating the capital requirement for insurance risk. For the primary approach, consistent with MICAT, the capital requirement for insurance risk is assumed to be proportionate to the mortgage insurance in-force outstanding. Alternatively, to reflect the fact that the riskiness of mortgages may vary with LTVs, a constant capital requirement ratio is assumed within each of 10 different LTV buckets, while LTVs are updated quarterly with the change in the national house price index.

## D. IMF Top-Down Stress Tests: Results

**149. Mortgage insurers are vulnerable to severe macroeconomic downturns with significant house price declines** (Figure 26)**.** Based on the stress tests that covered all three mortgage insurers, aggregate capital would turn negative. Mortgage insurers would need additional capital of Can$15 billion to meet the supervisory solvency target (i.e., 150 percent of the MICAT ratio).

**150. Cumulative insurance claims would amount to Can$25 billion, consistent with credit losses of banks' insured mortgage portfolios.** This compares to Can$1 billion during the three-year period 2015Q4-2018Q3. PD is assumed to be 2.8 percent per year on average 2019–2021 and

the LGD is assumed to be 43 percent over the same period. The ratio of total claims to mortgage insurance in-force outstanding is assumed to be the same for all three mortgage insurers.

**151. The value of investment portfolios remains largely unchanged.** The yield curve for domestic bonds shifts out in 2019–20 but then shifts back in 2021 leaving the market value of the mortgage insurers' bond portfolios largely unchanged.

**152. Total revenues would fall from Can$3.2 billion per year in 2016–18 to Can$1.6 billion a year in 2019–21.** This would occur despite tax refunds of Can$1.5 billion over the 3-year period. Total underwriting revenue would fall from Can$2.4 billion a year to Can$0.5 billion amid negative credit growth and a 5 percent decrease in the overall insured mortgage portfolio. Investment income would fall from Can$2.5 billion for the three-year period 2016-18 to Can$1.5 billion 2019–21. With total costs amounting to Can$24.3 billion and total revenue to Can$4.8 billion, mortgage insurers would record a total of Can$19.5 billion in losses over the stress testing horizon.

**153. Capital available would fall from Can$18 billion in 2018Q3 to negative Can$1 billion by 2021Q4.** This follows from the Can$19.5 billion in losses, a virtually unchanged value of the investment portfolio and a Can$0.8 billion decrease in liabilities due a reduction in the size of the outstanding insured mortgage portfolio. Notwithstanding the resulting negative capital projected in the stress test, the government guarantee would mitigate losses sustained by banks.

**154. Under the alternative assumption of updated LTVs, required capital would be Can$8.5 billion higher.** The capital requirement under MICAT remains relatively stable over the stress testing horizon and reaches Can$13.9 billion by the end of 2021 of which insurance risk accounted for approximately 80 percent. Updating the capital requirement for insurance with current house prices would increase the capital requirement to Can$22.3 billion by end-2021. This would imply a capital shortfall of approximately Can$23 billion.

**155. Required capital for insured mortgages may not sufficiently reflect potential deterioration of credit quality during severe downturns.** The seven D-SIFIs currently have capital buffers for insured mortgage exposures equivalent to 0.17 percent of outstanding insured mortgages.[41] Accounting for mortgage insurers' required capital for insurance risk, system-wide capital buffers would amount to 1.96 percent. In an adverse scenario, these buffers should go up to 4.32 percent.[42] This would imply additional capital need of Can$28 billion to cover expected and unexpected losses for insured mortgage exposures.

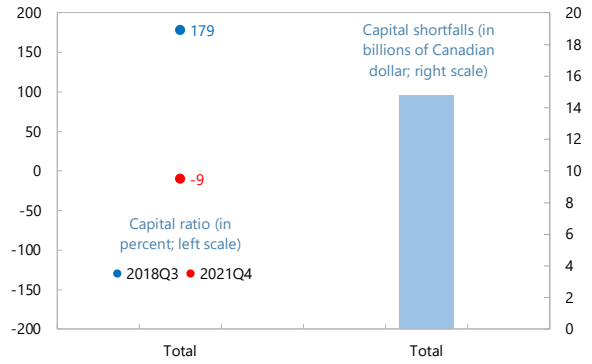
[41] As of October 2018, these seven entities had insured mortgage exposures of Can$453 billion. Capital buffers are calculated under the assumption of the minimum capital requirement at 8 percent and the capital surcharge for systemically important financial institutions at 1 percent.

[42] This approach on assessing capital requirements takes into account the deterioration of the overall credit quality of the portfolio both in terms of household affordability and in terms of deteriorating existing stock LTV distribution after the macrofinancial shocks are applied (see also the analysis on RWAs—Table A.IV.3 in Appendix IV). While admittedly the approach is relatively stylized and potentially oversimplified, it can be used to infer unexpected loss estimates (translating them into capital requirements) and distribute them between banks and mortgage insurers without diverting from core Basel principles on the overall capital requirements for the system.

## Figure 26. Canada: Results of Top-Down Mortgage Insurance Stress Test

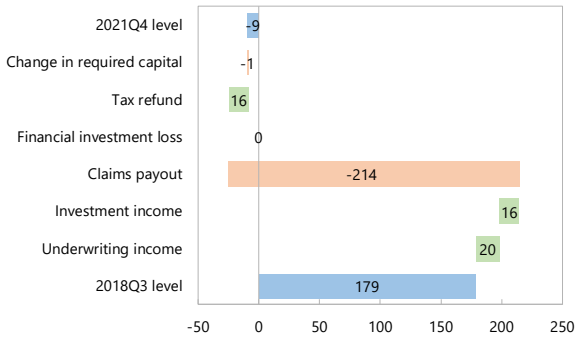
### Capital Ratio and Capital Shortfalls, 2018-21

Based on Mortgage Insurance Capital Adequacy Test (MICAT)

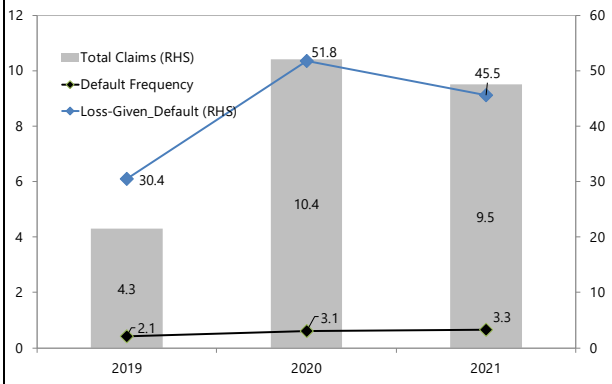



### Dynamics of Capital Ratio in the Adverse Scenario, 2018-21

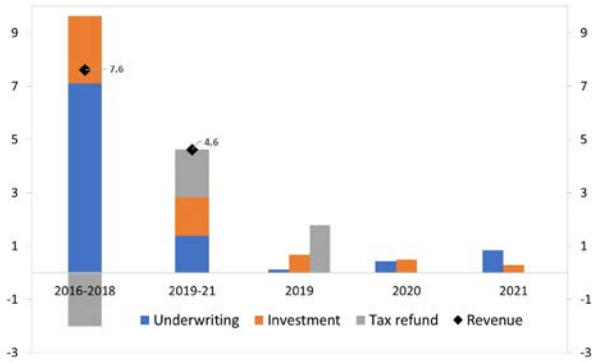
Based on the Mortgage Insurance Capital Adequacy Test (MICAT)
(In percent of 2018Q4 required capital)



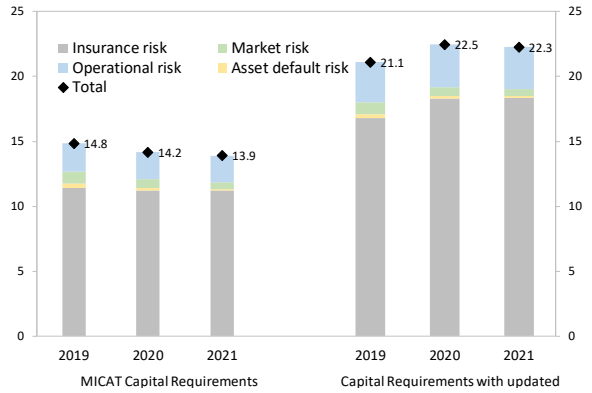

### Total claims and defaults (Can$ Billion)




### Revenue by Main Component (Can$ Billion)




### Capital Requirement by Component (Can$ Billion)




Sources: OSFI; IMF staff calculations.

## E. Policy Recommendations

**156. Mortgage insurers should hold more capital so that they are more resilient to severe macrofinancial shocks.** As illustrated by the stress tests, mortgage insurers may face a capital shortfall in a severely adverse scenario. Steps should be taken to ensure that required capital of mortgage insurers is enough to absorb tail-risk shocks. Furthermore, the capital requirements for mortgage exposures at lenders and mortgage insurers should be tightened to properly account for through-the-cycle credit risk that may exceed Canadian historical experience.

# RISK-TAKING IN NONBANKS AND FINANCIAL MARKETS

## A. Overview

**157. The FSAP assessed risks in nonbank financial institutions and financial market activities.** The nonbank sector has grown rapidly since the 2014 FSAP, driven to a large degree by investment funds. While these account for the majority of FSB-defined nonbank financial intermediation in Canada, institutional investors and other private financial institutions have a very large presence as well. Some financially risky private market activities may not be captured in official sector monitoring, raising the importance of improving data coverage for these segments.

**158. Risk-taking is rising among institutional investors, and asset valuations are stretched in a number of markets.** Pension funds and other institutional investors have invested in strong risk management and governance, but rising use of private market strategies and derivatives are adding to leverage and liquidity risks. Fixed income and real estate asset valuations are stretched, while dependence on foreign investors for corporate bond market funding has increased significantly. In a market stress scenario, rising liquidity and valuation risks could magnify losses and market volatility, while elevated dependence on foreign funding increases the risk that financial conditions would tighten sharply.

## B. Landscape of Nonbank and Financial Market Participants

**159. The nonbank sector (excluding insurance) has grown considerably in recent years, due largely to investment funds.** Assets of nonbank financial institutions (NBFIs) excluding insurers accounted for almost two-thirds of the Can$13.9 trillion in financial system assets (635 percent of GDP) (Figure 27). NBFIs excluding insurers also accounted for about four-fifths of the 71 percentage point increase in financial system assets relative to GDP between 2013 and 2018Q3. The bulk of this growth, equivalent to nearly half of the total increase in financial system assets in this period, is accounted for by the Can$2.3 trillion mutual fund sector (now 105 percent of GDP), which includes

exchange-traded funds (ETFs).[43] The second largest increase has been in pension fund assets (113 percent of GDP), which are the most important players in the institutional investor market. Other investment funds have a relatively small footprint (Can$570 billion in gross assets) but are growing rapidly, including hedge funds (Can$110 billion in gross assets).

**160. Investment funds have been the primary driver of growth in Canadian nonbank finance.** According to the FSB definition, nonbank financial intermediation in Canada is the 10th largest in the world in dollar terms (US$1.57 trillion at end-2017), having grown at roughly 11 percent a year during 2011–16 before slowing to 3.5 percent in 2017. Investment funds with fixed income holdings represent about three quarters of FSB-defined "nonbank financial intermediation" in Canada, and about 85 percent of its growth from 2011 to 2017 (to Can$2.1 trillion).

**161. Mutual funds, including ETFs, account for 105 percent of GDP, and dominate the retail asset management landscape.** The bulk of these funds are publicly offered open-ended mutual funds, which are not allowed to use leverage and require derivatives holdings be offset with cash collateralization. ETFs are the most rapidly growing part of this segment, but with about Can$160 billion in assets (10 percent of publicly offered fund assets) as of mid-2018 are still comparatively small. Holdings of foreign equities and bonds have accounted for 50 and 17 percent, respectively, of total sector asset growth excluding mutual fund shares. Bond funds and bond fund of funds accounted for slightly less than one-third of publicly offered fund assets. The money market segment uses constant net asset value accounting but is quite small.

**162. Pension funds (114 percent of GDP) are the most important institutional investor type, with involvement in core funding markets and large exposures to foreign markets.** Pension funds are highly active in Canadian repo markets, where they are large net borrowers from banks. They are major investors in provincial government bonds, holding over 30 percent of the total outstanding, and foreign assets, equivalent to about a third of total assets under management. Six large public pension funds, including the country's two social security systems, account for roughly two-fifths of all pension fund assets. These large funds are internationally active, have developed sophisticated investment capabilities across a wide range of asset classes, and have been recognized for their strong governance.[44]

**163. Other investment fund and trust structures are smaller (33 percent of GDP), but growing rapidly and subject to limited monitoring.** A subset of privately offered investment funds surveyed as part of the Ontario Securities Commission (OSC)'s biennial risk survey held Can$570 billion in gross assets as of end-2017. With fund net assets growing 14 percent in 2017, this segment grew faster than mutual funds or any other major sector.[45] Three quarters of the assets in OSC-surveyed funds were held by pooled funds, which are privately managed funds created for

[43] The overall size of the mutual fund industry may be overstated as roughly Can$600 billion in mutual fund units are held by other mutual funds (e.g., fund of funds).

[44] Private pension funds represent only 30 percent of pension fund assets, while other government-sponsored retirement savings programs (captured as mutual funds) hold an additional Can$1.2 trillion in assets.

[45] One-fifth of total investment in this segment comes from pension funds.

institutional investors. Leverage for the overall segment was moderate at about 120 percent (measured as gross assets relative to net assets), with hedge funds accounting for roughly 70 percent of the leverage used. Authorities' ability to monitor risk-taking in this sector is limited, as the survey is conducted every two years, the monitoring coverage is limited to funds with Ontario investors, and data is collected with a lag. Real estate investment trusts (REITs) are sizeable at Can$145 billion (as of end-2017); however, they predominantly hold equity investments and use longer-term leverage compared to peers in other markets, limiting refinancing risks.

**164. NBFIs engaged in credit intermediation beyond the asset management industry are small (an estimated 12 percent of GDP) and similarly face limited regulatory oversight.** Mortgage finance companies (MFCs) are important mortgage market participants, involved in origination, servicing, secondary market sales, and securitization. With about Can$60 billion in assets, these firms have high leverage; however, balance sheet risks are mitigated by their extensive use of government-backed mortgage insurance and guaranteed funding, which requires compliance with federal mortgage underwriting standards.[46] Mortgage investment companies (MICs) are smaller, with about Can$15 billion in assets as of end-2017, and use less leverage but invest in higher risk mortgages, typically with borrowers who face weaker income-based repayment capacity. There are other private lenders involved in consumer and unregulated real estate lending; however, authorities are currently seeking to address data gaps that currently preclude their ability to estimate the size of this sector.[47] The consumer and business leasing sector (primarily in the transportation sector) is comparatively larger at about Can$185 billion.

**165. The relatively large size of other private financial institutions (156 percent of GDP) points to other data gaps.** Captive financial institutions and money lenders (CFIML) account for almost one quarter of financial system assets (156 percent of GDP).[48] This category encompasses low-risk entities such as holding and management companies of nonfinancial firms, but also entities potentially engaging in significant financial risk-taking, e.g., private equity and similar private fund structures that may feature significant leverage or exposures to real estate. The latter is likely capturing pension funds and other institutional investors' increasing use of alternative asset strategies, which often involve investments in unconsolidated leveraged entities holding real estate, private equity, or private debt assets.

## C. Risk-taking Among Institutional Investors

**166. Institutional investors have increased risk-taking in their investment activities in recent years, which could magnify market volatility in the event of stress.** Canadian pension

[46] For details, see the Technical Note on Housing Finance in the context of the 2019 Canada FSAP.

[47] Statistics Canada has an initiative to construct a comprehensive economic account of nonbank financial institutions.

[48] CFIML are a designation in the System of National Accounts 2008 used in the Financial Stability Board's monitoring of nonbank financial intermediation. The category is defined as institutional units providing financial services, where either most of the assets or most of the liabilities are not transacted in open financial markets, i.e., between affiliates.

fund managers and other institutional investors are well-known internationally for using sophisticated investment and funding strategies. While such strategies can be prudently deployed as part of an overall portfolio strategy, most involve increased leverage and liquidity risk, and their growing popularity may create herding and positioning risks. These strategies include increasing allocations to alternative and private market investments, e.g. real estate, infrastructure, private equity, and private credit; derivatives-based strategies including bond forwards, option-writing, credit default and equity swaps; and leveraging publicly traded fixed income and equity holdings via short-term repurchases, commercial paper programs, and term debt. In the event of market stress, financial market volatility and losses could be exacerbated if institutional investors simultaneously reduced leverage and liquidated assets to meet capital calls.

**167. Risk-taking at large pension funds appears mitigated by strong risk management practices and in many cases offsets other risks facing these funds.** Large pension funds have invested heavily in sophisticated in-house risk management and hold large liquidity buffers to manage market shocks. Increased risk-taking taken to extend asset duration (e.g., via an unhedged interest rate swap position, or a leveraged long duration asset) is offset by reduced interest rate risk from pension liabilities. Funding risk is also limited by pension funds' liabilities, which are predominantly long-term. Investment policies that seek to achieve diversification of asset holdings across the globe help minimize concentration risk to specific asset classes and geographies.

**168. Alternative and private market investments have grown rapidly, with hard-to-track leverage and liquidity risks.** Statistics Canada data shows that pension fund holdings of private shares, real estate, claims on other entities, loans and other non-publicly traded assets have contributed to 40 percent of the increase in pension fund assets since 2013, slightly more than foreign equities (39 percent) (Figure 27). The share of difficult-to-value, illiquid Level 3 assets in the six largest public pension funds' portfolios have risen from 31 to 36 percent over this period. While these assets are suited to long-term, patient investors like pension fund managers, they often embed significant unreported leverage that could increase losses and may have capital calls or other features that could expose pension funds to liquidity risk. Their valuations also tend to rely on subjective inputs and models involving long-term horizons, creating potential for overvaluation.

**169. Leverage has increased by some measures.** The six large public pensions report gross leverage—as measured by pension fund gross assets divided by net assets—at about 130 percent post-crisis, declining somewhat in recent years.[49] However, this measure does not capture the undisclosed leverage in alternative and private market assets, which is typically embedded at the fund level and not reported at the pension manager level. Adjusting for these alternative and private market assets, the six large pension funds' estimated effective leverage in their publicly traded

For example, they may be holding companies or special purpose vehicles set up to channel funds or attract external funding as part of a larger nonfinancial corporation.

[49] According to ratings agencies, use of short-maturity borrowing has also declined. See Moody's (2018).

portfolios is closer to 150 percent. At the same time, broker-dealer lending has grown significantly, pointing to institutional investors' increased use of leverage.

**170. Rising derivatives use is increasing leverage and liquidity risks.** Institutional investors typically use derivatives to achieve a leveraged exposure, as well as to create customized risk exposures or offset interest rate risk from liability portfolios. Regardless, all uses increase liquidity risk and, for over-the-counter products, counterparty risk.[50] The six large public pension funds report increasing levels of gross notional derivatives positions outstanding relative to net assets, reaching nearly 200 percent as of 2017. While these positions are small on a net basis, likely the result of short-term leveraged position-taking, the gross amount is still relevant for counterparty and liquidity risks. Furthermore, trade repository data collected by the OSC shows considerable growth in non-plain vanilla derivatives by institutional investors.[51] Some of these non-plain vanilla derivatives, including bond forwards and equity swaps, are effectively "balance sheet rental" products that are typically used to achieve leveraged exposures to underlying bond or equity assets. About three-fourths of pension fund derivative exposures captured by the OSC data have foreign counterparties, mostly banks.

**171. Increased risk-taking and complexity make it difficult to assess whether pension funds would act countercyclically in stressed markets.** The increasing use of derivatives, leverage, and opaque private market exposures all significantly increase underlying liquidity risk and overall portfolio complexity, increasing uncertainty about how pension funds would react in severely stressed market conditions. Selling or financing large volumes of liquid assets to cover liquidity needs under stressed market conditions could also increase bond market liquidity and funding pressures, amplifying market volatility. Risks to market stability could be compounded if pension funds adopt similar investment strategies or correlated asset markets, or if smaller pension funds increase risk-taking without appropriate risk management capabilities.

## D. Asset Price Valuations and Other Market Risks

**172. Fixed income asset valuations are stretched by historical norms, as in many advanced economies.** One key measure of valuation for governments bonds, the term premium, or the compensation for the risk that short-term government bond yields do not evolve as expected, has in recent years reached multi-decade lows. By some models, term premiums have turned negative, indicating that investors are forgoing the higher returns available via continuously investing in shorter-term government bond yields. While term premia are compressed in many advanced economies, Canada stands out among peers for having among the flattest yield curves, in part reflecting large pension and insurer demand for longer-dated debt. The 30-year/2-year yield differential for government bonds has been lower than major bond markets for much of the post-

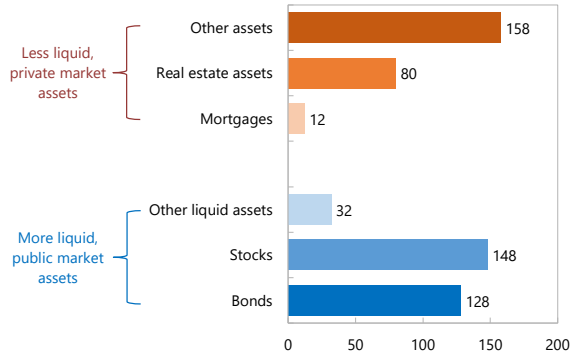
[50] Relative to financial intermediaries, institutional investors may have weaker incentives to manage this liquidity risk, as it requires larger holdings of lower-yielding liquid assets that lower returns.

[51] Within the OSC trade repository data, institutional investors encompassed pension funds, insurance funds, asset managers, special purpose vehicles, and other entities not otherwise identified as banks, broker-dealers, financial market infrastructure, or official sector entities.

## Figure 27. Canada: Risks from Nonbank and Market Activities

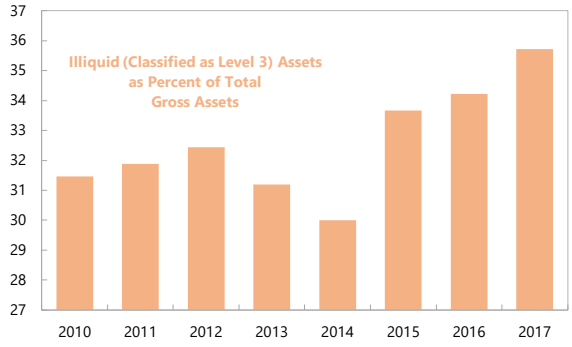
*Pension funds have rapidly increased their exposure to real estate, private equity, and other illiquid assets...*

**Contribution to Growth of Pension Funds' Assets, 2013-18**
(In billions of Canadian dollar; based on change during 2013Q4-2018Q3)



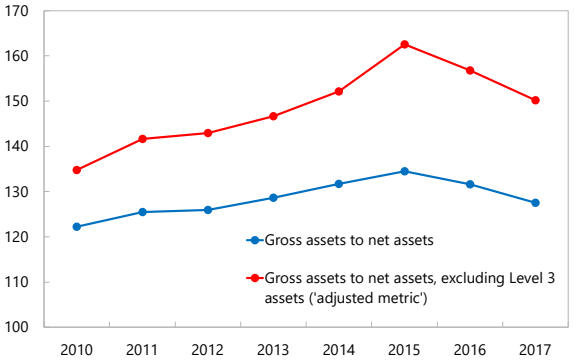

*...increasing their allocation to more complex, illiquid assets, particularly at large public pension funds.*

**Pension Fund Level 3 Assets: 2010-2017**
(In percent of total gross assets, based on six large public pension funds)



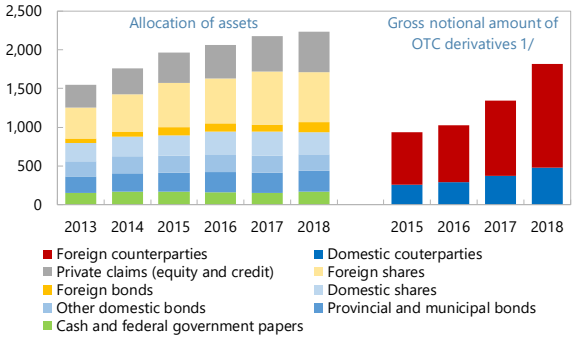

*Pension fund leverage is considerable when adjusting for illiquid alternative assets, which are separately leveraged.*

**Pension Funds' Reported Leverage, 2007-17**
(In percent; based on six major public pension funds)



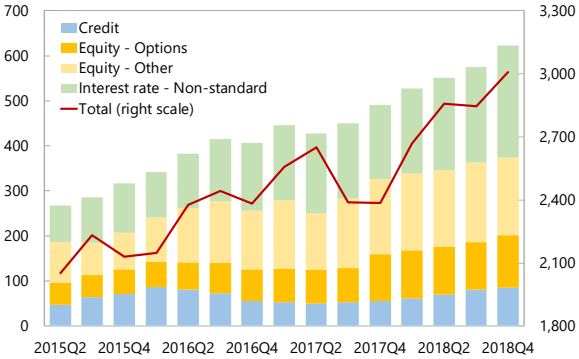

*Pension funds have increased exposures to foreign equities and private claims and used more OTC derivatives with foreign counterparts.*

**Pension Funds' Holding of Assets and Use of OTC Derivatives, 2013-18**
(In billions of Canadian dollar)



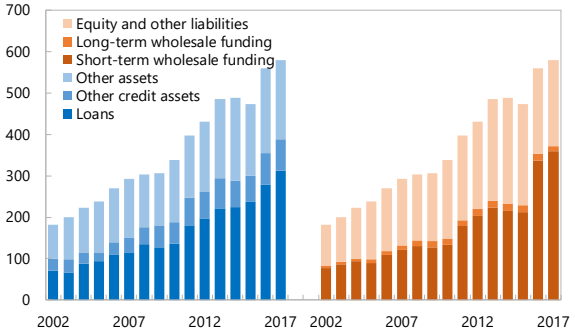

*Institutional investors are increasing use of non-standard OTC derivatives, which add leverage and liquidity risks.*

**Institutional Investors' OTC Derivative Positions, 2015-18** [1,2]
(In billions of Canadian dollar; based on gross notional position)




*Broker dealer lending and short-term wholesale funding has grown rapidly, supporting market risk-taking.*

**Brokers-Dealers' Lending and Short-term Wholesale Funding, 2007-17**
(In billions of Canadian dollar)




Sources: Pension fund annual reports; Ontario Securities Commission; Bank of Canada; Haver Analytics; and IMF staff estimates.
[1/] Data based on OTC derivatives data submitted to the Ontario Securities Commission.
[2/] Institutional investors include pension funds, asset managers, investment funds, and other financial entities not identified as banks or other risk intermediaries.

GFC period (Figure 28). Corporate bond duration-adjusted credit spreads are also near historically low levels, and price close to the low levels seen in the United States. The implied price of volatility in government bonds has also fallen to multi-year lows.

**173. Commercial real estate prices are stretched.** Capitalization rates—a measure of estimated annual net income generated from a property expressed as a percentage of its purchase price—have been steadily trending downwards since the end of the GFC, according to CBRE Group. While spreads between the national average cap rate and 10-year government bond yields have not compressed to the levels seen pre-GFC, valuations for certain CRE property types and in major metropolitan areas are particularly stretched, e.g., multifamily residential (capitalization rates at or below 4 percent) and office real estate.

**174. Domestic equity market valuations are close to historical averages.** Canada's stock markets are largely comprised firms in mature industries like finance, energy, and mining. These sectors have not seen the same valuation pressures that the technology and semiconductor sectors have seen in other countries. The ratio of stock prices to analyst-estimated forward earnings, a common measure of market valuations, are well within historical norms.

**175. Canadian corporate bonds are increasingly owned by non-residents.[52]** Non-resident investors have absorbed 85 percent of the net increase in Canadian corporate bond issuance since end-2012. This has increased nonresidents' ownership share of Canadian corporate issuance from 32 to 48 percent as of 2018Q4. Much of this issuance is likely denominated in foreign currency, as such debt accounted for 91 percent of the net issuance between 2014 and end-2018.[53] Financial firms, in large part the D-SIBs, account for nearly 60 percent of this issuance. Anecdotally, foreign investors and financial firms are also increasingly important participants in Can$-denominated derivative markets.

**176. Fixed income-focused investment funds have grown rapidly and have been increasing exposure to credit and duration risk, increasing the risk of a redemption shock.** Investment funds (primarily open-ended mutual funds and exchange traded funds) have been the fastest growing segment of the Canadian financial system since 2013. Fixed income assets accounted for roughly 28 percent of these funds' underlying assets, including in the large portion of funds classified as mixed or balanced funds. At the same time, credit and duration risk in these funds have been increasing. In the funds examined in the investment fund stress test (see Section on Investment Fund Liquidity Stress Tests), holdings of debt rated BBB and below has risen from 11 to 23 percent of assets since 2008, cash has fallen from 7 to 3 percent of assets, and portfolio duration has increased. In a period of stress involving large redemptions from mutual fund investors, forced liquidations of this less liquid debt could be significant, increasing risk premia and potentially triggering further rounds of selling.

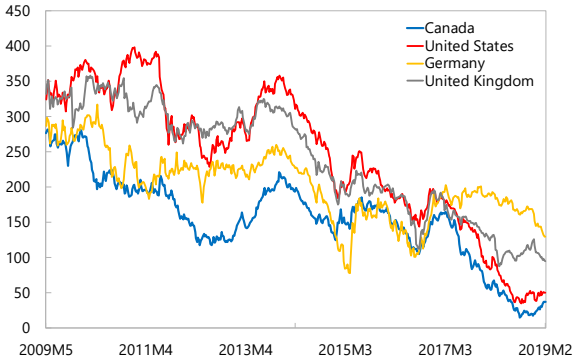
[52] The term "corporate bond" refers to debt securities issued by non-government entities, including nonfinancial firms and financial institutions.

[53] This figure excludes mortgage-backed securities issued by CMHC, i.e., Canada Mortgage Bonds.

## Figure 28. Canada: Asset Valuations and Market Risks

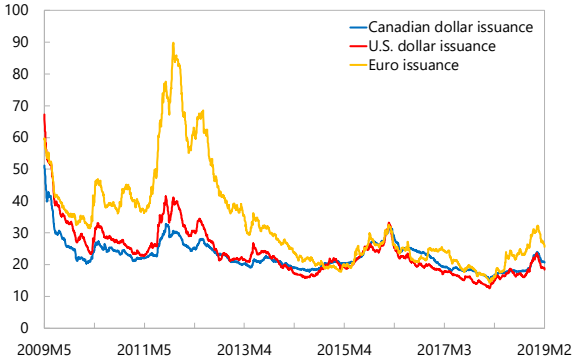
*Government bond yield curves are consistently flatter than major market peers, reflecting pension demand for long-term bonds*

**Government Bond: Yield Curve Slope, 2009-19**
(In bais points; based on difference between 30-year and 2-year bonds)



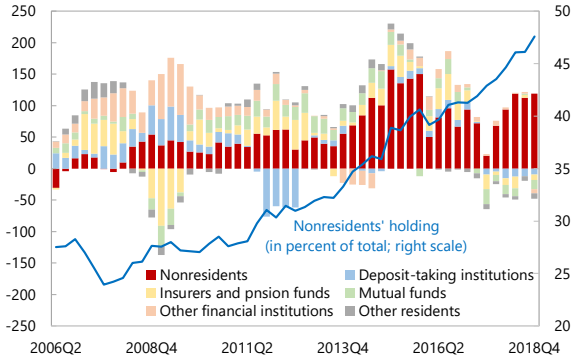

*Corporate bond spreads have trended toward historic lows in recent years*

**Corporate Bond: Duration-adjusted Spreads, 2009-19**
(In bais points)



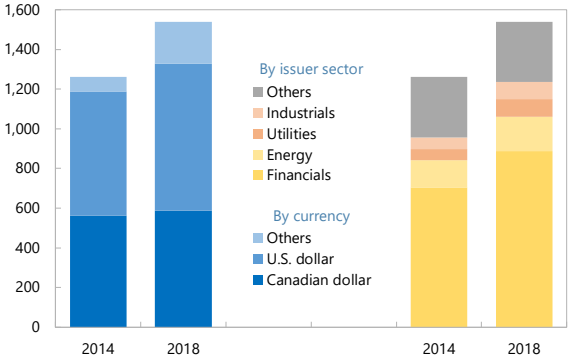

*Corporate bond issuance has relied overwhelmingly on foreign demand…*

**Change in Investors' Holding of Corporate Bonds, 2006-18**
(In billions of Canadian dollar; year-on-year)



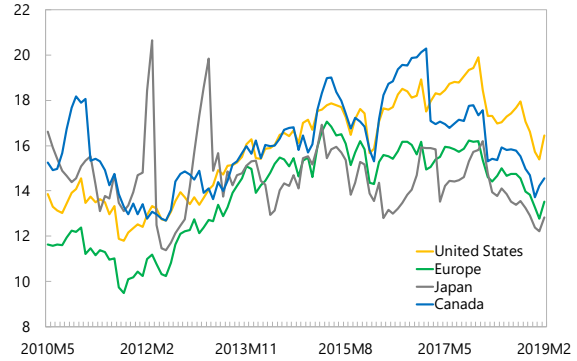

*And has largely been issued in foreign currencies, predominantly by financial sector borrowers*

**Canada: Corporate Bonds Outstanding, 2014-18**
(In Can$ billion)



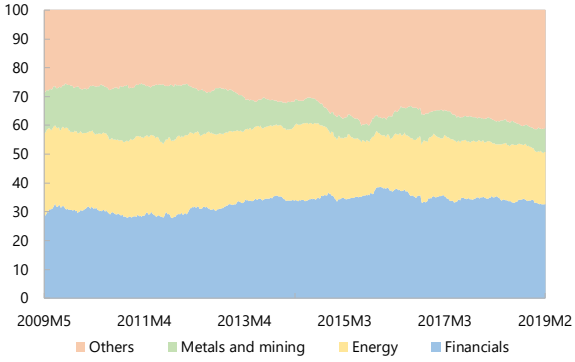

*Equity valuations are closer to historic norms…*

**Equity: Forward Price-to-Earnings, 2010-19**
(In multiples)




*…Reflecting the weight of mature, established industries which have not seen stretched valuations globally*

**Toronto Stock Exchange: Market Capitalization, 2009-19**
(In percent of total)




Sources: Bloomberg; Haver Analytics.

**177. Stretched valuations, risks in investment funds, and rising foreign ownership in fixed income markets increase the risk of a rapid tightening in financial conditions.** Canadian bond market issuers are exposed to the risk of a decompression of risk premiums, whether specific to Canada or part of a global re-pricing of inflation and other risks, which could trigger volatility and investor deleveraging. Vulnerabilities from growing foreign-currency bond funding would depend on the extent of currency mismatch, for which data is lacking, although a large portion of financial sector issuance supports foreign-currency assets. Even assuming currency hedging, however, sustained depreciation of the exchange rate could still decrease the attractiveness of foreign funding, leading to deleveraging over time.

## E. Policy Recommendations

**178. Authorities should strengthen their capacity to monitor risks in the complex and fast-evolving nonbank financial sector.** Authorities face data limitations in monitoring the growth and risk profile of private consumer and real estate lenders, as well as the extent of risk-taking and leverage in private NBFIs and the funds that they set up. The growth in nonfinancial real estate firms' debt and the broader difficulty of tracking risks in private fund structures points to the urgent need to strengthen data collection and increase surveillance of the nonbank sector.

**179. Given the systemic relevance of large pension funds, stronger oversight of these entities, along with greater transparency, would be helpful.** Increasing the detail, standardization, and reporting frequency of pension fund financial disclosures would make it easier to monitor and assess risk-taking by pension funds. Standardized liquidity stress-testing techniques and assumptions, to be used in conjunction with in-house techniques, would also increase transparency and comparability around liquidity risk management.

# INVESTMENT FUND LIQUIDITY STRESS TESTS

## A. Overview

**180. The FSAP, in collaboration with the BoC, assessed financial stability risks associated with investment fund redemptions during market stress.** The FSAP and the BOC conducted stress tests of open-ended mutual funds with large corporate bond allocations. The exercise estimates the amount of potential forced bond sales under stressed conditions, using redemption shocks based on the observed sensitivity of net fund flows to fund performance as well as historical values. The exercise was conducted using a single sample of over Can$323 billion in mutual fund assets, which held about 25 percent of the Canadian dollar-denominated corporate bond market as of 2018 (Table 10).

**181. Corporate bond markets would be vulnerable to large scale investment fund redemptions, although the results are sensitive to assumptions.**[54] Depending on the calibration of the redemption shock and assumed liquidation preferences of the fund, forced selling of corporate bonds could reach the equivalent of 1 to 5 percent of the outstanding stock of corporate bonds. On a credit rating basis, the impact would be disproportionately large on corporate bond segments rated BBB and below, where the sample funds held an outsized share of this asset class (44 percent). Investment funds in the sample also hold a large (17 percent) share of AA-rated bonds, which are largely provincial government bonds, which could see forced sales equivalent to 3 percent of that market. The BOC estimates that forced corporate bond sales equivalent to 5 percent of the outstanding stock would generate 93 basis points in increased excess bond premium (a measure of the yield required in excess of the CDS-implied credit spread. These results could however vary by 30-40 basis points depending on the choice of liquidation preference and the extent of opportunistic buying from other long-term investors.

**182. The exercise combines features of the BOC's analytical framework and investment fund liquidity stress testing elements used in prior FSAPs.** The analysis first calibrates redemption shocks in three different ways, using fund-level data from the sample. It then estimates asset sales generated by these funds under different liquidation assumptions. One novel aspect of this investment fund stress test exercise is the incorporation of credit rating information of bonds held by sample funds, which can allow for greater granularity about which segment of the bond market might experience stress related to outflows.

## B. Methodology

### Stress Testing Sample

**183. The stress test fund sample includes 238 Canadian domestic-currency corporate bond-focused funds** (Table 10)**.** The sample uses Morningstar data prepared by the BOC and is limited to open-ended mutual funds with large exposures (defined as 20 percent of assets or higher) to Canadian corporate bonds denominated in Canadian dollars. Funds with large exposures to foreign bonds are also significant within Canada's investment fund universe; however, these are excluded because any resulting market liquidity and financial condition impacts would be largely concentrated in foreign bond markets. The sample also excludes money market funds, closed-end funds, funds of funds, exchange-traded funds, funds that do not have lifetime average AUM of at least Can$50 million, and funds without lifetime average allocations to Canadian corporate bonds of at least 20 percent.

[54] The term "corporate bond" refers to debt securities issued by non-government entities, including nonfinancial firms and financial institutions.

**Table 10. Investment Fund Stress Testing: Fund Sample Data**

| | Investment Fund Sample | | | All Investment Funds | | Total Market Size | |
|---|---|---|---|---|---|---|---|
| | *Total* | *of which: bond funds* | *of which: mixed funds* | *value* | *sample share* | *value* | *sample share* |
| Number of funds | **238** | **192** | **46** | 3,454 | *7%* | n/a | |
| Market value of assets *(Can$ billion)* | **323** | **241** | **82** | 1,680 | *19%* | n/a | |
| --Of which: corporate bonds | **147** | **124** | **23** | 191 | *77%* | 580 | *25%* |
| --Of which: government bonds | **101** | **91** | **10** | 102 | *99%* | 1,307 | *8%* |

Source: Haver Analytics; Bank of Canada; and IMF staff calculations.

**184. The sample includes both fixed income and "balanced" funds, as the latter are popular in Canada and in many cases have large allocations to corporate debt.** The fund sample had a market value of Can$323 billion as of end-2018Q3. Roughly three-fourths of total fund assets in the sample are in funds with a fixed income mandate ("bond funds"), and the remainder are in balanced or mixed mandate funds ("mixed funds"), which hold combinations of fixed income and equity securities and are the largest segment in the mutual fund sector by assets. Corporate bonds were 46 percent of AUM for the sample and 28 percent of AUM for mixed funds. Government and other fixed income holdings accounted for 41 and 14 percent of AUM at bond and mixed funds, respectively.[55] Across all fund types, allocations to riskier investment grade and high-yield bonds are considerable: 10 percent of fund sample holdings were bonds with a rating of BB or lower (high yield) and another 13 percent were rated BBB.

**185. The sample accounts for a small share of investment funds overall but represents most of the mutual fund sector's holdings of domestic-currency bonds.** Sample funds represent only about one-fifth of assets of the total investment fund sector (excluding fund of funds). However, roughly half of the investment fund sector's assets are foreign bonds, equities, and currencies. Sample funds accounts for about three-quarters of the sector's domestic-currency corporate bond holdings, and about one quarter of all Canadian dollar-denominated corporate bond issuance outstanding. It holds a relatively smaller share (8 percent or less) of Canadian dollar-denominated government bonds (including all levels of government).[56]

**186. Historical return and redemption data are from Morningstar and date back to January 2002.** Including 54 funds which wound down before end-2018Q3, the historical fund flow data set

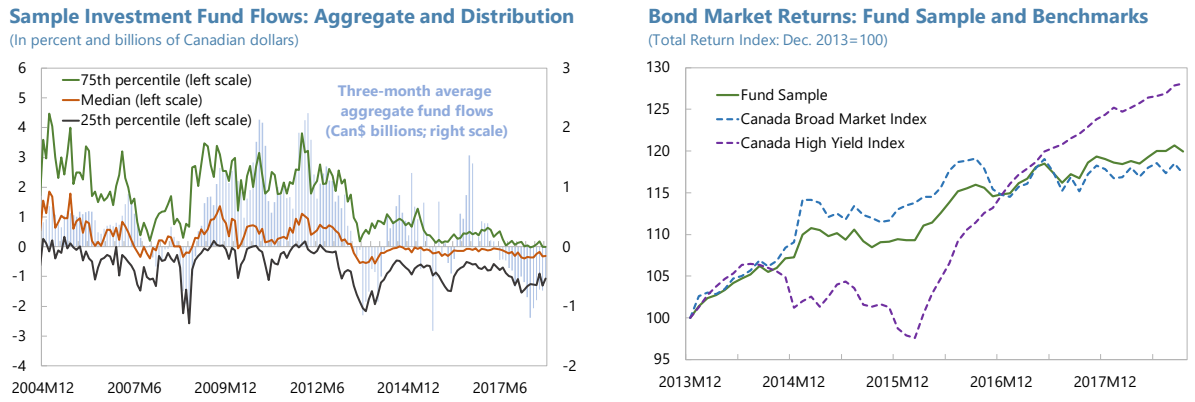
[55] Other fixed income consists of fixed income derivatives and securitized products. Total market value of these holdings was Can$9 billion, or three percent of fund assets.

[56] The corporate bond market share is an estimate because some sample corporate bond holdings may be foreign corporate bonds swapped into Canadian dollars. The government bond market share is likely overstated because the fund sample's government bond holdings includes some Crown corporation issuance.

has 29,321 monthly observations, with each fund having an average of 97 observations (i.e., about 8 years of data).[57] The data set excludes fund flow observations where the implied fund return exceeds 20 percent or is below -20 percent.[58]

**187. Sample funds have modestly outperformed benchmark returns but nonetheless have seen steady redemptions in recent quarters** (Figure 29)**.** The fund sample underperformed the broad Canadian dollar-denominated debt market from 2014 through 2016 as high-yield returns suffered. Since 2017, sample funds have however outperformed the broad market, albeit modestly and in an environment of low returns for investment grade bonds. Fund inflows were largest in the four years following the GFC but have turned to steady outflows since mid-2017, as returns remain low and ETFs and foreign bond strategies have grown in popularity. At an aggregate level, the largest monthly historical outflow within the sample was -1.6 percent in December 2008. This is significantly lower than the largest outflow experiences of U.S. bond funds dating back to 2000, which are -3.2 percent.

**Figure 29. Canada: Investment Fund Sample Fund Flows and Returns**




Source: Bank of Canada; Morningstar; Bloomberg LP; Bank of America Merrill Lynch; and IMF staff calculations.

## Calibration of Redemption Shocks

**188. Three calibrations were used to generate fund-level redemption shocks.** The first two followed the recent Brazil FSAP (IMF 2018) in using values drawn from the historical distribution of fund flows. The third used the BOC framework, which uses performance-flow sensitivities estimated by BOC staff at the fund level.

[57] Fund flows are defined as the market value of investor purchases or redemptions of a fund's shares in month *t* divided by the market value of that fund at month *t-1*.

[58] The implied fund return is calculated as the change in total market value of the firm between month *t* and *t-1*, less the change attributable to investor flows in month *t*, divided by fund market value at month *t-1*. The limit of 20 percent reflects that the largest reported historical monthly fund return values in the sample were -18.6 percent and 9.9 percent.

- **The first shock calibration used first-percentile historical fund flows of the entire fund sample.** This calibration used the first percentile of the distribution of monthly outflows for all funds of a given fund mandate (bond or mixed). This assumed a single redemption shock for each type of fund regardless of firm-specific factors. This approach is useful in simulating a broad, system-wide shock which many individual funds may not have experienced in the past; since it used the full sample of funds including wound-down funds, it accounted for survivor bias. Given that the left tail of the distribution may primarily include fund flow observations from risky and smaller funds, it may however generate excessively large outflows for less risky funds.
- **The second shock calibration used the first-percentile historical fund flow for each individual fund.** This calibration used the first percentile of each funds' own historic distribution of monthly fund flows. This approach resulted in a unique redemption shock for each fund that may better reflect its individual risk profile. However, this limited the potential magnitude of shocks for funds that are relatively new or have increased risk exposures since prior episodes of market turbulence.
- **The BOC calibration stipulated a decline in fund performance from rising interest rates and then uses an estimated performance-flow sensitivity to gauge investor redemptions.** The scenario starts with the simplified assumption of a 100 basis points parallel increase to the yield curve over one quarter, which is loosely consistent with the 60 to 140 basis points increase in government rates seen across the yield curve in the first year of the FSAP adverse scenario. Using fund-level duration as of 2018Q3, this is translated into an initial negative shock to the value of bond holdings. The BOC approach then uses empirically estimated relationships between fund flows and fund performance to gauge investor redemptions in response to this duration shock at the fund level.[59] As the Canadian bond fund market has expanded in a largely benign period of financial market stability, with few episodes of volatility related to Canada-specific factors, this approach is useful for testing the impact of a large but plausible shock that exceeds anything in recent Canadian history.

## C. Results

### Magnitude of Fund Outflows

**189. The first and second calibrations generated aggregate outflows of 7.2 percent and 4.3 percent.** This first percentile fund flow rate was -8.6 percent for bond funds within the sample and -5.6 percent for mixed funds, for a sample-wide rate of -7.1 percent using the first calibration method.[60] Under the second calibration method, the weighted average of the first percentile fund flow of all funds in the sample, was -4.3 percent. These redemption shocks could underestimate potential vulnerabilities for bond funds with significant exposure to high-yield bonds.

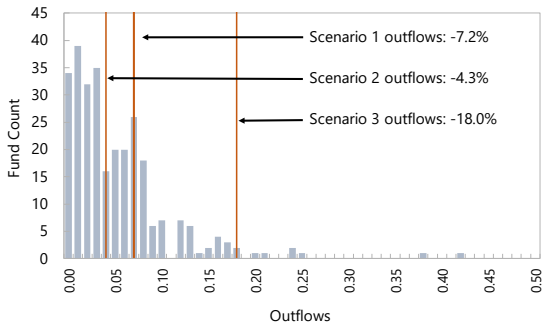
[59] See Arora et al; (2019) for further methodological details on this estimation.

[60] Wound-down firms with no data on investment mandate were assumed to be bond funds.

**190. The BOC framework generated a larger redemption shock at 18.0 percent.** The median fund-level redemption was 17.5 percent. At the fund level, the shock is larger than the historical first-percentile largest monthly historical redemption for 97 percent of funds in the sample. By comparison, the first calibration is larger than 69 percent of funds' first-percentile redemptions, while the second calibration is larger than just half of first-percentile redemptions (Figure 30). The magnitude of the generated fund redemptions in this third approach in part reflects the severity of the assumed 100 basis points interest rate shift, which has occurred only once for 5-year Canadian government bonds since the sample began (2002Q2). This shock is triple the standard deviation for 3-month changes to the 5-year yield over the last decade (33 basis point).

**Figure 30. Canada: Investment Fund Redemption Scenarios**

**Fund First-Percentile Historical Outflows and Scenario Redemption Shocks**




Note: The grey bars show the distribution of each sample fund's first-percentile monthly fund flow. The orange bar shows the aggregate fund flows under each redemption shock calibration.

## Asset Sales

**191. Two approaches are used to calculate the composition of portfolio sales by fund managers to meet redemption requests.**

- **Pro-rata sales (or "vertical slicing").** In a pro-rata asset sale, assets are sold in proportion to the fund's current asset allocation, to maintain the existing structure of asset allocation. This is assumed to be the default choice for most funds in the stress test, because (i) mixed funds and indexed funds are assumed to prefer to maintain their asset allocation given their fund mandates; and (ii) in times of market stress, fund managers may seek to preserve liquid assets in anticipation of future redemption demands.[61] Given that all redemption scenarios would be consistent with severe market stress, the pro-rata approach is considered to be most appropriate for this analysis.

[61] BOC analysis suggests that bond funds' likelihood of selling less liquid assets to meet demand is indeed a function of market conditions, with bond funds more likely to sell less-liquid assets during times of higher market volatility. See Arora and Ouellet Leblanc (2018).

- **Waterfall (or "horizontal slicing") approach.** In this approach, fund managers use their most liquid assets to satisfy investor redemptions, in order of their liquidity characteristics (e.g., first cash, then government bonds, etc.). This analysis loosely follows the Basel III LCR haircut schedule to generate a liquid asset hierarchy given the portfolio composition data that is available. Assets are assumed to be sold in the following order—(i) cash; (ii) AAA and AA bonds; (iii) equities; (iv) other bonds in the following order: A, BBB, BB, B, and so on; and (v) other assets.[62] This approach is provided for comparison purposes.

**192. With pro rata sales, forced selling of corporate bonds would reach 5 percent of the total stock outstanding** (Figure 31)**.** The fund sample would sell some Can$11.9 billion, Can$6.5 billion, and Can$29.7 billion in corporate bonds under the first, second, and third calibration, respectively. This is equivalent to roughly 2, 1, and 5 percent of domestic-currency corporate bonds. Government bond sales would be comparatively more manageable, with sales equivalent to about 1.5 percent of the outstanding market under the third and most severe calibration.

**193. Pro rata sales by credit rating suggest greater potential stress for lower-yielding bonds and other bond segments.** Sample funds' bond holdings (including both corporate and government bonds) are skewed towards lower-yielding bonds compared to the overall Canadian dollar-denominated bond market (Figure 31).[63] As a result, pro rata sales imply comparatively larger asset sales relative to the outstanding size of lower-rated bond market segments. The relatively small high-yield market would see the largest impact, given that fund sample-reported speculative-grade bond holdings are larger than the Bank of America Merrill Lynch Canadian dollar-denominated high yield corporate bond index.[64] Some investment grade segments however may also see disproportionate impacts—investment funds hold roughly 17 percent of the AA-rated bond segment, about three quarters of which are provincial government bonds, and 23 percent of the BBB market, three quarters of which comprise nonfinancial corporate papers. Under the third and most severe calibration, this would result in forced selling of AA- and BBB-rated bonds equivalent to three and five percent of those market segments.

**194. Waterfall sales would by contrast limit the overall impact on corporate bond and lower-rated markets but would concentrate selling in government-issued and higher-rated bonds.** While government bond sales under the waterfall sales assumption would more than double relative to the pro rata sales assumptions, corporate bonds sales would decline by a larger factor relative to the pro rata sales assumptions. From a credit ratings perspective, the overall impact would be primarily concentrated on the AAA segment. Under the third and most severe redemption shock, AAA bond sales would rise from 1.5 percent of AAA bonds outstanding to 4 percent.

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[62] An alternative waterfall specification is performed with bonds categorized by government, corporate, and other. The ordering would be: (i) cash, (ii) government bonds; (iii); equities; (iv) corporate bonds; and (v) other assets.

[63] The broad Canadian-denominated bond market ratings distribution is based on bond-level data from Bloomberg. The average of DBRS and the Bloomberg composite rating grades were used.

[64] This anomaly is attributed to currency swapped holdings of foreign-issued corporate bonds.

## Figure 31. Canada: Investment Fund Stress Test: Estimated Asset Sales


Note: In Panel 2, bars shown are the range of bond sales (both corporate and government) across the three redemption calibrations, as percentages of Canadian dollar-denominated bonds outstanding per ratings bucket. In Panel 2 and 3, the estimated size of bond market segments by ratings grade is based on bond-level data fro Bloomberg. The average of DBRS and the Bloomberg composite rating grades were used. In Panel 4, weekly trading volumes are the sum of institutional client, retail client, and non-resident investor trading volumes in 2018, divided by 52 (the number of weeks in a year).

**195. The overall price impact of fund redemption-driven bond liquidation is challenging to quantify precisely but would likely be severe.** The BOC's bond market trading liquidity supply model (Arora and others 2019) estimates that investment fund corporate bond sales of Can$31.7 billion would increase corporate bond liquidity risk premiums by 93 basis points.[65] If long-term institutional investors did not participate in absorbing the increased bond supply, however, estimated liquidity risk premiums would rise to around 140 basis points, close to the 165 basis point premium observed in Canadian markets during the GFC.

**196. The price impact would likely be sensitive to the pace of redemptions and the breadth of bonds sold.** While this analysis is based primarily on data with a monthly frequency, available weekly data in Canada and other regions show that instances of heightened fund flows are often concentrated within shorter time spans. If the fund flows are assumed to occur within the span of a

[65] This estimate is based on determining the market clearing price that broker-dealers and institutional investors would require based on their own cost of funding, capital, market conditions, and other factors, based on a model similar to Baranova (2016).

week, the redemption-triggered bond sales would be quite large relative to average volumes, potentially magnifying downward price pressures due to supply effects. Figure 31 shows that implied corporate bond sales in this scenario (under pro rata sales) would equal roughly one to three times the average weekly corporate bond trading volumes in 2018 by institutional, retail, and non-resident investors. The price impact could also be larger if the bonds sold due to fund redemptions were among the smaller and less frequently traded bonds, which might require deeper discounts to sell.

## D. Policy Recommendations

**197. Authorities should continue to strengthen risk surveillance for investment funds.** For systemic and market risk monitoring purposes, authorities should consider regularly monitoring funds' bond portfolios on a fund-level or even bond-level basis. This will provide a more granular and higher-frequency understanding of the distribution of credit and liquidity risk exposures within the investment fund sector. Policymakers and regulators should also seek to more actively assess funds' liquidity risk management capabilities, including for investment grade assets, and consider requiring regular disclosures to supervisors or investors on relevant policies and assessments. Finally, authorities should also consider encouraging greater adoption of liquidity management tools such as redemption gates, fees and swing pricing, to limit incentives for investors to withdraw money when they see other investors exiting.

## Table 11. Canada: Investment Fund Sample Asset Holdings and Sales

| | Holdings | | |
|---|---|---|---|
| | Fixed Income Mandate | Mixed Mandate | Total |
| **Cash** | 7.7 | 3.9 | **11.5** |
| **Equity** | 0.9 | 40.7 | **41.5** |
| **Other** | 9.2 | 3.4 | **12.6** |
| **Bonds** | 223.0 | 34.4 | **257.5** |
| *Bond detail:* | | | |
| ***Gov.*** | *90.6* | *10.3* | ***100.9*** |
| ***Corp.*** | *124.2* | *22.9* | ***147.1*** |
| ***AAA-AA*** | *130.7* | *17.4* | ***148.0*** |
| ***A-BBB*** | *72.7* | *11.9* | ***84.6*** |
| ***High yield*** | *19.7* | *5.2* | ***24.9*** |

| | | Sales: Pro Rata | | | Sales: Waterfall | | |
|---|---|---|---|---|---|---|---|
| | | Fixed Income Mandate | Mixed Mandate | Total | Fixed Income Mandate | Mixed Mandate | Total |
| **Calibration 1** | **Cash** | 0.7 | 0.2 | **0.9** | 6.2 | 2.7 | **8.8** |
| | **Equity** | 0.1 | 2.3 | **2.4** | 0.0 | 0.1 | **0.1** |
| | **Other** | 0.8 | 0.2 | **1.0** | 0.0 | 0.0 | **0.0** |
| | **Bonds** | 19.1 | 1.9 | **21.1** | 14.4 | 1.9 | **16.3** |
| | **Total** | **20.6** | **4.6** | **25.3** | **20.6** | **4.6** | **25.3** |
| | *Bond detail:* | | | | | | |
| | ***Gov.*** | *7.8* | *0.6* | ***8.3*** | *12.5* | *1.8* | ***14.3*** |
| | ***Corp.*** | *10.6* | *1.3* | ***11.9*** | *1.8* | *0.0* | ***1.8*** |
| | ***AAA-AA*** | *11.2* | *1.0* | ***12.2*** | *14.1* | *1.9* | ***16.0*** |
| | ***A-BBB*** | *6.2* | *0.7* | ***6.9*** | *0.2* | *0.0* | ***0.2*** |
| | ***High yield*** | *1.7* | *0.3* | ***2.0*** | *0.1* | *0.0* | ***0.1*** |
| **Calibration 2** | **Cash** | 0.4 | 0.1 | **0.5** | 4.5 | 1.1 | **5.6** |
| | **Equity** | 0.1 | 1.1 | **1.2** | 0.1 | 0.0 | **0.1** |
| | **Other** | 0.3 | 0.1 | **0.4** | 0.0 | 0.0 | **0.0** |
| | **Bonds** | 12.0 | 1.0 | **13.0** | 8.2 | 1.0 | **9.3** |
| | **Total** | **12.8** | **2.2** | **15.0** | **12.8** | **2.2** | **15.0** |
| | *Bond detail:* | | | | | | |
| | ***Gov.*** | *5.5* | *0.3* | ***5.8*** | *7.4* | *1.0* | ***8.3*** |
| | ***Corp.*** | *5.9* | *0.6* | ***6.5*** | *0.8* | *0.0* | ***0.8*** |
| | ***AAA-AA*** | *7.5* | *0.5* | ***8.0*** | *8.0* | *1.0* | ***9.1*** |
| | ***A-BBB*** | *3.6* | *0.3* | ***3.9*** | *0.1* | *0.0* | ***0.1*** |
| | ***High yield*** | *0.9* | *0.2* | ***1.1*** | *0.1* | *0.0* | ***0.1*** |
| **Calibration 3** | **Cash** | 1.9 | 0.7 | **2.6** | 7.5 | 3.8 | **11.3** |
| | **Equity** | 0.5 | 7.4 | **7.9** | 0.6 | 2.2 | **2.8** |
| | **Other** | 2.3 | 0.6 | **2.9** | 0.0 | 0.0 | **0.0** |
| | **Bonds** | 43.5 | 6.7 | **50.2** | 40.1 | 9.4 | **49.5** |
| | **Total** | **48.1** | **15.4** | **63.6** | **48.1** | **15.4** | **63.6** |
| | *Bond detail:* | | | | | | |
| | ***Gov.*** | *16.6* | *2.0* | ***18.6*** | *29.3* | *7.8* | ***37.1*** |
| | ***Corp.*** | *25.3* | *4.4* | ***29.7*** | *10.2* | *0.0* | ***10.2*** |
| | ***AAA-AA*** | *25.1* | *3.3* | ***28.4*** | *36.1* | *9.4* | ***45.6*** |
| | ***A-BBB*** | *14.4* | *2.2* | ***16.6*** | *3.3* | *0.0* | ***3.3*** |
| | ***High yield*** | *4.0* | *1.2* | ***5.2*** | *0.6* | *0.0* | ***0.6*** |

Note: "Bond detail" does not sum to total sales for government and corporate breakout because it leaves out other fixed income (e.g., securitizations), which are only 4 percent of total bond holdings, and in the waterfall scenarios, because the government/corporate breakdown reflects an alternative liquidation ranking which results in small differences in the quantity of equities sold.

# Appendix I. House Price-at-Risk (HaR) Methodology

**The city-level HaR analysis follows a two-stage approach as proposed by Adrian, Boyarchenko and Giannone (2019) and IMF (2019).**

**In the first stage, quantile regression models are estimated for each city.** Specifically, a quantile regression is run with city-level residential real house prices as the dependent variable:

$$CityHP^{q}_{i,t+h} = \rho_1 CityHP_{i,t} + \rho_2 HP2INC_{i,t} + \rho_3 ResInv_{i,t} + \beta_1 \Delta HHD_t + \beta_2 FCI_t + \beta_3 FDI_t + \beta_4 OtherCF_t + \beta_5 OIL + \epsilon_{i,t} \quad (1)$$

where h is the horizon (e.g., 4 quarters-ahead, 12 quarters-ahead), q is the quantile (q=0.1, 0.25, 0.5, 0.75, and 0.9), and ε the error terms. Household debt (HHD), inward foreign direct investments (FDI), residential investment (ResInv), and other capital inflows (Other CF) are scaled by overall GDP. FCI is the price-based financial conditions index, estimated over 1980:Q1–2018:Q3 (similar methodology to IMF (2017a), Chapter 3. The HP to income ratio (HP2INC) is at the city level. Residential Investment is the city level residential investment as a share of provincial level GDP. OIL is the log growth rate of oil price index, year-on-year. The dependent variable (CityHP) is city-level real house price growth, year-on-year. An autoregressive term is considered as well.

**The house price-to-income ratio is constructed at the city-level, using quarterly house prices over the 1980-2018 period provided by CREA.** For each city, average nominal house prices in dollar terms are divided by nominal disposable income in each province. Next, the house price-to-income ratio is scaled by the long-term average to obtain a proxy for current market valuation in each city. The selected period for the long-term average is 2000–2017, calibrated to match the OECD reported level of Canada-wide house price-to-income ratios.

**In a second stage, a skewed-*t* distribution is fitted for each city house price series at each point in time**. The distribution uses the predicted values for each quantile obtained in the first stage. In general, house prices-at-risk refer to the lower fifth quantile of the city-specific distribution, at each point in time, using the fitted t-student parameters.

**To test the robustness of the results, alternative models are estimated.** For instance, smaller models are estimated, and additional controls are added, such as portfolio investments. Equation (1) is the one with highest pseudo-$R^2$ across all cities. The coefficients of capital flows variables from equation (1) remain broadly consistent across specifications. Across all quantiles, the average pseudo-$R^2$ across all Canadian cities 4 quarters-ahead and 12 quarters-ahead is around 0.37 and 0.43, respectively.

***Bank Solvency Stress Testing***

| Domain | | Assumptions | |
|---|---|---|---|
| | | **Top-Down by Bank of Canada** | **Top-Down by FSAP Team** |
| 1. Institutional perimeter | Institutions included | • Seven domestic systemically important financial institutions (D-SIFIs), including six domestic systemically important banks (D-SIBs) and the credit cooperative group in Québec | |
| | Market share | • For six D-SIBs, about 97 percent of banking sector assets (excluding foreign bank branches)<br>• For seven D-SIFIs, above 90 percent of total assets of deposit-taking institutions | |
| | Data and baseline date | • OSFI: regulatory returns and supervisory data, supplemented by ad-hoc data collection<br>• AMF: regulatory returns<br>• Statistics Canada: National Household Survey data<br>• Data as of October 2018<br>• Scope of financial consolidation: group-wide | • OSFI: regulatory returns and supervisory data, supplemented by ad-hoc data collection<br>• AMF: regulatory returns supplemented by ad-hoc data collection<br>• Statistics Canada: National Household Survey data<br>• Moody's Analytics: CreditEdge data on corporate default probability<br>• Data as of October 2018<br>• Scope of financial consolidation: group-wide |
| 2. Channels of risk propagation | Methodology | • Balance sheet approach<br>• Projections of key balance sheet, income statement, and capital account items<br>• Quasi-static balance sheet assumption<br>• Net interest income is projected based on effective interest rates for each interest-sensitive asset/liability segment. Overlays account for repricing profiles of assets and liabilities and spreads to reflect credit risk and liquidity conditions.<br>• Non-interest income is split into market-sensitive sources (e.g., underwriting and wealth management fees) and non-market sensitive sources (e.g., deposit and loan fees). Market sensitive income is projected based on the evolution of a basket of asset prices. Non-market | • Balance sheet approach<br>• Projections of key balance sheet, income statement, and capital account items<br>• Quasi-static balance sheet assumption<br>• Net interest income is projected based on effective interest rates for each interest-sensitive asset/liability segment, together with an overlay of spreads to reflect credit risk and liquidity conditions. Additional pass-through constraints are applied in parallel with the satellite model projection.<br>• Non-interest income is projected based on its sensitivity to macrofinancial conditions.<br>• Operational expenses are kept equal to the 2018 level but are adjusted in terms of foreign-currency composition. |

| Domain | | Assumptions | |
|---|---|---|---|
| | | **Top-Down by Bank of Canada (BOC)** | **Top-Down by FSAP Team** |
| 2. Channels of risk propagation | Methodology | sensitive income is projected based on a fixed ratio to total loans.<br>• Granular projections of credit risk parameters are performed, including exposures at default (EADs), probabilities of default (PDs), and loss given default (LGDs) for each asset class and geography.<br>• Accounting provisions assumes a partial drawdown of undrawn exposures under stress.<br>• IFRS 9-expected credit losses are projected based on a simplified approach (i.e., no projected stage transitions) that reallocates provisions toward earlier periods.<br>• The impact on profit and loss and "other comprehensive income" (OCI)—due to fair value through profit or loss (FVTPL) positions and fair value through other comprehensive income (FVOCI) positions—is estimated.<br>• The impact of exchange rate movements on risk-weighted assets, credit losses, and pre-provision net income is not assessed.<br>• Risk-weighted assets are adjusted to reflect overall asset growth and appropriate changes in the quality of credit exposures. | • Granular projections of credit risk parameters are performed, including EADs, PDs, and LGDs for each asset class and geography.<br>• IFRS 9-expected credit losses are projected in line with PDs, using a stage transition matrix.<br>• The impact on profit-and-loss and OCI due to FVTPL and FVOCI positions is estimated.<br>• The mark-to-market approach is used to assess the impact of exchange rates, equity prices, and commodity prices on net open positions.<br>• The consolidation of balance sheet and income statement accounts for exchange rate movements.<br>• Risk-weighted assets are adjusted to reflect overall asset growth and appropriate changes in the quality of credit and market exposures. |
| | Satellite models for macrofinancial linkages | • The Household Risk Assessment Model (HRAM)—is used to estimate PDs for mortgage and home equity lines of credit (HELOCs).<br>• For other exposures, a suite of error correction models is used to project consolidated nonperforming loan ratios. Projections are then translated into PDs per geographies using expert judgement.<br>• Error correction models are used to project effective interest rates. | • Several empirical models are used, together with the Bayesian Model Average technique, to estimate effective interest rates. Models may be bank-specific or may be adjusted for bank-specific starting points.<br>• A simplified conservative approach is used to project non-interest income.<br>• A structural model approach, partially relying on Monte Carlo simulations, is used to estimate PDs and LGDs for mortgage exposures. |

| Domain | | Assumptions | |
|---|---|---|---|
| | | **Top-Down by Bank of Canada (BOC)** | **Top-Down by FSAP Team** |
| 2. Channels of risk propagation | Satellite models for macrofinancial linkages | | • Several empirical models are used, together with the Bayesian Model Average technique, to estimate scenario dependent point-in-time (PiT) PDs for other credit exposures. Model outputs depend on bank-specific starting points. |
| 3. Tail shocks | Stress test horizon | • Three years (2018Q4–2021Q4) | |
| | Scenario analysis | • Based on two common macrofinancial scenarios.<br>• The scenarios specify key macrofinancial variables (e.g., real GDP growth, inflation rate, unemployment rates, exchange rates, equity prices, house prices, interest rates, and credit growth) for Canada and important geographies/countries, as well as global variables (e.g., commodity prices).<br>• The baseline scenario is based on October 2018 *World Economic Outlook* (WEO) projections.<br>• The adverse scenario is simulated using the Global Macrofinancial Model (GFM). The adverse scenario features a severe recession that occurs concurrently with significant financial market stress and a sharp housing market correction. The main triggers would be external developments, including global trade disruptions, tightening global financial conditions, and weaker-than-expected global economic activity, as described in the Risk Assessment Matrix (RAM).<br>• The central feature of the adverse scenario is tighter-than-expected monetary policy by some major central banks in response to potential de-anchoring of inflation expectations, which would be induced by the disruption in international trade and global production chains. With disorderly monetary tightening, significant global financial market stress would set off global housing market and credit cycle downturns. The impact of these negative external shocks would then be amplified by existing macrofinancial vulnerabilities, such as housing market imbalances and high household debt, resulting in a sharp housing market correction and deterioration in bank asset quality. Significant financial stress would also materialize in Canada.<br>• Under the adverse scenario, the Canadian economy would encounter two years of output contraction (2018 and 2019), with cumulative real GDP growth of -2 percent during 2019–21, equivalent to 3 standard deviation. Based on growth-at-risk analysis, its likelihood is 3.8 percent. | |
| | Sensitivity analysis | • A number of sensitivity exercises surrounding the scenario analysis are explored. | • A number of sensitivity exercises surrounding the scenario analysis are explored.<br>• Shocks to household affordability that critically affect PDs of mortgage exposures are simulated under an alternative assumption in which higher-risk borrowers are asked for additional interest rate spreads to compensate banks for larger capital charges. This would amplify stress on households' affordability. |

| Domain | | Assumptions | |
|---|---|---|---|
| | | **Top-Down by Bank of Canada (BOC)** | **Top-Down by FSAP Team** |
| 3. Tail shocks | Sensitivity analysis | | • Assessment of the impact on accounting lifetime expected credit loss for Stage II mortgage exposures because of a shorter contractual lifetime vs a longer average amortization lifetime.<br>• Assessment of the relative impact on losses due to the utilization of committed credit lines in an adverse scenario with no balance sheet restrictions (impact of large undrawn EADs).<br>• Credit exposure concentration risks are also assessed, taking into account market structure specificities. |
| 4. Risks and buffers | Risks/factors assessed (how each element is derived; assumptions) | • Credit risk captures all drawn and undrawn balances associated with on-balance sheet loan portfolios and exposures at amortization cost.<br>• Market risk is reflected in valuation effects of FVTPL and FVOCI positions, as well as net open financial positions (i.e., currencies, equities, and commodities).<br>• Net interest income is affected by the margin rate implied by asset-side and liability-side interest rates.<br>• On-balance sheet credit EADs evolve broadly based on credit growth assumption in scenarios.<br>• Off-balance sheet credit EADs associated with undrawn balances are assumed to grow in proportion with drawn balances such that utilization remains fixed. All facilities are assumed to be contractually irrevocable to extend funds in the future.<br>• In the solvency module, EADs linked to securities holdings remain constant. | • Credit risk captures all on- and off-balance sheet loan portfolios and exposures at amortization cost.<br>• Market risk is reflected in valuation effects of FVTPL and FVOCI positions, as well as net open financial positions (i.e., currencies, equities, and commodities).<br>• Net interest income is affected by the change in the reference rate and by the margin rate implied by asset-side and liability-side interest rates.<br>• On-balance sheet credit EADs evolve broadly based on credit growth assumption in scenarios.<br>• Off-balance sheet credit EADs are assumed to evolve in alignment with credit growth assumption in scenarios. All facilities are assumed to be contractually irrevocable to extend funds in the future. |

| Domain | | Assumptions | |
|---|---|---|---|
| | | **Top-Down by Bank of Canada (BOC)** | **Top-Down by FSAP Team** |
| 4. Risks and buffers | Behavioral adjustments | • In addition, the framework features the contagion module based on the MacroFinancial Risk Assessment Framework (MFRAF). This framework can analyze contagion effects, including interaction between solvency and liquidity conditions.<br>• Dividends are equal to the greater of (i) the most recent historical dividend (2018Q4) or (ii) the dividend implied by a fixed ratio of dividends to post-tax net income. Dividends are not reduced unless there is a breach of the capital conservation buffer. Should this occur, the maximum dividend payout is subject to regulatory restrictions. | • EADs linked to securities holdings remain constant.<br>• If relevant, maturing assets are replaced by exposures of the same type of risk.<br>• Maturing capital instruments are generally not allowed to be renewed in the adverse scenario. Some exceptions may be granted for certain capital instruments issued in foreign currency by overseas subsidiaries. For example, an exception might be made to acknowledge the impact of foreign exchange shocks.<br>• If a bank's capital falls below regulatory requirements, no prompt corrective action is assumed.<br>• Dividends anchored to the previous fiscal year's level (before the cut-off date) are assumed to be paid by banks. When the capital conservation buffer is breached, restrictions on dividend distributions are aligned with the regulatory framework. |
| 5. Regulatory and market-based standards and parameters | Calibration of risk parameters | • Scenario dependent forward paths for PiT PDs and LGDs are estimated for each asset class and geography based on historical non-performing loan ratios (for the corporate sector) or a structural model based on microsimulations using the HRAM (for the household sector).<br>• Given the limited availability of PiT LGD data, some proxies are used.<br>• For internal ratings-based (IRB) exposures, risk-weighted assets are projected on the basis of updated regulatory through-the-cycle (TTC) PDs and downturn LGDs, using appropriate scaling multipliers from the PiT parameters. | • Scenario dependent forward paths for PiT PDs and LGDs are estimated for each asset class and geography.<br>• Estimation of expected credit losses for mortgage exposures is based on projected distributions of debt-servicing ratios (DSR) and loan-to-value ratios (LTV).<br>• IFRS 9-expected credit losses are projected by estimating stage transition matrices based on projected PiT PDs and stage transition rates. Estimations of lifetime expected losses assume a transition to baseline parameters after 5 years. |

| Domain | | Assumptions | |
|---|---|---|---|
| | | **Top-Down by Bank of Canada (BOC)** | **Top-Down by FSAP Team** |
| 5. Regulatory and market-based standards and parameters | Calibration of risk parameters | | • Given the limited availability of PiT LGD data, some very basic proxies are used.<br>• For internal ratings-based (IRB) exposures, risk-weighted assets are projected on the basis of updated regulatory through-the-cycle PDs and downturn LGDs, using appropriate scaling multipliers from the PiT parameters.<br>• For standardized approach (STA) exposures, risk-weighted assets are projected based on constant risk weight densities. |
| | Regulatory/accounting and market-based standards | • In the baseline, hurdles include the regulatory minimum, the capital conservation buffer, the D-SIFI surcharge, and the applicable countercyclical capital buffer and/or domestic stability buffer.<br>• In the adverse scenario, hurdles include the regulatory minimum and the D-SIFI surcharge.<br>• Hurdle rates are based on common equity tier-1, tier-1, and total capital ratios. | |
| 6. Reporting format for results | Output presentation | • System-wide evolution of common equity tier1, tier-1 and total capital ratios<br>• Distribution of bank capital positions<br>• Contribution to key drivers to system-wide net income and capital positions, including differences between baseline scenarios and adverse scenarios<br>• Number of institutions with capital below the hurdles, and the share of their assets<br>• Amount of capital shortfalls | |

***Bank Liquidity Stress Testing***

| Domain | | Assumptions |
|---|---|---|
| | | **Top-Down by FSAP Team** |
| 1. Institutional perimeter | Institutions included | • Seven domestic systemically important financial institutions (D-SIFIs), including six domestic systemically important banks (D-SIBs) and the credit cooperative group in Québec |
| | Market share | • For six D-SIBs, about 97 percent of banking sector assets (excluding foreign bank branches)<br>• For seven D-SIFIs, above 90 percent of total assets of deposit-taking institutions |
| | Data and baseline date | • OSFI: regulatory returns based on the Liquidity Coverage Ratio (LCR) and Net Cumulative Cash Flow (NCCF)<br>• AMF: regulatory returns based on the LCR and the NCCF<br>• Data as of September 2018<br>• Scope of financial consolidation: group-wide |
| 2. Channels of risk propagation | Methodology | • The exercise is based on two types of tests—LCR test and cash-flow analysis.<br>• The LCR test is in line with the standard Basel monitoring tool, featuring total liquidity and liquidity in all significant currencies (Canadian dollar, U.S. dollar, euro, British pound, and Japanese yen).<br>• The cash-flow analysis analyzes the net cash balance, accounting for available unencumbered assets, contractual cash inflows (no inflows are recognized for maturing loans, assuming that renewals or origination is not affected at the system-wide level) and outflows.<br>• For the cash-flow analysis, relevant second-round effects are considered, including margin calls for existing collateral of funding positions, central bank liquidity provisions, additional asset haircuts due to fire sales, additional repo haircuts due to increased collateral supply, and wholesale funding market freezes as a result of bank solvency and liquidity concerns. |
| | Satellite models for macrofinancial linkages | • For the cash-flow analysis, asset haircuts reflect two components: (i) shocks to interest rates and asset prices as captured in the macrofinancial scenarios; and (ii) additional haircuts required by counterparties to accept specific assets as collateral for secured funding transactions. |
| | Stress test horizon | • For the LCR test, the stress test horizon is 30 days.<br>• For the cash-flow analysis, the horizon of stress events would normally be 3 months. |
| 3. Tail shocks | Scenario analysis | • For the LCR test, three scenarios are considered: (i) a run on retail deposits, with higher run-off rates for retail deposits; (ii) a run on wholesale funding, with higher run-off rates for corporate deposits and other wholesale funding; and (iii) a combination of runs on retail deposits and wholesale funding.<br>• For the cash-flow analysis, a series of scenarios are considered, with a range from mild to severely adverse liquidity conditions. The cash-flow analysis considers both funding and market liquidity risks. |
| | Sensitivity analysis | N/A |

| Domain | | Assumptions |
|---|---|---|
| | | **Top-Down by FSAP Team** |
| 4. Risks and buffers | Risks/factors assessed (how each element is derived; assumptions) | • Funding liquidity risk is reflected in funding run-off rates and asset roll-over rates, the latter providing cash inflows related to non-renewal of maturing assets.<br>• Market liquidity risk is reflected in asset haircuts, which could be influenced by market movements, fire sales, and collateral supply constraints. |
| | Behavioral adjustments | • Liquidity from the Bank of Canada's Emergency Lending Assistance is not considered. |
| 5. Regulatory and market-based standards and parameters | Calibration of risk parameters | • The LCR tests are based on regulatory and stress parameters.<br>• The cash-flow analysis may incorporate relevant second-round effects.<br>• Stress funding run-off rates, asset roll-over rates, and asset haircuts are calibrated based on empirical evidence and relevant international experiences. |
| | Regulatory/accounting and market-based standards | • LCR per Basel III; the hurdle set at 100 percent<br>• Net cash balance for the cash-flow analysis; to pass, a non-negative net cash balance is required, where the balance reflects net cash outflows and counterbalancing capacity. |
| 6. Reporting format for results | Output presentation | • Changes in the system-wide liquidity position, including important drivers for cash outflows, cash inflows, and counterbalancing capacity<br>• Distribution of bank liquidity positions<br>• Number of institutions with LCR below 100 percent and/or negative net cash balance<br>• Amount of liquidity shortfalls, including by currencies |

### *Life Insurance Stress Testing*

| Domain | | Assumptions |
|---|---|---|
| | | **Top-Down by FSAP Team** |
| 1. Institutional perimeter | Institutions included | • Five largest life insurers, including three globally active federally regulated entities and two domestically oriented, provincially regulated entities in Québec |
| | Market share | • Above 90 percent of life insurers' total assets<br>• About 80 percent of life insurers' total net premiums |
| | Data and baseline date | • OSFI: regulatory returns, supplemented by ad-hoc data collection<br>• AMF: regulatory returns, supplemented by ad-hoc data collection<br>• Data as of December 2018<br>• Scope of financial consolidation: group-wide |
| 2. Channels of risk propagation | Methodology | • Balance sheet approach<br>• Static balance sheet assumption<br>• The exercise assesses the instantaneous impact of macrofinancial shocks on the solvency position through three main channels.<br>• Projections of key balance sheet and capital account items by six key geographies (i.e., Canada, Europe, Japan, the United Kingdom, the United States, and others)<br>• The mark-to-market approach is used to assess the impact of macrofinancial shocks on investment portfolios, which would in turn affect available capital.<br>• The assessment of actuarial liabilities due to changes in discount rates as a result of changes in risk-free rates, which would in turn affect available capital.<br>• Adjustments to base solvency buffer are made to reflect changes in credit risk and market risk. |
| | Satellite models for macrofinancial linkages | • N/A |
| | Stress test horizon | • Three years (2018Q4–2021Q4) |
| 3. Tail shocks | Scenario analysis | • Based on one macrofinancial scenario—the adverse scenario<br>• The scenarios specify key macrofinancial variables (e.g., real GDP growth, inflation rate, unemployment rates, exchange rates, equity prices, house prices, interest rates and credit growth) for Canada and important geographies/countries, as well as global variables (e.g., commodity prices). |

| Domain | | Assumptions |
|---|---|---|
| | | **Top-Down by FSAP Team** |
| 3. Tail shocks | Scenario analysis | • The adverse scenario is simulated using the GFM. The adverse scenario features a severe recession that occurs concurrently with significant financial market stress and a sharp housing market correction. The main triggers would be external developments, including global trade disruptions, tightening global financial conditions and weaker-than-expected global economic activity, as described in the RAM. The central feature of the adverse scenario is tighter-than-expected monetary policy by some major central banks in response to potential de-anchoring of inflation expectations, which would be induced by the disruption in international trade and global production chains. With disorderly monetary tightening, significant global financial market stress would set off global housing market and credit cycle downturns. The impact of these negative external shocks would then be amplified by existing macrofinancial vulnerabilities such as housing market imbalances and high household debt, resulting in a sharp housing market correction and deterioration in bank asset quality. Significant financial stress would also materialize in Canada.<br>• Under the adverse scenario, the Canadian economy would encounter two years of output contraction (2018 and 2019), with cumulative real GDP growth of -2 percent during 2019–21, equivalent to 3 standard deviation. Based on growth-at-risk analysis, its likelihood is 3.8 percent.<br>• Given the methodological approach, the exercise considers two periods of the adverse scenario. The first period is 2019Q3, which reflects the most severe financial market stress. The second period is 2021Q4, which features the lowest interest rates. |
| | Sensitivity analysis | • A number of sensitivity exercises surrounding the scenario analysis are explored. In particular, alternative assumptions regarding changes in risk-free interest rates that would generate a more material impact are examined. |
| 4. Risks and buffers | Risks/factors assessed (how each element is derived, assumptions) | • Market risk and credit risk affect the valuation of investment portfolios.<br>• Interest rate risk, i.e. only changes in risk-free interest rates, affect actuarial liabilities. |
| | Behavioral adjustments | • The surplus allowance is assumed to remain proportional to the present value of liabilities. |
| 5. Regulatory and market-based standards and parameters | Calibration of risk parameters | • Risk-free interest rates, as well as asset prices (i.e., credit spreads, equity prices, and house prices) are calibrated in line with the macrofinancial scenario.<br>• The yield curves of risk-free interest rates, which critically determine liability-side discount rates in the exercise, are interpolated based on relevant short-term and long-term government bond yields.<br>• Macrofinancial shocks mainly affect available capital and base solvency buffer. |
| | Regulatory/accounting and market-based standards | • Regulatory capital framework based on Canada's Life Insurance Capital Adequacy Test (LICAT)<br>• Hurdle rates based on the regulatory minimums for the LICAT's core and total capital ratios at 50 percent and 90 percent, respectively. |

| Domain | | Assumptions |
|---|---|---|
| | | Top-Down by FSAP Team |
| 5. Regulatory and market-based standards and parameters | Regulatory/accounting and market-based standards | • The total capital ratio is based on the sum of available capital (including both tier-1 and tier-2 capital), surplus allowance and eligible deposits, divided by base solvency buffer. The core capital ratio is based on the sum of tier-1 capital, surplus allowance (only 70 percent), and eligible deposits (only 70 percent), divided by base solvency buffer. |
| 6. Reporting format for results | Output presentation | • System-wide evolution of core and total capital ratios.<br>• Distribution of life insurers' capital positions<br>• Contribution to key drivers to system-wide capital position<br>• Number of institutions with capital below the hurdles, and the share of their assets<br>• Amount of capital shortfalls |

### *Mortgage Insurance Stress Testing*

| Domain | | Assumptions |
|---|---|---|
| | | **Top-Down by FSAP Team** |
| 1. Institutional perimeter | Institutions included | • All three mortgage insurers, all federally regulated |
| | Market share | • 100 percent of mortgage insurers' total assets |
| | Data and baseline date | • OSFI: regulatory returns<br>• CMHC: data equivalent to OSFI regulatory returns<br>• Data as of September 2018<br>• Scope of financial consolidation: mortgage insurance business |
| 2. Channels of risk propagation | Methodology | • Balance sheet approach<br>• Projections of key balance sheet, income statement and capital account items<br>• Passive balance sheet assumption<br>• Premium earnings are projected in line with overall insured mortgage credit growth (based on the scenario) and adjusted to reflect institutions' behavior under stress.<br>• Claims are projected to mirror banks' potential losses on mortgage exposures. A cross-check with estimated expected credit losses incurred by banks would be made.<br>• Other income and expense components are projected based on their sensitivity to macrofinancial conditions.<br>• The mark-to-market approach is used to assess the impact of macrofinancial shocks on investment portfolios, which would in turn affect available capital.<br>• Adjustments to minimum required capital are made to reflect changes in credit risk, insurance risk, market risk and operational risk.<br>• Insurance risk is adjusted based on LTV that reflects updated house prices (as sensitivity analysis). |
| | Satellite models for macrofinancial linkages | • Empirical models are used to project key components of non-premium income and expenses. |
| | Stress test horizon | • Three years (2018Q4–2021Q4) |
| 3. Tail shocks | Scenario analysis | • Based on two common macrofinancial scenarios<br>• The scenarios specify key macrofinancial variables (e.g., real GDP growth, inflation rate, unemployment rates, exchange rates, equity prices, house prices, interest rates, and credit growth) for Canada and important geographies/countries, as well as global variables (e.g., commodity prices).<br>• The baseline scenario is based on October 2018 WEO projections. |

| Domain | | Assumptions |
|---|---|---|
| | | Top-Down by FSAP Team |
| 3. Tail shocks | Scenario analysis | • The adverse scenario is simulated using the GFM. The adverse scenario features a severe recession that occurs concurrently with significant financial market stress and a sharp housing market correction. The main triggers would be external developments, including global trade disruptions, tightening global financial conditions and weaker-than-expected global economic activity, as described in the RAM. The central feature of the adverse scenario is tighter-than-expected monetary policy by some major central banks in response to potential de-anchoring of inflation expectations, which would be induced by the disruption in international trade and global production chains. With disorderly monetary tightening, significant global financial market stress would set off global housing market and credit cycle downturns. The impact of these negative external shocks would then be amplified by existing macrofinancial vulnerabilities such as housing market imbalances and high household debt, resulting in a sharp housing market correction and deterioration in bank asset quality. Significant financial stress would also materialize in Canada.<br>• Under the adverse scenario, the Canadian economy would encounter two years of output contraction (2018 and 2019), with cumulative real GDP growth of -2 percent during 2019–21, equivalent to 3 standard deviation. Based on growth-at-risk analysis, its likelihood is 3.8 percent. |
| 4. Risks and buffer | Risks/factors assessed (how each element is derived, assumptions) | • Credit and market risks affect the valuation of investment portfolios.<br>• Insurance risk is captured in two aspects—claim payouts and minimum required capital.<br>• New mortgage insurance business evolves in line with overall insured mortgage credit growth (based on the scenario) and institutions' behavior under stress (e.g., during the global financial crisis).<br>• |
| | Behavioral adjustments | • Net income, through the impact on equity, determines the overall size of investment portfolios. The asset allocation in investment portfolios remains unchanged.<br>• If relevant, maturing assets are replaced by exposures of the same type of risk.<br>• If mortgage insurers' capital falls below regulatory requirements, no prompt corrective action is assumed.<br>• Dividends are paid if mortgage insurers generate positive post-tax net income and do not need additional capital. |
| 5. Regulatory and market-based standards and parameters | Calibration of risk parameters | • Claim payouts are projected based on expected credit losses for mortgage exposures under the bank solvency stress tests.<br>• Changes in insurance risk, which would affect minimum required capital, are estimated to reflect changes in house prices and thus changes in LTV.<br>• The impact of relevant asset prices on investment portfolios in terms of credit and market risks (i.e., credit spreads, interest rates, equity prices) are assessed according to the macrofinancial scenarios. |

| Domain | | Assumptions |
|---|---|---|
| | | **Top-Down by FSAP Team** |
| 5. Regulatory and market-based standards and parameters | Regulatory/accounting and market-based standards | • Regulatory capital framework based on Canada's Mortgage Insurance Capital Adequacy Test (MICAT)<br>• Hurdle rates based on the supervisory target for the MICAT's capital ratio at 150 percent.<br>• The MICAT's capital ratio is based on available capital divided by two-thirds of minimum required capital. |
| 6. Reporting format for results | Output presentation | • System-wide evolution of MICAT ratio.<br>• Distribution of mortgage insurers' capital positions.<br>• Contribution to key drivers to system-wide net income and capital position, including differences between the baseline scenario and the adverse scenario.<br>• Number of institutions with capital below the hurdles, and the share of their assets.<br>• Amount of capital shortfalls. |

***Investment Fund Stress Testing***

| Domain | | Assumptions | |
|---|---|---|---|
| | | **Top-Down by Bank of Canada (BOC)** | **Top-Down by FSAP Team** |
| 1. Institutional perimeter | Institutions included | • Open-ended Canada-domiciled mutual funds with lifetime average allocations to Canadian dollar-denominated corporate bond above 20 percent and lifetime average assets under management of at least Can$50 million<br>• Only funds with fixed income and balanced mandates<br>• Sample funds held Can$323 billion in assets under management as of 2018Q3 | |
| | Market share | • 19 percent of total assets of mutual funds<br>• Samples funds held 77 percent of corporate bonds (including both financial and nonfinancial issuers) held by mutual funds, 25 percent of outstanding Canadian corporate bonds, and 8 percent of outstanding Canadian government bonds (including subnational issuers). | |
| | Data and baseline date | • Morningstar: monthly fund-level assets (including the allocation) and fund flows (defined as net sales or redemptions of mutual fund shares)<br>• Fund flow data since January 2002<br>• Asset holding data as of September 2018 | |
| 2. Channels of risk propagation | Methodology | • The exercise quantifies the amount of asset sales (particularly, corporate bonds) following redemption shocks.<br>• Fund-level redemptions are calibrated by (i) assuming a duration-driven shock to fund performance based on a shift in interest rates; and (ii) estimating investors' net redemptions in response to that shock, based on an estimated sensitivity of fund flows to fund-level performance.<br>• The exercise also quantifies the price impact on corporate bonds due to the forced sales. | • The exercise quantifies the amount of asset sales (particularly, corporate bonds) following redemption shocks.<br>• Fund-level redemptions are calibrated based on historical fund-flows experience |
| | Satellite models for macrofinancial linkages | • Each fund's sensitivity is estimated based on the observed relationship between fund flows and a CAPM model-derived measure of "alpha," or fund outperformance relative to a benchmark. | N/A |

| Domain | | Assumptions | |
|---|---|---|---|
| | | **Top-Down by Bank of Canada (BOC)** | **Top-Down by FSAP Team** |
| 2. Channels of risk propagation | Satellite models for macrofinancial linkages | • The resulting price impact on corporate bonds is estimated as a function of the balance sheet constraints and market conditions faced by broker-dealers and leveraged investors. | |
| | Stress test horizon | N/A | |
| 3. Tail shocks | Scenario analysis | • A parallel increase in the yield curve by 100 basis points | • Two exogenous redemption shocks are calibrated at the fund-level using the first percentile of the historical distribution of monthly fund flows.<br>• The first shock is based on the distribution combining all funds of a given investment mandate (i.e., fixed-income and balanced).<br>• The second shock is based on the distribution of each individual fund. |
| | Sensitivity analysis | • N/A | |
| 4. Risks and buffers | Risks/factors assessed (how each element is derived, assumptions) | • Market risk affects performance of mutual funds, which in turn creates liquidity risk that entails bond sales. Then, performance of mutual funds is affected by resulting bond sales. | |
| | Behavioral adjustments | • Sales of corporate bonds and other assets resulting from redemptions are calculated through an assumption that fund managers liquidate fund assets on a pro-rata basis as well as a waterfall basis (i.e., based on the liquidity hierarchy). | |
| 5. Regulatory and market-based standards and parameters | Calibration of risk parameters | • Fund-level redemptions are calibrated based on the fund-level sensitivity of net fund flows to fund performance. | |
| | Regulatory/accounting and market-based standards | • N/A | |
| 6. Reporting format for results | Output presentation | • Amount of forced corporate bond sales, relative to outstanding amounts of bonds and trading volumes by bond types<br>• Resulting price impact on corporate bonds | • Amount of forced corporate bond sales, relative to outstanding amounts of bonds and trading volumes by bond types |

# Appendix III. Credit Risk Satellite Models

**1. A series of econometric models were estimated to produce scenario dependent forward paths for point-in-time (PiT) probabilities of default (PDs) for the different exposure segments.** The selection of the modelling approach was largely driven by the availability of historical data for calibration purposes. Due to the very low default rates in the domestic market, obtaining reliable and informative historical time series on most of the segments is a challenging task. This is because any approach that would back out default rates from impairment flows might suffer from the presence of significant outliers; individual exposure impairments or random write-off decisions might have a significant impact on the inferred historical PD rates.

**Corporate Segments**

**2. In order to enhance robustness, the modelling of PD PiT satellites for corporate segments was based on historical default rates data obtained by a third-party provider.**[1] Separate models were estimated for the two main geographies (Canada and the United States); the U.S. models were also used as a proxy for the ROW segments. Some bridging was needed because of differences in the industries covered by the third-party provider and the exact segments that were used for stress testing purposes; a mapping that used weighted combinations of the provider segments for each of the industry-based starting-point exposures was used. For those segments that could not be proxied by a relatively accurate mapping by industry, the generic corporate satellite model was used as a proxy.[2]

**3. A Bayesian Model Averaging (BMA) econometric technique and the relevant infrastructure was employed for modelling and projecting the default rate at the individual geography and portfolio levels.** The BMA approach operates with a pool of equations (several hundreds or thousands) per dependent variable, to which weights are assigned that reflect their relative predictive performance, which then results in a "posterior model" equation.[3] The pool of equations contains a large number of equations for every single credit risk indicator (per portfolio segment and geography), by considering all possible combinations of predictors from a pool of potential predictor variables, including variables such as real GDP, investment, consumption, exports, price inflation, and short- and long-term interest rates.

**4. Various techniques were used to capture PD dynamics.** To ensure that the models only produce PD predictions between 0 and 1 (or, equivalently, between 0 and 100 percent) and to

[1] Historical default rates from Moody's Analytics Creditedge were used to obtain historical series for all segments considered.

[2] In total, models for 10 industrial segments were estimated for Canada and 15 industrial segments for the U.S. After applying the necessary segment mapping between basic and composite segments, forward path estimates for the 11 active corporate industrial segments were obtained for all geographies.

[3] See Gross and Población (2017). The methodology that has been employed to develop the models is known as a Bayesian Averaging of Classical Estimates (BACE) method; see Sala-I-Martin, Doppelhofer, and Miller (2004).

capture nonlinearities in the relationship between the dependent and explanatory variables, the following logit transformation was applied to the original PD:

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

To estimate the impact of shocks of macrofinancial variables on PDs, the logit-transformed PDs were modeled as a linear function of the aforementioned exogenous macroeconomic and financial factors (regressors). The model specification also allows inclusion of the autoregressive lags as well as lags of the explanatory variables, to account for the backward-looking nature of credit risks.

The conditional PD PiT forecast for each segment estimated by the model were then attached to the starting point of bank PDs in logistic space to generate full path under both the baseline and adverse scenarios.

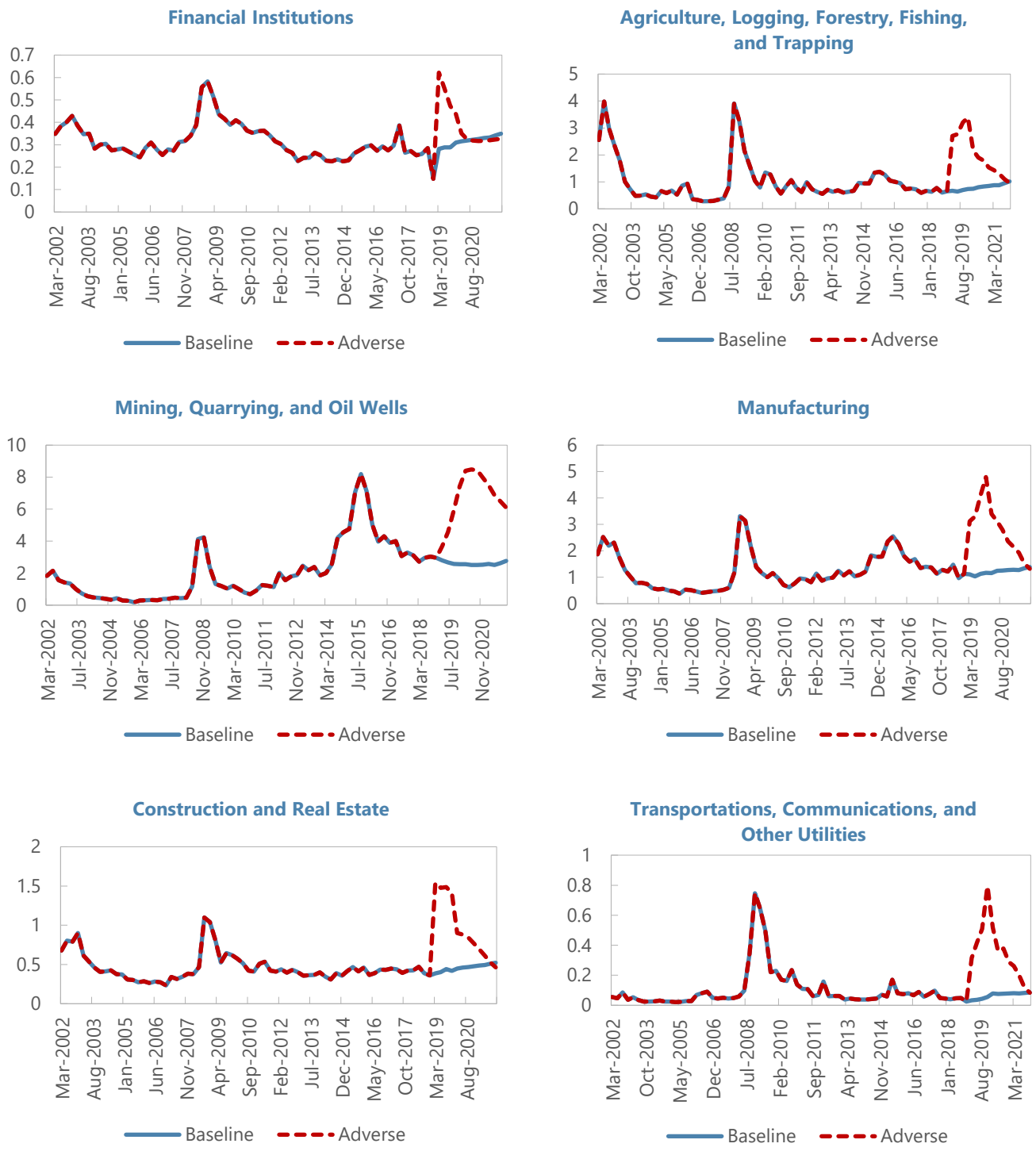
**5. A wide set of explanatory variables were used for the estimation of credit risk satellite models.** For both domestic and foreign credit exposures (mainly U.S.), similar set of input variables were used to explain and project PD PiTs for all segments, such as real GDP, investment, inflation, unemployment rate, short-term and long-term interest rate spread, equity prices, as well as private credit by sectors. For real estate and construction PD models, however, housing price was included as an add-on factor to capture the potential impact of a housing bubble (and the subsequent collapsing of the housing market) on the credit quality of existing mortgage portfolios. Inputs other than interest rates are subject to quarterly growth transformation, and interest rates and the unemployment rate were taken as percentage point changes between periods. The sample period used for calibration ranges between 2000 and 2018, and a quarterly frequency was used in accordance with standard method.

**6. The model selection for the BMA follows several criteria.** A unique benefit of the BMA approach is for the users to select different model specifications, such as the number of autoregressive lags, number of explanatory variables under permutation, and number of lags for each explanatory variable. Staff used the following five information criteria to determine the best specification for each model: R-square, the Durbin Watson statistics, number of significant variables with high posterior inclusion probability, the quality of in-sample forecast, and ultimately, the size of the impact in the forecasting period. The ideal candidate would have a relatively high R-square, a Durbin Watson statistic between 1.5 to 2.5, a small root-mean-square-error, and a historically consistent size of impact under stress.

**7. The scenario dependent PD projections are broadly in line with historical stress episodes** (Figure III.1 for Canada and Figure III.2 for the U.S.). This is reflected in the forward-looking PD paths for both Canada and the U.S., in which the size of impact for Canada is in line with the stress experienced during the GFC, while that for the U.S. is consistent with both the level experienced during the GFC and the Dot-com bubble. Nonetheless, the results display salient idiosyncrasies among segments, with the highest PDs under stress assigned to energy related sectors (mining, etc.) and the lowest PDs to communication, transportation, and other utilities.

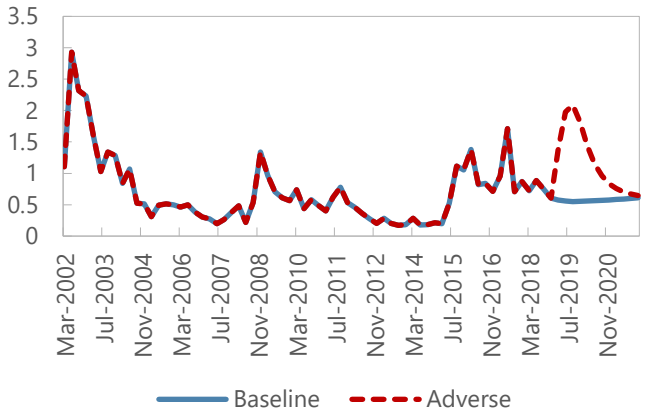
**8. Investment, unemployment rate, equity returns, and credit-related measures play significant roles in the determination of underlying credit risks.** This is reflected in the high posterior inclusion probability and sizable long run multiplier estimate (i.e., coefficients for both the contemporaneous and lagged terms for the independent variables) for the corporate segment PDs in both geographies. Variables related to long-term and short-term interest rate spreads seem to weigh more in the determination of U.S.-based corporate PDs, and volatility in housing prices proves to influence considerably the financial resilience in real-estate and construction segments. (Table III.1 and Table III.2)

**Figure III.1. Canada: PD PiT Models for Corporates**
(In percent)

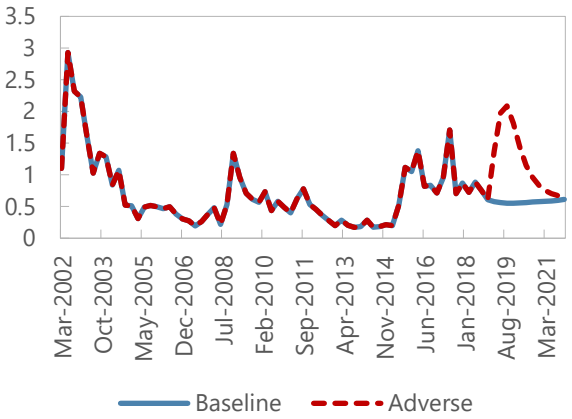


## Figure III.1. Canada: PD PiT Models for Corporates (concluded)

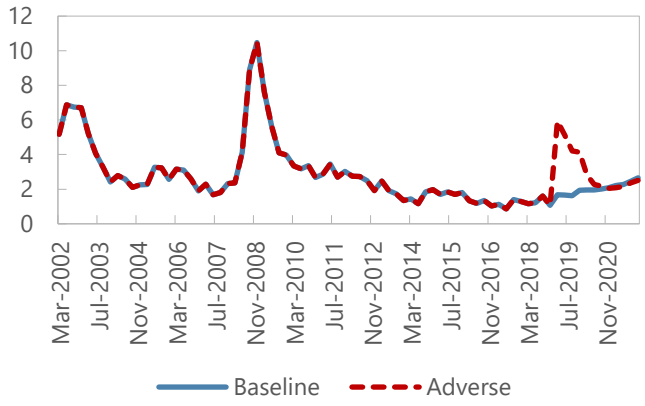
### Wholesale Trade



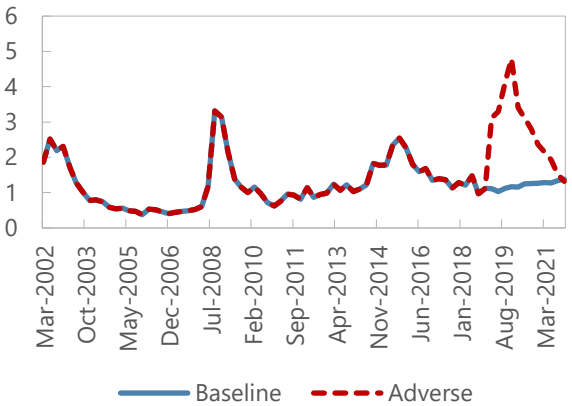

### Retail Trade




### Services




### Non-residential Mortgages




### Other Business Loans

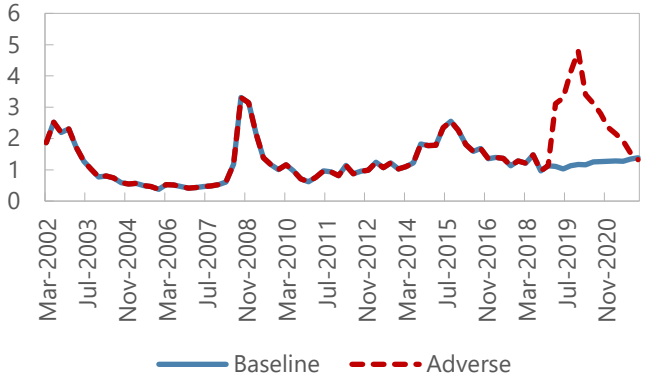
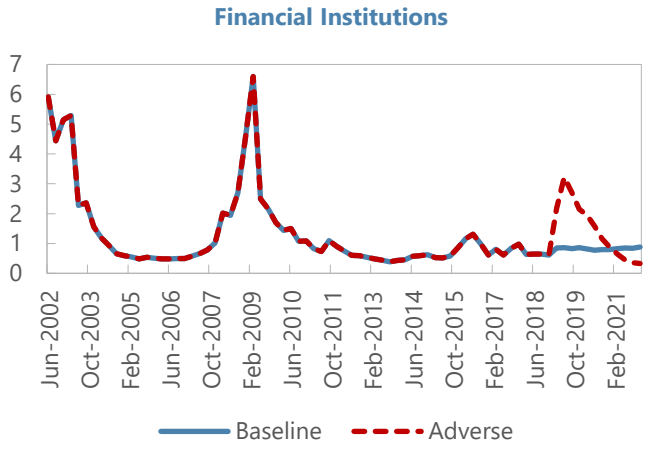
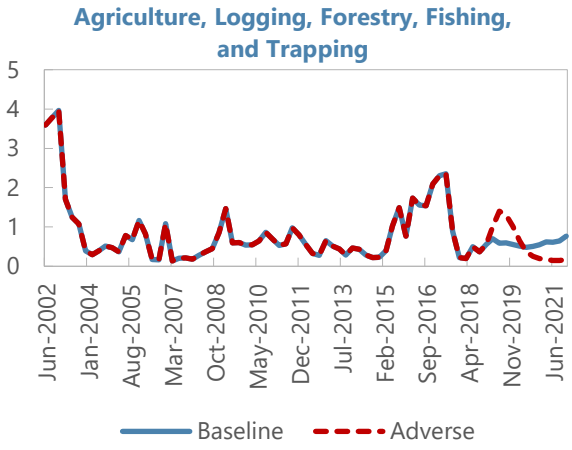
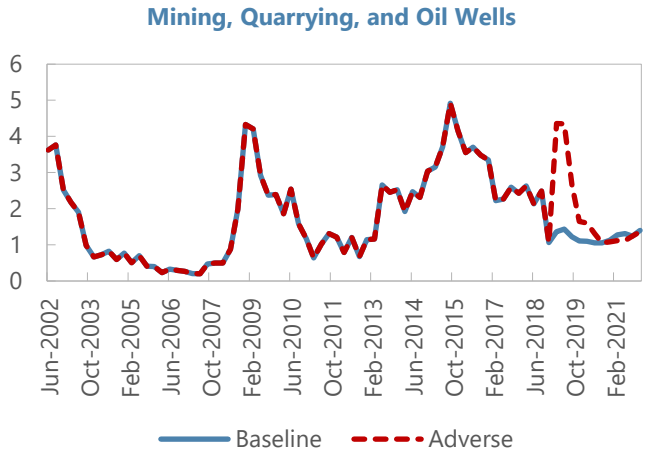
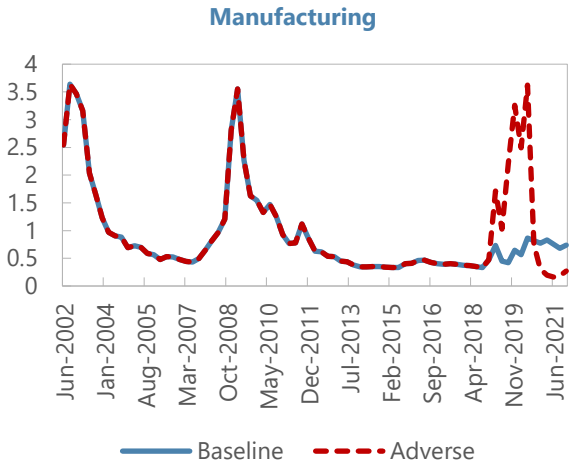


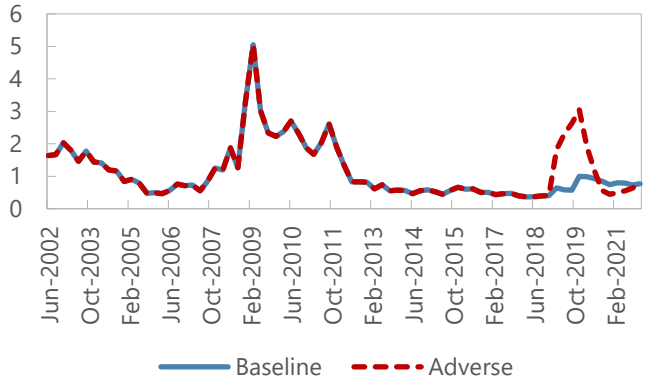
**Figure III.2. United States: PD PiT Models for Corporates**
(In percent)



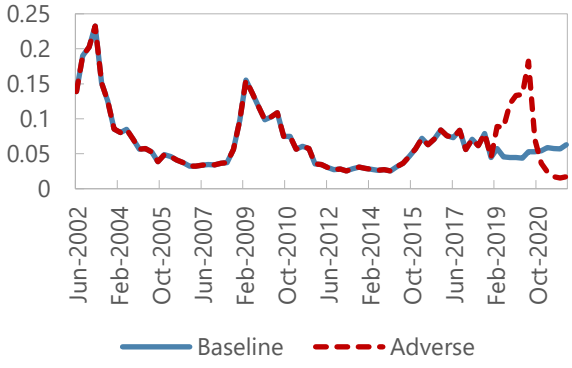



**Figure III.2. United States: PD PiT Models for Corporates (concluded)**

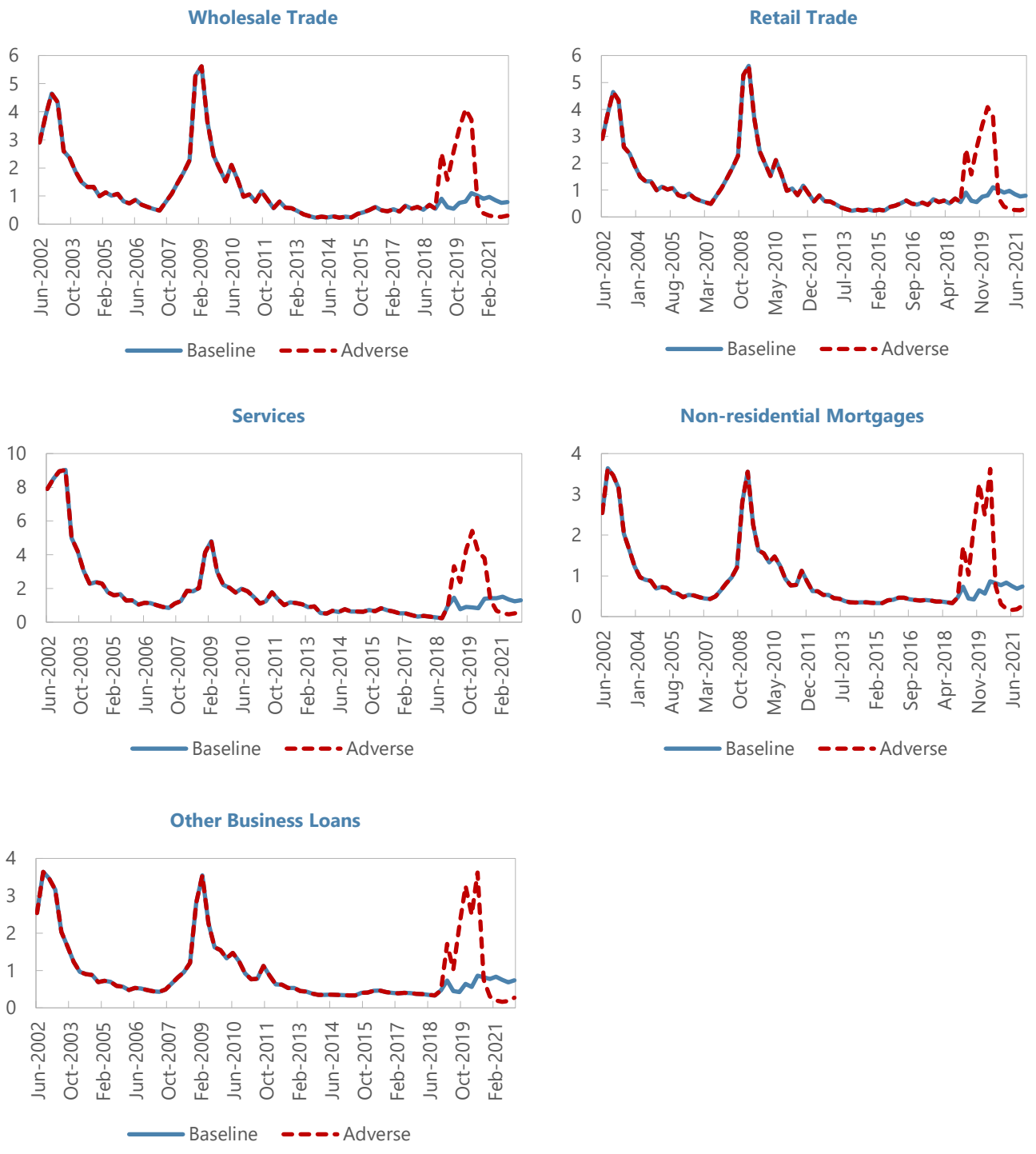


**Table III.1. Canada: Estimation of the Corporate Credit Risk Satellite Model**

Equation estimates for default rates by portfolio (normalized long-run multipliers)

(Dependent variable: Moody's EDF)

| | Canada group | Financials group | Lumber & forestry group | Mining group | Oil, gas & coal expl/prod group |
|---|---|---|---|---|---|
| | Normalized posterior long-run multiplier with sign restriction | | | | |
| Real GDP growth, qoq | 0 | -0.02 | -0.03 | 0 | 0 |
| Real GDP growth, yoy | 0 | -0.02 | 0 | 0 | 0 |
| Real investment growth, qoq | -0.02 | -0.02 | -0.07* | -0.01 | -0.08* |
| Real investment growth, yoy | -0.38* | 0 | 0 | 0 | 0 |
| Inflation, qoq | 0 | 0 | 0 | 0 | 0 |
| Inflation, yoy | 0 | 0 | 0 | -0.01* | 0 |
| Unemployment rate, percent | 0 | 0 | 0.01 | 0 | 0 |
| Unemployment rate, percentage point change, qoq | 0 | 0.18* | 0.02 | 0.01 | 0 |
| Unemployment rate, percentage point change, yoy | 0 | 0.04* | 0.01 | 0 | 0 |
| Long term sovereign yield spread against U.S., percent | 0 | 0 | 0.02 | 0 | 0 |
| Short term interest rate spread against policy rate, percent | 0 | 0 | 0 | 0 | 0 |
| Equity indices, percentage change, qoq | -0.2* | -0.36* | -0.19* | 0 | -0.18* |
| Equity indices, percentage change, yoy | -0.21* | -0.03 | -0.09* | -0.01 | 0 |
| Credit to household, percentage change, qoq | 0 | 0 | 0 | -0.79* | -0.21* |
| Credit to household, percentage change, yoy | -0.16* | 0 | 0 | -0.03 | -0.22* |
| Credit to corporate, percentage change, qoq | 0 | -0.05 | -0.11* | 0 | 0 |
| Credit to corporate, percentage change, yoy | 0 | -0.59* | -0.57* | 0 | 0 |
| Total private credit, percentage change, qoq | -0.01 | 0 | 0 | 0 | 0 |
| Total private credit, percentage change, yoy | -0.04* | 0 | 0 | 0 | 0 |
| Housing price, percentage change, qoq | | 0 | | | |
| Housing price, percentage change, yoy | | -0.01 | | | |
| R square | 0.64 | 0.64 | 0.56 | 0.93 | 0.90 |
| Durbin Watson | 0.82 | 0.91 | 0.71 | 1.82 | 1.56 |
| Number of lags of independent variables | 2 | 2 | 2 | 2 | 2 |
| Number of observation | 66 | 66 | 66 | 66 | 66 |

## Table III.1. Canada: Estimation of the Corporate Credit Risk Satellite Model (concluded)

| | Construction & real estate development group | Utilities group | Consumer products retail/wholesale group | Business services group | Consumer durables and services group |
|---|---|---|---|---|---|
| | Normalized posterior long-run multiplier with sign restriction | | | | |
| Real GDP growth, qoq | 0 | -0.05* | 0 | -0.02 | -0.04* |
| Real GDP growth, yoy | -0.05 | -0.66* | -0.02 | 0 | -0.01 |
| Real investment growth, qoq | 0 | -0.03 | 0 | -0.02 | -0.01 |
| Real investment growth, yoy | -0.31* | 0 | -0.04 | 0 | 0 |
| Inflation, qoq | 0 | 0 | 0 | 0 | 0 |
| Inflation, yoy | 0 | 0 | 0 | 0 | 0 |
| Unemployment rate, percent | 0 | 0 | 0 | 0 | 0 |
| Unemployment rate, percentage point change, qoq | 0 | 0.06* | 0.07 | 0.03 | 0.21* |
| Unemployment rate, percentage point change, yoy | 0.02 | 0.13* | 0.01 | 0.03* | 0.1* |
| Long term sovereign yield spread against US, percent | 0.07 | 0 | 0 | 0.63* | 0 |
| Short term interest rate spread against policy rate, percent | 0 | 0 | 0.05 | 0 | 0 |
| Equity indices, percentage change, qoq | -0.46* | -0.25* | -1.03* | -0.3* | -0.06* |
| Equity indices, percentage change, yoy | -0.01 | -0.02* | 0 | -0.01 | 0 |
| Credit to household, percentage change, qoq | 0 | 0 | 0 | 0 | 0 |
| Credit to household, percentage change, yoy | 0 | -0.01* | 0 | 0 | 0 |
| Credit to corporate, percentage change, qoq | -0.02 | 0 | -0.08 | -0.1* | -0.04 |
| Credit to corporate, percentage change, yoy | -0.44* | 0 | -0.14* | -0.04* | -0.38* |
| Total private credit, percentage change, qoq | 0 | 0 | -0.01 | 0 | 0 |
| Total private credit, percentage change, yoy | 0 | 0 | -0.02 | 0 | 0 |
| Housing price, percentage change, qoq | 0 | | | | |
| Housing price, percentage change, yoy | -0.16* | | | | |
| R square | 0.71 | 0.67 | 0.77 | 0.65 | 0.38 |
| DW | 1.50 | 1.12 | 2.22 | 0.92 | 0.25 |
| Number of lags of independent variables | 2 | 2 | 2 | 2 | 2 |
| Number of observation | 66 | 66 | 66 | 66 | 66 |

Notes:
1: * Denotes a higher posterior inclusion probability than the prior inclusion probability, which indicates variable statistical significance.
2: For various portfolio segments presented here, the equations do contain lags of either the dependent variable or the exogenous right-hand-side variables (beyond their contemporaneous inclusion), or both.
3: A long-run multiplier is defined as the sum of all coefficients of a given right-hand-side variable on its contemporaneous and lagged terms. The long-run multiplier is normalized, moreover, by multiplying it by the ratio of the standard deviation of the left-hand-side and the respective right-hand-side variable that is concerned.
4: The normalized long-run multiplier is interpreted as follows: a one-standard-deviation change in the concerned right-hand-side variable induces the normalized multiplier times the historical standard deviation of the left-hand-side variable. Note that the default rates on the left-hand side have been included in the equation in logit format. The normalized multipliers can be compared across variables and equations.
Source: IMF staff calculations.

## Table III.2. United States: Estimation of the Corporate Credit Risk Satellite Model

(Dependent variable: Moody's EDF)

| | U.S. group | Lumber & forestry group | Mining group | Oil refining group | Real estate group | Utilities, electric group | Utilities, gas group |
|---|---|---|---|---|---|---|---|
| | Normalized posterior long-run multiplier with sign restriction | | | | | | |
| Real GDP growth, qoq | 0 | -0.01 | 0 | -0.01 | -0.01 | 0 | 0 |
| Real GDP growth, yoy | 0 | -0.07 | 0 | 0 | 0 | 0 | 0 |
| Real investment growth, qoq | 0 | 0 | 0 | 0 | -0.02 | 0 | 0 |
| Real investment growth, yoy | 0 | -0.45* | 0 | -0.35* | 0 | -0.02* | -0.29* |
| Inflation, qoq | 0 | 0 | -0.04 | 0 | 0 | 0 | 0 |
| Inflation, yoy | 0 | 0 | -0.38* | 0 | 0 | 0 | 0 |
| Unemployment rate, percent | 0 | 0.11* | 0 | 0 | 0.06* | 0 | 0 |
| Unemployment rate, percentage point change, qoq | 0 | 0.02 | 0 | 0.29* | 0.17* | 0.15* | 0.02 |
| Unemployment rate, percentage point change, yoy | 0.58* | 0.05 | 0 | 0.22* | 0.16* | 0.22* | 0.2* |
| Long term sovereign yield spread against U.S.swap, percent | 0 | 0 | 0.24* | 0.55* | 0 | 0 | 0.66* |
| Short term interest rate spread against policy rate, percent | 0 | 0 | 0.13* | 0.02* | 0 | 0 | 0.14* |
| Equity indices, percentage change, qoq | -0.48* | -1.08* | -0.11* | -0.05* | -0.12* | -0.01 | -0.01 |
| Equity indices, percentage change, yoy | -0.67* | 0 | -0.03 | -0.01 | -0.06* | -0.68* | -0.02 |
| Credit to household, percentage change, qoq | 0 | -0.01 | 0 | 0 | 0 | 0 | 0 |
| Credit to household, percentage change, yoy | 0 | 0 | -0.22* | 0 | 0 | 0 | 0 |
| Credit to corporate, percentage change, qoq | 0 | -0.02 | 0 | -0.02 | 0 | -0.01 | 0 |
| Credit to corporate, percentage change, yoy | -0.29* | -0.06 | 0 | 0 | -0.58* | -0.18* | 0 |
| Total private credit, percentage change, qoq | 0 | -0.01 | 0 | 0 | 0 | 0 | 0 |
| Total private credit, percentage change, yoy | 0 | -0.01 | 0 | 0 | 0 | 0 | 0 |
| Housing price, percentage change, qoq | | | | | -0.04 | | |
| Housing price, percentage change, yoy | | | | | -0.3* | | |
| R square | 0.89 | 0.88 | 0.63 | 0.85 | 0.84 | 0.66 | 0.60 |
| Durbin Watson | 0.64 | 2.05 | 0.55 | 1.14 | 0.79 | 0.30 | 0.36 |
| Number of lags of independent variables | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Number of observation | 66 | 66 | 66 | 66 | 66 | 66 | 66 |

## Table III.2. United States: Estimation of the Corporate Credit Risk Satellite Model (concluded)

| | Agriculture group | Business products wholesale group | Business services group | Construction group | Consumer durables retail/wholesale group | Consumer products retail/wholesale group | Consumer services group | Finance companies group |
|---|---|---|---|---|---|---|---|---|
| | Normalized posterior long-run multiplier with sign restriction | | | | | | | |
| Real GDP growth, qoq | 0 | 0 | 0 | 0 | 0 | -0.02 | 0 | 0 |
| Real GDP growth, yoy | 0 | 0 | 0 | 0 | 0 | -0.03 | 0 | 0 |
| Real investment growth, qoq | 0 | 0 | 0 | 0 | 0 | -0.05 | 0 | 0 |
| Real investment growth, yoy | 0 | -0.01 | -0.04 | -0.01 | 0 | -0.18* | 0 | -0.31* |
| Inflation, qoq | -0.02 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Inflation, yoy | -0.01 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Unemployment rate, percent | 0 | 0 | 0 | 0.08* | 0 | 0 | 0.03 | 0 |
| Unemployment rate, percentage point change, qoq | 0 | 0.25* | 0.09* | 0 | 0.05 | 0.02 | 0.01 | 0.08* |
| Unemployment rate, percentage point change, yoy | 0 | 0.3* | 0.29* | 0.78* | 0.81* | 0.08 | 0 | 0.02 |
| Long term sovereign yield spread against U.S. swap, percent | 0.41* | 0 | 0 | 0 | 0 | 0.01 | 0 | 0 |
| Short term interest rate spread against policy rate, percent | 0 | 0 | 0 | 0 | 0 | 0.05 | 0 | 0 |
| Equity indices, percentage change, qoq | -0.01 | -0.09* | -0.03* | -0.45* | -0.29* | -1.58* | -0.1* | -0.42* |
| Equity indices, percentage change, yoy | -0.21* | -0.55* | -0.58* | -0.02 | -0.57* | 0 | -0.64* | -0.62* |
| Credit to household, percentage change, qoq | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Credit to household, percentage change, yoy | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Credit to corporate, percentage change, qoq | 0 | 0 | 0 | 0 | 0 | -0.01 | -0.01 | 0 |
| Credit to corporate, percentage change, yoy | -0.01 | -0.1* | -0.02 | -0.35* | -0.11* | -0.01* | -0.6* | 0 |
| Total private credit, percentage change, qoq | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total private credit, percentage change, yoy | -0.01 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Housing price, percentage change, qoq | | | | -0.06* | | | | |
| Housing price, percentage change, yoy | | | | -0.06* | | | | |
| R square | 0.30 | 0.67 | 0.57 | 0.81 | 0.81 | 0.91 | 0.61 | 0.86 |
| Durbin Watson | 0.91 | 0.29 | 0.19 | 0.81 | 0.77 | 2.18 | 0.42 | 0.83 |
| Number of lags of independent variables | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Number of observation | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 |

Notes:
1: * Denotes a higher posterior inclusion probability than the prior inclusion probabilities, which indicates variable statistical significance.
2: For various portfolio segments presented here, the equations do contain lags of either the dependent variable or the exogenous right-hand-side variables (beyond their contemporaneous inclusion) or both.
3: A long-run multiplier is defined as the sum of all coefficients of a given right-hand-side variable on its contemporaneous and lagged terms. The long-run multiplier is normalized, moreover, by multiplying it by the ratio of the standard deviation of the left-hand-side and the respective right-hand-side variable that is concerned.
4: The normalized long-run multiplier in interpreted as follows: a one-standard-deviation change in the concerned right-hand-side variable induces the normalized multiplier times the historical standard deviation of the left-hand-side variable. Note that the default rates on the left-hand side have been included in the equation in logit format. The normalized multipliers can be compared across variables and equations.
Source: IMF staff calculations.

**Consumer Loans**

**9. There is very limited historical data available for modelling of consumer loans PD PiTs based on regulatory returns.** Due to the remarkably low default (or delinquency) rates, any impairment flow-based method of deducing historical PD PiTs by banks suffers from being severely distorted by one-off events (e.g., bulk recognitions of impairments or write-offs). Econometric models based on such time series were not robust enough, and the projected paths for the two scenarios were relatively unstable and sometimes counterintuitive. A consumer model proxy was developed based on the relatively longer public time series data of the Canadian Bankers Association on credit card delinquencies and loss rates.[1] Given limited disclosure on the components of loss rates, a LGD of 90 percent was used to back out the historical PDs for the respective segment. To preserve degree of freedom provided by a small sample, only the minimum and the most relevant explanatory variables were chosen to project the scenario-based credit card PDs (e.g., the unemployment rate and short-term interest rate spreads).[2]

**10. Our small satellite econometric model was applied to credit cards after checking for consistency of the output with historically observed default rates.** This model served also as proxy for the consumer credit segment using a 60 percent scaling factor on the PD PiT forward path to reflect the lower sensitivity of this segment to economic downturns. In the absence of counterfactual evidence, the same PD PiT forward paths were used for all banks (for each consumer exposure segment), assuming that there are no major differences in terms of credit quality characteristics across banks.

**11. The unemployment rate appears most relevant in explaining the movement in consumer PDs (Table III.3).** Although both variables contribute positively to the rise in consumer PDs, the unemployment rate plays a more significant role, as evidenced by a larger coefficient and high t statistic. The result coincides with the hypothesis that labor market conditions are closely associated with the level of disposable income and repayment capacity of borrowers. The sharp increase in both the unemployment rate and the short-term spread under the adverse scenario also resulted in a more pronounced forward-looking PD path than the one observed during the global financial crisis (6.3 percent under the adverse vs 5.3 percent under the GFC; Figure III.3).

**Loss Given Default Modelling**

**12. The projection of PiT LGDs for the two scenarios were based on the regulatory (downturn) LGDs for each AIRB segment**. Given that historical LGD data series were not available, LGD proxies were used for the LGD PiTs under the baseline and adverse scenarios for corporate and consumer credit segments. Under the baseline, the PiT LGD was assumed to be 80 percent of the downturn LGD for the entire scenario horizon. In the adverse scenario, a LGD PiT was assumed that was 10 percent higher than the downturn LGD, and capped at the value of 95 percent For the

[1] The data series can be found at CBA.

[2] A simple OLS estimator is deemed appropriate in this context, given the limited sample and a small number of explanatory variables included in the model.

mortgage-related segments, the structural model deployed also projected as a separate LGD PiT path for each scenario.

**Table III.3. Canada: Estimation of the Consumer Loan Credit Risk Satellite Model by OLS Estimator**

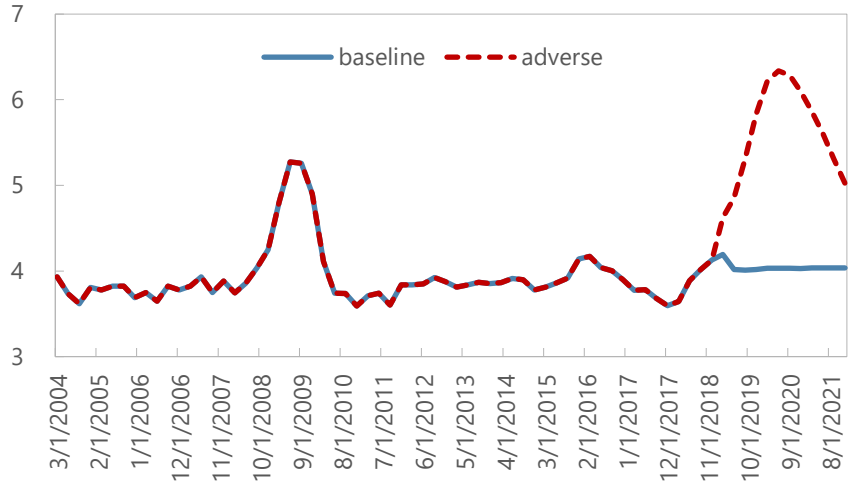
(Dependent variable: Year-on-year change in the HH NPL ratio)

| | |
|---|---|
| Unemployment rate, percentage point change, yoy | 0.124*** |
| | (3.850) |
| Short term interest spread, percent | 0.092 |
| | (0.390) |
| Constant | -3.218*** |
| | (-43.80) |
| R-square | 0.254 |
| # of observations | 58 |

Source: IMF staff calculations.
t-statistics in parentheses
* Denote significance at the 10 percent level, ** at the 5 percent level, and *** at the 1 percent level

**Figure III.3. Canada: Probability of Default—Credit Cards**

(In percent)




Source: IMF staff calculations.

# Appendix IV. A Structural Model for Mortgage Defaults

**1. Historical default time series on mortgage exposures are heavily skewed towards the zero level since Canada has never experienced a severe housing market crisis.** Steadily increasing house prices may have entirely masked a significant number of default events, since even under distress, mortgage borrowers would have sold their properties in the market for a higher price than the loan value and would have realized the positive equity generated by rising prices and amortization effects. The adverse macro scenario on the other hand, projects a quite severe set of shocks for macroeconomic variables—mortgage interest rates, unemployment rates, house prices, and inflation prices—that could drive mortgage defaults to significantly higher levels. Hence, pure econometric modelling on historical data may not be an optimal method to capture the non-linear nature of mortgage defaults in a market that has not experienced any significant downturns.

**2. A structural model for capturing mortgage defaults was the preferred modelling option for the Canada FSAP.** The model takes into account household affordability conditions and their changes in accordance with the scenario path. House price shocks and household behavioral assumptions are also used to estimate scenario-dependent default rates and loss rates. The approach is based on the approach described in the TUI model[1] first introduced by the Reserve Bank of New Zealand and has been used, with some additional adaptations for each specific case, in several FSAP missions.[2] The model was further enhanced with the use of household survey microdata that enable the integration of an additional layer that captures behavioral reactions from borrowers[3] and also captures the Canada-specific two-layer structure of mortgage insurance.

**3. The specific FSAP model implementation made extensive use of household microdata obtained from the National Household Survey (Statistics Canada).** The household microdata from the latest wave (2016) of the survey were used to infer a joint distribution for the following variables: current DSR ratio, current LTV ratio, and current Household Liquid Wealth. An additional Mortgage Insurance Flag variable was used to capture whether the mortgage was insured. After the necessary cleaning and winsorizing, a first joint distribution was derived from the survey data set.

**4. The structural component of the model defines the probability of a household being in a stress condition.** This probability is given as a function of the change in the Debt Service Ratio (DSR) due to an interest rate change and the change in the unemployment rate in the scenario. Under the general form, this distress probability is given by the structural function:

[1] See Harrison and Mathew (2008).

[2] See, for example, IMF (2017b).

[3] This is done along the general principles described in Laliotis et al. (2019), Laliotis and Población (2016) and Gross and Población (2017), where the micro data repository is used to calibrate distributions and simulate borrower behavioral reaction elements under the application of LTV/DTI limits following the application of a macroprudential borrower-based measure.

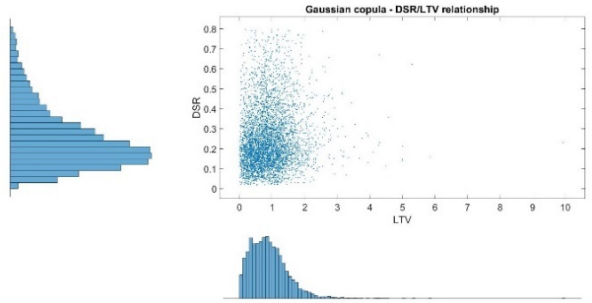
$$PSS_t = a_0 \cdot D + a_1 \cdot DSR_t^{\beta 1} + \alpha_1 \cdot \Delta DSR_t^{\beta 2} + \alpha_3 \cdot \left(\alpha_4 \cdot u_t + \alpha_5 \cdot (\Delta u_t)^{\beta 3}\right) \qquad \text{(Eq.1)}$$

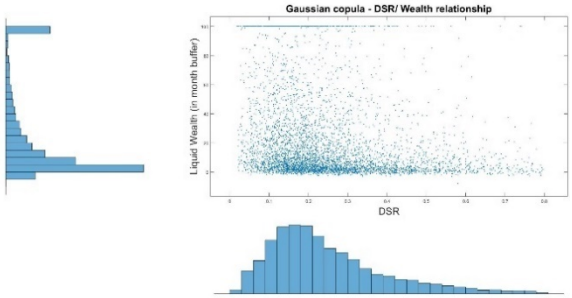
with $DSR_t$ denoting the borrower's DSR post stress, $\Delta DSR_t$ the delta in DSR vs the cut-off date, $u_t$ the unemployment rate, and $\Delta u_t$ the change in unemployment rate from the cut-off date. The equation (above) captures the borrower affordability component and how this is affected by the macro-scenario shock.[4]

**Figure IV.1 Canada: The Structural Model for Mortgage Defaults**

*The DSR distribution has a significant tail above 0.4, …*

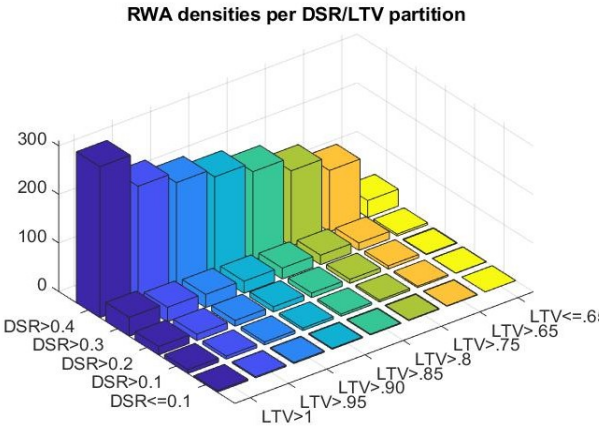
*Which is also associated with lower wealth buffers relative to the remaining distribution.*

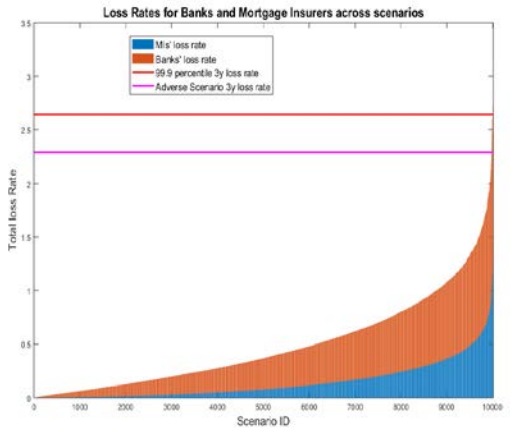



*Risky partitions are heavily penalized in terms of projected RWA density…*

*…under a scenario that is quite severe for both mortgage insurers and banks.*

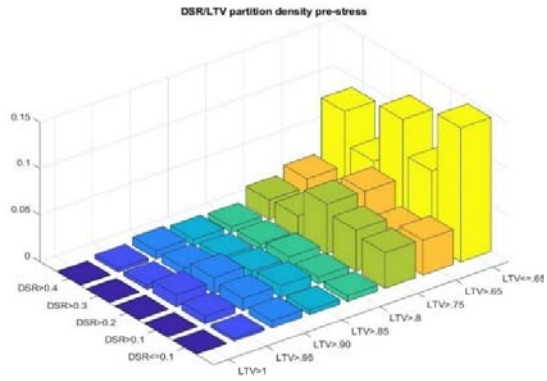


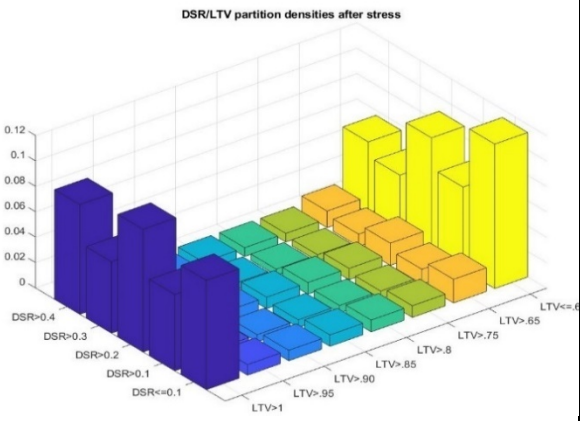

[4] The original TUI model (Harrison and Mathew, 2008) was slightly adapted with the introduction of a DSR ending-level term (second term of Eq 1) to also account for potential defaults of high-risk borrowers (households with high DSRs should go through the default test).

**Figure IV.1 Canada: The Structural Model for Mortgage Defaults (concluded)**

*The initial system-wide distribution appears to be concentrated on the safe partitions, …*




*…but the magnitude of the shock in the adverse scenario reveals a challenging post-stress reality.*




Sources: IMF staff estimates.

**5. Additional conditions need to be met in order to assume that a mortgage exposure reaches default.** At a second stage, default occurs only when the household is in distress (post first stage), the household's Liquid Wealth is not enough to cover servicing needs, and the value of the loan is higher than the value of the collateral (negative equity condition is a prerequisite for default). Therefore, default occurs only if the post-stress LTV is higher than 1 and if any wealth buffers are not enough to cover the servicing needs after a distress event. Hence, under a positive house price assumption the model captures any potential masking of defaults due to price appreciation. In this positive house price scenario, an outright sale would be triggered by a borrower's distress as opposed to a default event.

Default probability is given by formula

$$PD_t = PSS_t \cdot \frac{\{\#|\tilde{V}_t - C < L \text{ and } B^t(LW_0)=0\}}{(\#iterations)}, \qquad \text{Eq.2}$$

where the first term within the brackets denotes the probability that the property value after stress $\tilde{P}_T$ minus some liquidation discount $C$ is lower than the outstanding loan notional $L$, and the second term denotes that the stochastic behavioral rule $B^t(x)$—which accounts for the use of Liquid Wealth $LW_0$ at the cut-off—has failed to save the loan from default.[5] The $\#iterations$ suggest that this outcome is the result of a significant number of Monte Carlo simulations in which any type of behavioral rules can be incorporated and any type of house price shock distributions can be modelled.

[5] In the actual calibration for the solvency ST a linear survival rule was implemented as the behavioral rule: the survival probability is linear between a wealth buffer of 8 and 36 months. Buffers below 8 months will not be sufficient to weather a default event and borrowers with wealth buffers exceeding 36 months would survive the distress event with probability 1.

**6. The conditional LGD is driven by the discounted sale price of the house.** The sale occurs at time t+s (where s denotes the average time to realize the collateral); the sale proceeds are net of transaction costs (discounted at a rate reflecting the scenario interest rate premium) and assume an additional foreclosure liquidation discount $\delta$:

$$LGD_t = 1 - \frac{(1-\delta)P_{t+s}}{L*(1+r_t+cs_t)^s} \qquad \text{Eq.3}$$

**7. The joint distribution is partitioned along the DSR and LTV dimensions.** Using LTV partitioning values of 1, 0.95, 0.9, 0.85, 0.8, 0.75, and 0.65, and DSR partitioning values of 0.15, 0.2, 0.3, and 0.4, the first two dimensions of the household data are mapped to a 5 by 8 partitioned space. For each DSR/LTV partition a Monte Carlo simulation (on house price changes anchored to a central house price shock) is used to produce model-based projections on average PDs and LGDs. A portfolio average PD (or LGD) would correspond to the weighted average of the projected PDs (LGDs) per DSR/LTV density partition. This means the portfolio distribution along the two dimensions (DSR and LTV) can be used to produce an overall portfolio estimate. Using the fourth dimension of the joint distribution (which refers to the insured flag), separate model projections for insured and uninsured portfolios are estimated.

**Using the Model in the Scenario's Expected Loss Mode**

**8. The system-wide DSR/LTV distribution is used to produce system-wide projections under any macro scenario.** The distribution obtained from the Household Survey data is further adjusted to reflect the aggregate current LTV distribution as reported by banks in their regular regulatory reports. In practice, this adjustment results in shifting parts of the density towards higher LTV buckets since the aggregate current LTV is slightly higher than the one reported in the survey.[6] Table IV.1 presents the results of the calibrated model for the two stress test scenarios. The results are based on the system-wide DSR/LTV distribution, adjusted to the current LTV.

**Table IV.1 Canada: Mortgage Default-Scenario Paths for Structural Model**

(In percent)

| | | PD Y1 | PD Y2 | PD Y3 | LGD Y1 | LGD Y2 | LGD Y3 | EL Y1 | EL Y2 | EL Y3 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Aggregate** | **Baseline** | 0.3 | 0.3 | 0.2 | 24.1 | 19.1 | 13.9 | 0.1 | 0.0 | 0.0 |
| | **Adverse** | 1.4 | 2.5 | 2.8 | 27.4 | 47.6 | 41.1 | 0.4 | 1.2 | 1.1 |
| **Insured only** | **Baseline** | 0.6 | 0.5 | 0.4 | 25.0 | 20.9 | 14.4 | 0.1 | 0.1 | 0.1 |
| | **Adverse** | 2.1 | 3.1 | 3.3 | 30.0 | 51.5 | 45.5 | 0.6 | 1.6 | 1.5 |
| **Uninsured only** | **Baseline** | 0.1 | 0.1 | 0.1 | 19.4 | 8.9 | 8.2 | 0.0 | 0.0 | 0.0 |
| | **Adverse** | 0.9 | 2.1 | 2.4 | 22.8 | 43.1 | 36.5 | 0.2 | 0.9 | 0.9 |

[6] Higher property values are usually reported by households in a survey mode compared to more prudent property estimates at a bank loan level.

**9. A three-year horizon is used as the core setup parameter of this mortgage default structural model.** Distressed households are measured under the assumption of a three-year horizon, and the calibration of all parameters follows this principle. Therefore, the model targets an outcome that reflects probabilities of default, loss rates, and LGDs at the end of a three-year horizon. In order to produce full parameter paths for the full three years under a specific scenario, an approximation is used: starting from year 1, each end-year macro shock is applied to the model, and the respective one-year PD and LGD values are backed out after accounting for already calculated years. For example, the second year PD is backed out using the two-year macro shocks and after accounting for the one-year PD produced by the model using the one-year scenario.

**Using the Model in the Unexpected Loss Mode—A Range of Scenarios**

**10. A further use of the model relates to the estimation of unexpected losses, thereby assessing the level of RWA densities for specific portfolios.** Under this use mode, a full range of scenarios is considered. Using the same starting point the DSR/LTV distribution of each macro scenario leads to a distinct total loss projection. If the model is run for a set of macroeconomic scenarios of substantial dimension, a Basel 99.9 quantile equivalent of the loss distribution would correspond to the Basel unexpected loss threshold or capital requirement. Hence, a capital charge can be produced based on the specific credit quality characteristics as captured by the joint distribution of the four household variables (DSR, LTV, Liquid Wealth, and indication of insurance).

**11. The structural model was also used in this capital-projecting mode to assess the level of RWAs associated with mortgage portfolios.** In this mode, the model outcome was used as a challenger for capital charges and RWA densities and guided the assessment of capital adequacy of insured and uninsured portfolios for both banks and mortgage insurers. A large number of macroeconomic scenarios were generated that included only the three variables that the model uses: interest rate shocks, unemployment changes, and house price shocks. The joint distribution of the three shocks was anchored around the mean shocks of the baseline scenario.[7] After simulating 10,000 scenarios, the distribution of losses was estimated, and the loss value corresponding to the 99.9 quantile of the distribution was used to define the unexpected losses. Table IV.2 and the third panel of Figure IV.1 present the results expressed in RWA densities for each DSR/LTV bucket.

[7] A joint normal distribution was assumed with a positive shock on interest rates with a mean of 1.1 percent, a marginal unemployment change of 0.1 percent, and a positive house price change with a mean of 4 percent. Standard deviations were set to 1, 0.5, and 15 percent, respectively. A negative correlation of -0.3 was assumed between interest rate shocks and house price shocks, and a positive correlation of 0.3 between interest rates and unemployment to reflect some needed level of conservatism and to counterbalance the positive impact of the baseline anchoring.

**Table IV.2. Canada: RWA Densities for DSR and LTV Partitions**

| | LTV>1 | LVT>0.95 | LTV>0.9 | LVT>0.85 | LTV>0.8 | LVT>0.75 | LTV>0.65 | LVT<0.65 |
|---|---|---|---|---|---|---|---|---|
| **DSR>0.4** | 310.8 | 240.9 | 219.0 | 201.4 | 182.7 | 154.9 | 126.2 | 34.7 |
| **DSR>0.3** | 38.9 | 30.1 | 27.1 | 24.9 | 22.5 | 19.6 | 15.3 | 4.0 |
| **DSR>0.2** | 17.2 | 13.1 | 12.0 | 10.6 | 9.5 | 8.2 | 6.5 | 1.6 |
| **DSR>0.15** | 8.1 | 6.5 | 6.0 | 5.2 | 4.6 | 4.0 | 3.1 | 0.7 |
| **DSR<0.15** | 3.2 | 2.5 | 2.3 | 1.9 | 1.7 | 1.5 | 1.1 | 0.2 |

**12. The two-layered structure of the Canadian mortgage market could be further analyzed using the fourth variable of the joint distribution: a flag indicating that a mortgage is insured.** Expected loss estimates for a specific scenario can be attributed to banks or insurers based on the insurance flag and the waterfall of losses. By doing so, a separate view for insured and non-insured segments on expected losses per DSR/LTV partition can be produced. In the unexpected loss mode, two distinct DSR/LTV density partitions—corresponding to insured and uninsured portfolios—were used to infer portfolio-weighted projections of RWA densities at the system-wide level. These were then compared to existing capital buffers of banks and mortgage insurers.

**13. Finally, the model was also used to assess the capital requirements that would arise if the scenario were to materialize.** The model allows for the migrations of exposures within the DSR/LTV partition table, after applying the scenario shocks. Consequently, a post-stress DSR/LTV density partition table can be directly used to project the capital needs in the post-adverse scenario period. The post-stress DSR/LTV distribution is illustrated in the fifth panel of Figure IV.1; the relevant RWA density model estimates for both types of portfolios, and for the pre- and post-adverse scenarios, are summarized in Table IV.3.

**Using the Model in the Bank-Specific Starting Point Mode**

**Table IV.3. Canada: Model-projected RWA Densities: Pre- and Post-Stress**
(In percent)

| | RWA density pre-stress | RWA density post-stress |
|---|---|---|
| **Insured** | 24.0 | 53.8 |
| **Non-insured** | 14.0 | 35.8 |
| **Aggregate** | 18.3 | 43.4 |

**14. Differences in the LTV distribution can also be used to inform bank-specific starting points**. In a similar mode with the one described above, one can use the bank-specific DSR/LTV distribution to project scenario-specific forward paths. The bank-specific weights across the 5 by 8 DSR/LTV partitions are used to produce a bank weighted PD and loss-rate projection; this reflects

the idiosyncratic credit properties of individual bank portfolios. This approach captures, in relative terms, the different credit quality characteristics of the mortgage portfolios at the bank level.

**15. As a further extension, a more granular approach that takes into account the regional concentration of those mortgage portfolios has also been developed.**[1] A fifth variable that captures the regional/provincial dimension of the household survey data was used to generate a number of different DSR/LTV distributions at the provincial level. Based on data obtained from regulatory reporting on the regional concentration of exposures, DSR/LTV distributions were combined with a modified adverse scenario where house price shocks at the regional level were produced. The estimation of house price shocks across provinces, the house-price-at-risk (HaR) methodology, or any other similar technique able to produce regional projections can be used.

**Model Assessment**

**16. The structural model for mortgage exposures provides a reasonable alternative for the projection of economic loss events that may have rarely (if ever) occurred in many jurisdictions.** The structural model manages to efficiently capture the masking of historical default events due to rising house prices. It seems to produce some intuitively reliable estimates on loss-rate projections and on the driving factors that these losses can be attributed to.

**17. Results are largely consistent with stressed PD forecasts based on econometric models for other countries.** Under the adverse scenario, cumulative three-year PDs for the entire market reach 6.7 percent. This market-wide three-year PD can be further decomposed to a cumulative PD of 8.5 percent for the insure part of the market and a three-year PD of 5.3 percent for uninsured mortgages. Under the baseline, the model projected a cumulative three-year PD of 0.8 percent, which is also consistent with the observed default rates in the current benign macroeconomic environment.

**18. The model proves to be quite versatile and relatively easy to adjust.** A whole range of behavioral rules, some of which can be based on satellite models of any type, can be easily integrated in the basic concept. Moreover, the level of granularity can be adjusted to capture the idiosyncratic components of specific portfolios at the desired level of granularity (or to the extent that the available data allows). Even more importantly the different modes of use (scenario specific, capital charge mode, bank specific mode) offer a wide range of possible usage in analyzing and challenging the outcomes of bank internal models. They also provide a consistent and powerful way to enable some sensitivity analysis in a manner that does not require huge computational effort. Finally, and since the approach is orthogonal to traditional econometric modelling techniques, it could be used to fill significant analytical gaps in countries where historical episodes of distress are rare or complement the analysis in countries where a classical calibration is indeed possible.

[1] This line of work is of exploratory nature and was not incorporated in the solvency ST exercise; scenario projections did not contain any domestic geographical breakdown. It is referenced here as an indicative example of how the authorities could incorporate relatively simple modelling techniques in order to reflect and incorporate bank specificities in their modelling framework, as recommended in Para. 55.

# Appendix V. Net Interest Income Satellite Models

Due to data reporting issues for certain banks, the estimation of interest rate models was based on banking system aggregated interest rate data, for both asset and liabilities, weighted by total outstanding amounts for each respective segment per bank. Interest rates entered the BMA estimation toolkit in levels without any binding constraints.

Bank-specific starting points and their respective deviation from system-wide aggregates were used to inform the system-level satellite model projections and produce bank-specific interest rate forward paths.

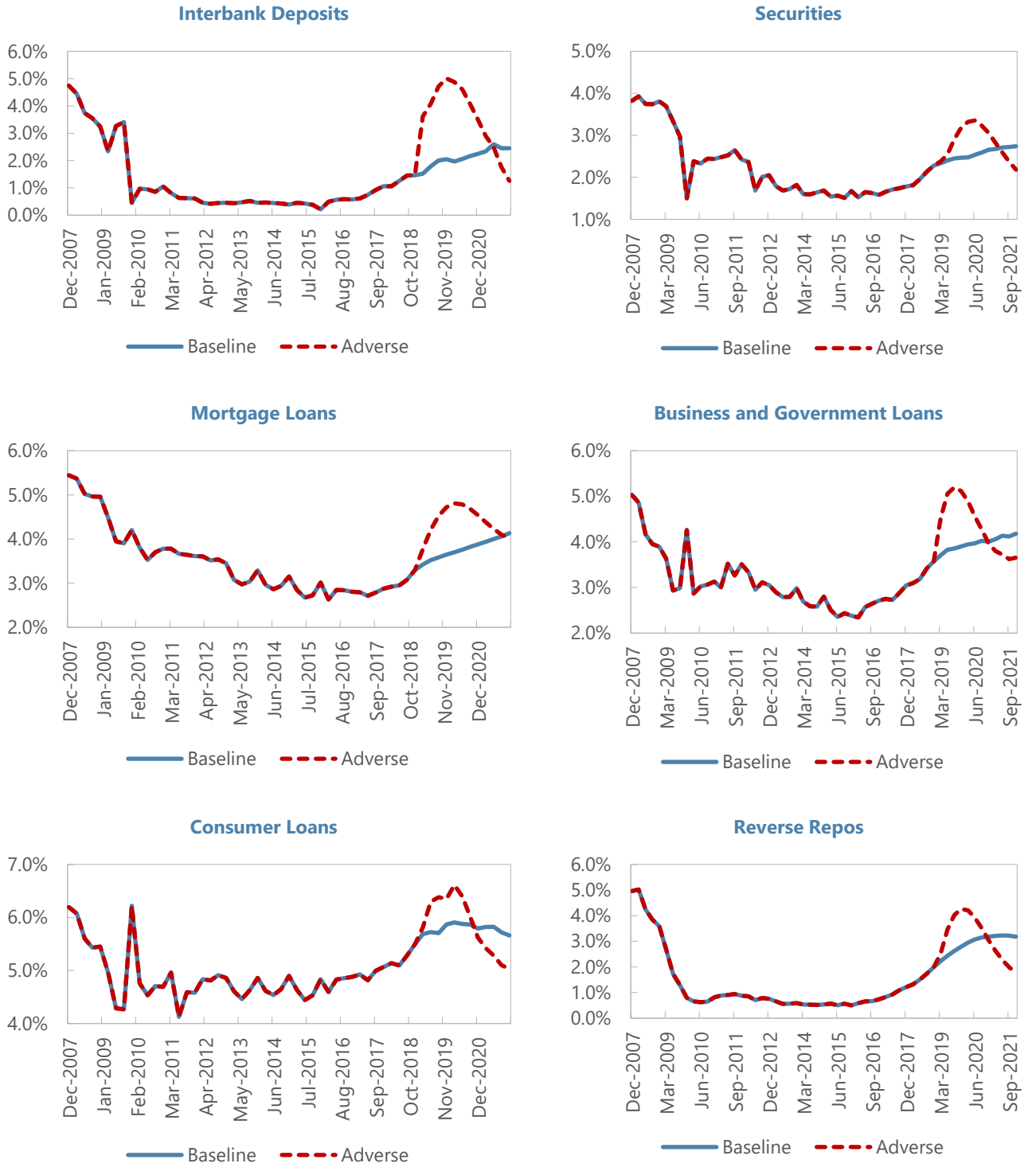
The modelling approach produced quarterly effective interest rate projections for all banks and scenarios—and for the 12 asset and liability segments described in paragraph 68 (and illustrated in Table 9). Additional pass-through constraints were applied (as described in paragraph 70 under the adverse scenario).

***Interest Rate Risks***

**1. Variables related to money market rate and long-term yields are the main contributors to projections of bank interest earnings and funding costs (Table V.1).** The long-run multiplier for short-term and long-term interest rates is sizable in terms of the determination of lending and funding rates. Specifically, three-month money market rates, 10-year government bond yields, and term premia for both the U.S. and Canada explain the majority of changes in the lending and funding rates. The longrun passthrough from market rates to bank interest rates appears to be significant, particularly from short-term rates to interest rates on overnight and term deposits, business and consumer loans, and reverse repos, and from long-term yields to business and government loans, as well as subordinate debt.

**2. The projected interest rate paths were broadly in line with bank portfolio segment characteristics** (Figure V.1.A and Figure V.1.B)**.** On the liability side, this is reflected in a more severe long-term interest rate impact on unsecured debt portfolios and other (wholesale) funding as opposed to the low scenario sensitivity of retail funding segments (both sight and term).

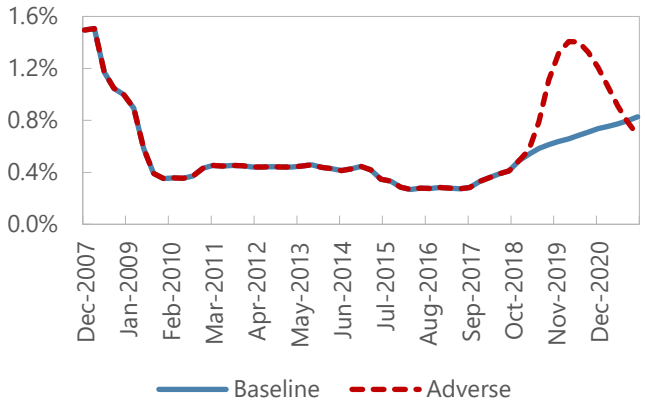
**Figure V.1.A. Canada: Interest Rate Models for Bank Portfolios, Assets**
(In percent)



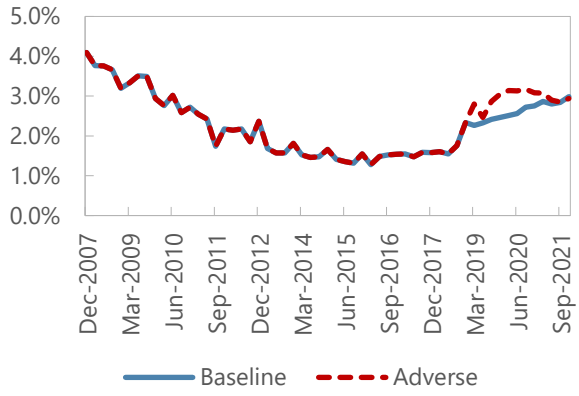
## Figure V.1.B. Canada: Interest Rate Models for Bank Portfolios, Liabilities

(In percent)

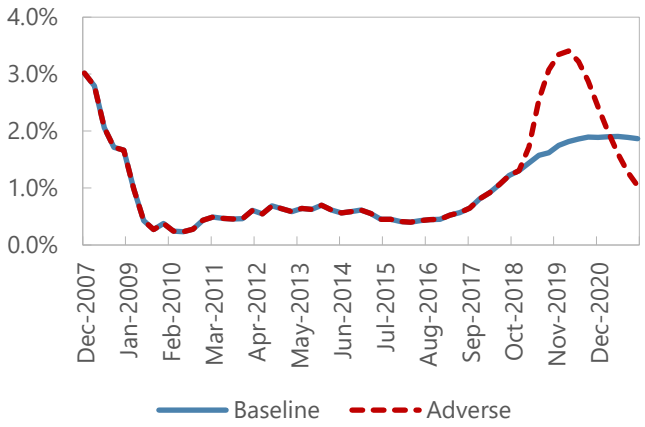
### Personal Demand Deposits



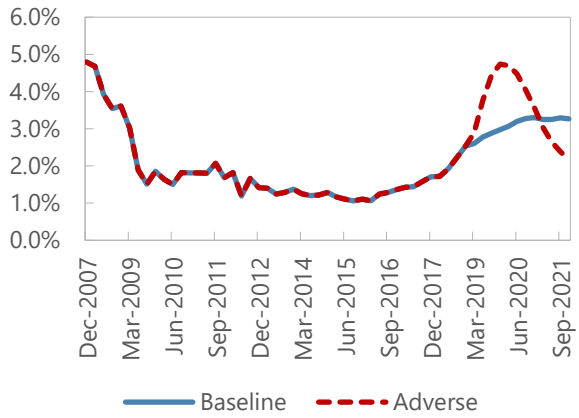

### Personal Term Deposits



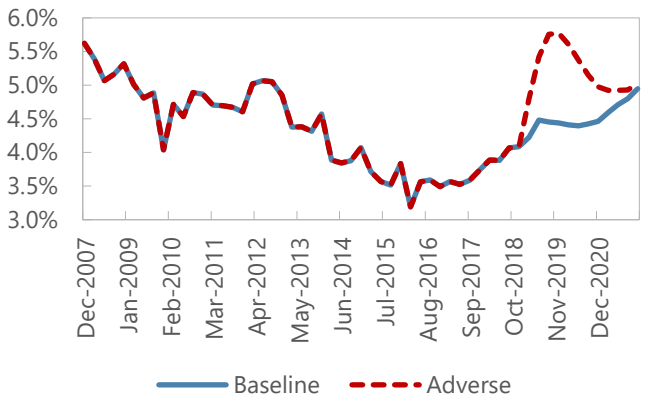

### Other Demand Deposits



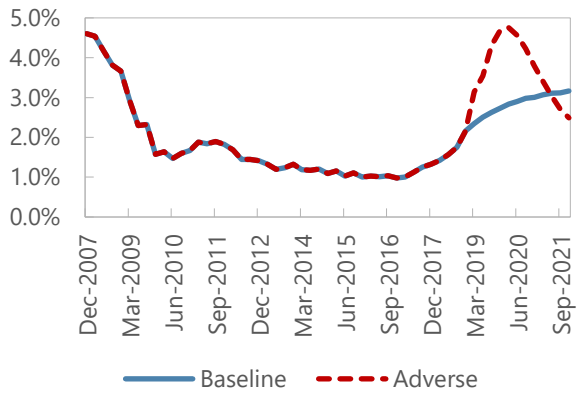

### Other Term Deposits (Wholesale)




### Subordinated Debt




### Other Interest Bearing Liabilities



## Table V.1. Canada: Estimation of the Interest Risk Satellite Model

Equation estimates for effective interest rates by asset/liability segment (normalized long-run multipliers)

(Dependent Variable: Segment Effective Interest Rate, percent)

| | Interbank deposits | Securities | Mortgage loans | Business and Gov't loans | Consumer loans | Reverse repos | Personal demand deposits | Personal term deposits | Other demand deposits | Other term deposits (wholesale) | Subordinated debt | Other interest bearing liabilities |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Normalized posterior long-run multiplier with sign restriction | | | | | | | | | | | |
| Real GDP growth, Canada, yoy | 0 | 0 | 0 | 0 | 0 | 0.03 | 0 | 0 | 0 | 0 | 0 | 0 |
| Real GDP growth, U.S., yoy | 0 | 0.02 | 0 | 0 | 0 | 1.03* | 0 | 0 | 0 | 0 | 0.01 | 0.01 |
| Inflation, Canada, yoy | 0 | 0.15* | 0.02 | 0 | 0 | 0.05 | 0 | 0 | 0 | 0.17* | 0.01 | 0 |
| Inflation, U.S., yoy | 0.05* | 0.23* | 0.01 | 0.01* | 0 | 0 | 0 | 0 | 0 | 0.06* | 0.02* | 0 |
| Real investment growth, Canada, yoy | 0 | 0.1* | 0 | 0 | 0 | 0.01 | 0 | 0 | 0 | 0 | 0 | 0 |
| Real investment growth, U.S., yoy | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.01 | 0 |
| Unemployment rate, Canada | 0 | 0 | -0.01 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Unemployment rate, U.S. | -0.14* | -0.01* | -0.01 | 0 | 0 | -0.04 | 0 | 0 | 0 | 0 | 0 | 0 |
| Unemployment rate, , Canada, percentage point change, yoy | 0 | -0.01 | 0 | 0 | 0 | -0.12 | 0 | 0 | 0 | 0 | 0 | 0 |
| Unemployment rate, , U.S., percentage point change, yoy | 0 | -0.05 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -0.01 | 0 |
| Short term rate, Canada | 0.46* | 0.28* | 0.27* | 0 | 0.02 | -0.15* | 0.92* | 0.01 | 0.74* | 0.04 | 0.01 | 0.57* |
| Short term rate, U.S. | 0 | 0.22* | 0.44* | 0.76* | 0.74* | 2.58* | 0.03* | 0.58* | 0.45* | 0.83* | 0.34* | 0.4* |
| Long term sovereign yield, Canada | 0 | 0.04 | 0.58* | 0.77* | 0.14* | 0 | 0.16* | 0.38* | 0 | 0.26* | 1.03* | 0.24* |
| Long term sovereign yield, U.S. | 0 | 0.07 | 0 | 0 | 0 | 0.08 | 0 | 0 | 0 | 0 | 0 | 0 |
| Term premium, Canada | 0.01 | 0.35* | 0.16* | 0 | 0 | 0 | 0.01* | 0.42* | 0 | 0.03 | 0 | 0.22* |
| Term premium, U.S. | 0.19* | 0.14* | 0.21* | 0 | 0.01 | 0.01 | 0.17* | 0.01 | 0 | 0.15* | 0 | 0.13* |
| Equity indices, Cananda, percentage change, yoy | 0 | 0 | 0.01 | 0.01 | 0.1* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Equity indices, U.S., percentage change, yoy | 0 | 0 | 0 | 0.01 | 0.03* | 0 | 0 | 0 | 0.19* | 0 | 0 | 0 |
| Exchange rate, Canada, percentage change, yoy | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.16* | 0 | 0.01 | 0 |
| R square | 0.95 | 0.93 | 0.95 | 0.84 | 0.64 | 1.00 | 0.99 | 0.91 | 0.99 | 0.97 | 0.92 | 0.96 |
| Durbin Watson | 2.84 | 2.72 | 2.06 | 2.11 | 2.12 | 2.08 | 1.30 | 2.00 | 1.83 | 2.01 | 2.18 | 1.69 |
| Number of lags of independent variables | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Number of observation | 75 | 75 | 75 | 75 | 75 | 75 | 75 | 75 | 75 | 75 | 75 | 75 |

Notes:

1: * Denotes a higher posterior inclusion probability than the prior inclusion probabilities, which indicates variable statistical significance.

2: For various segments presented here, the equations do contain lags of either the dependent variable or the exogenous right-hand-side variables (beyond their contemporaneous inclusion), or both.

3: A long-run multiplier is defined as the sum of all coefficients of a given right-hand-side variable on its contemporaneous and lagged terms. The long-run multiplier is normalized, moreover, by multiplying it by the ratio of the standard deviation of the left-hand side and the respective right-hand-side variable that is concerned.

Source: IMF staff calculations.

# Appendix VI. Non-Interest Income Business Activity Segments and Scaling Factors

| | | Income Segment Scaling Factors, Adverse Scenario (In percent) | | |
|---|---|---|---|---|
| | | 2019 | 2020 | 2021 |
| | **Non-interest Non-trading Income (Market Sensitive)** | | | |
| S1 | Investment management and custodial fees | 15 | 10 | 10 |
| S2 | Mutual fund fees | 25 | 15 | 10 |
| S3 | Underwriting and advisory fees | 35 | 20 | 10 |
| S4 | Securities commissions and fees | 20 | 15 | 10 |
| | **Non-interest Non-trading Income (Non-market Sensitive)** | | | |
| S5 | Deposit account and other payment service fees | 5 | 5 | 5 |
| S6 | Debit and credit card fees | 5 | 5 | 5 |
| S7 | Loan and acceptance fees | 5 | 5 | 5 |
| S8 | Net insurance revenues | 10 | 10 | 10 |
| S9 | Other non-interest income | 5 | 5 | 5 |

The projected non-interest income under the adverse scenario for business segment $s$ and scenario year $y_i$ is based on the following formula for each bank within the scope of the exercise:

$$I_s^{y_i} = \sum_l \min\left(I_s^{2018} - \sigma_s^{2013-2018}, I_s^{2018} * \left(1 - r_s^{y_i}\right)\right) * \frac{A_s^{y_i}}{A_s^{2018}} * f_l^{y_i}$$

where:

$I_s^{2018}$ denotes the income for segment $s$ for year 2018,

$\sigma_s^{2013-2018}$ is the standard deviation of income for segment $s$ for the years 2013 to 2018,

$r_s^{y_i}$ is the scaling factor of the table above for segment $s$ for the year $y_i$,

$A_s^{y_i}$ denotes the total assets size of the bank for segment $s$ for the year $y_i$, and

$f_l^{y_i}$ denotes the proportion of income—adjusted for currency appreciation—in currency $l$.

In the baseline scenario, segment income was assumed to be constant and equal to the segment income during 2018 adjusted only for currency appreciation. Operational expenses were assumed to remain constant at the 2018 levels but were also adjusted to account for the scenario projected currency appreciation.

# Appendix VII. LCR Stress Test Scenarios

| | Scenario | ST Scenarios | | |
|---|---|---|---|---|
| | 1 - Regulatory | 2 - ST Retail | 3 - ST Wholesale | 4 - ST Combined |
| **1. Stock of High-quality Liquid Assets (HQLA)** | | | | |
| **1.1. Level 1 Assets** | | | | |
| | **Weight** | | | |
| Coins and banknotes | 1.00 | 1.00 | 1.00 | 1.00 |
| Total central bank reserves, of which: | | | | |
| part of central bank reserves that can be drawn in times of stress | 1.00 | 1.00 | 1.00 | 1.00 |
| part of central bank reserves that cannot be drawn in times of stress | | | | |
| Securities with a 0 percent risk weight: | | | | |
| issued by sovereigns | 1.00 | 1.00 | 1.00 | 1.00 |
| guaranteed by sovereigns | 1.00 | 1.00 | 1.00 | 1.00 |
| issued or guaranteed by central banks | 1.00 | 1.00 | 1.00 | 1.00 |
| issued or guaranteed by PSEs | 1.00 | 1.00 | 1.00 | 1.00 |
| issued or guaranteed by BIS, IMF, ECB and European Community, or MDBs | 1.00 | 1.00 | 1.00 | 1.00 |
| For non-0 percent risk-weighted sovereigns: | | | | |
| sovereign or central bank debt securities issued in domestic currencies by the sovereign or central bank in the country in which the liquidity risk is being taken or in the bank's home country | 1.00 | 1.00 | 1.00 | 1.00 |
| domestic sovereign or central bank debt securities issued in foreign currencies, up to the amount of the bank's stressed net cash outflows in that specific foreign currency stemming from the bank's operations in the jurisdiction where the bank's liquidity risk is being taken | 1.00 | 1.00 | 1.00 | 1.00 |
| **Total stock of Level 1 assets** | | | | |
| Adjustment to stock of Level 1 assets | | | | |
| Adjusted amount of Level 1 assets | | | | |
| **1.2. Level 2A Assets** | | | | |
| | **Weight** | | | |
| Securities with a 20 percent risk weight: | | | | |
| issued by sovereigns | 0.85 | 0.85 | 0.85 | 0.85 |
| guaranteed by sovereigns | 0.85 | 0.85 | 0.85 | 0.85 |
| issued or guaranteed by central banks | 0.85 | 0.85 | 0.85 | 0.85 |
| issued or guaranteed by PSEs | 0.85 | 0.85 | 0.85 | 0.85 |
| issued or guaranteed by MDBs | 0.85 | 0.85 | 0.85 | 0.85 |
| Non-financial corporate bonds, rated AA- or better | 0.85 | 0.85 | 0.85 | 0.85 |
| Covered bonds, not self-issued, rated AA- or better | 0.85 | 0.85 | 0.85 | 0.85 |
| **Total stock of Level 2A assets** | | | | |
| Adjustment to stock of Level 2A assets | | | | |
| Adjusted amount of Level 2A assets | 0.85 | 0.85 | 0.85 | 0.85 |
| **1.3. Level 2B Assets** | | | | |

| | Scenario | ST Scenarios | | |
|---|---|---|---|---|
| | 1 - Regulatory | 2 - ST Retail | 3 - ST Wholesale | 4 - ST Combined |
| | Weight | | | |
| Residential mortgage-backed securities (RMBS), rated AA or better | 0.75 | 0.75 | 0.75 | 0.75 |
| Non-financial corporate bonds, rated BBB- to A+ | 0.50 | 0.50 | 0.50 | 0.50 |
| Non-financial common equity shares | 0.50 | 0.50 | 0.50 | 0.50 |
| Sovereign or central bank debt securities, rated BBB- to BBB+ | 0.50 | 0.50 | 0.50 | 0.50 |
| **Total stock of Level 2B RMBS assets** | | | | |
| Adjustment to stock of Level 2B RMBS assets | | | | |
| Adjusted amount of Level 2B RMBS assets | 0.75 | 0.75 | 0.75 | 0.75 |
| **Total stock of Level 2B non-RMBS assets** | | | | |
| Adjustment to stock of Level 2B non-RMBS assets | | | | |
| Adjusted amount of Level 2B non-RMBS assets | 0.50 | 0.50 | 0.50 | 0.50 |
| Adjusted amount of Level 2B (RMBS and non-RMBS) assets | | | | |
| Adjustment to stock of HQLA due to cap on Level 2B assets | | | | |
| Adjustment to stock of HQLA due to cap on Level 2 assets | | | | |

**2. Net Cash Outflows**

**2.1. Cash Outflows**

**2.1.1. Retail Deposit Run-off**

| | Weight | | | |
|---|---|---|---|---|
| Total retail deposits, of which: | | | | |
| Insured deposits, of which: | | | | |
| in transactional accounts, of which: | | | | |
| eligible for a 3 percent run-off rate, of which: | | | | |
| are in Canada | 0.03 | **0.05** | **0.10** | **0.10** |
| are not in Canada | 0.03 | **0.05** | **0.10** | **0.10** |
| eligible for a 5 percent run-off rate | 0.05 | 0.05 | **0.10** | **0.10** |
| in non-transactional accounts with established relationships that make deposit withdrawal highly unlikely, of which: | | | | |
| eligible for a 3 percent run-off rate, of which: | | | | |
| are in Canada | 0.03 | **0.05** | **0.05** | **0.05** |
| are not in Canada | 0.03 | **0.05** | **0.05** | **0.05** |
| eligible for a 5 percent run-off rate | 0.05 | 0.05 | 0.05 | 0.05 |
| in non-transactional and non-relationship accounts | 0.10 | 0.10 | 0.10 | 0.10 |
| Uninsured deposits | 0.10 | **0.15** | **0.15** | **0.15** |
| Sourced from an unaffiliated third-party | 0.10 | **0.15** | **0.15** | **0.15** |
| Foreign currency | 0.10 | **0.15** | **0.15** | **0.15** |
| Term deposits with a remaining maturity of > 30 days | 0.00 | 0.00 | 0.00 | 0.00 |

| | Scenario | ST Scenarios | | |
|---|---|---|---|---|
| | 1 - Regulatory | 2 - ST Retail | 3 - ST Wholesale | 4 - ST Combined |
| **Total retail deposit run-off** | | | | |
| **2.1.2. Unsecured Wholesale Funding Run-off** | | | | |
| | **Weight** | | | |
| Total unsecured wholesale funding | | | | |
| Total funding provided by small business customers, of which: | | | | |
| Insured deposits, of which: | | | | |
| in transactional accounts, of which: | | | | |
| eligible for a 3 percent run-off rate, of which: | | | | |
| are in Canada | 0.03 | **0.08** | **0.08** | **0.08** |
| are not in Canada | 0.03 | **0.08** | **0.08** | **0.08** |
| eligible for a 5 percent run-off rate | 0.05 | **0.08** | **0.08** | **0.08** |
| in non-transactional accounts with established relationships that make deposit withdrawal highly unlikely, of which: | | | | |
| eligible for a 3 percent run-off rate, of which: | | | | |
| are in Canada | 0.03 | **0.08** | **0.08** | **0.08** |
| are not in Canada | 0.03 | **0.08** | **0.08** | **0.08** |
| eligible for a 5 percent run-off rate | 0.05 | **0.08** | **0.08** | **0.08** |
| in non-transactional and non-relationship accounts | 0.10 | 0.10 | 0.10 | 0.10 |
| Uninsured deposits | 0.10 | 0.10 | **0.25** | **0.25** |
| Sourced from an unaffiliated third-party | 0.10 | 0.10 | **0.25** | **0.25** |
| Foreign currency | 0.10 | 0.10 | **0.25** | **0.25** |
| Term deposits with a remaining maturity of > 30 days | 0.00 | 0.00 | 0.00 | 0.00 |
| Total operational deposits, of which: | | | | |
| provided by non-financial corporates | | | | |
| insured, with a 3 percent run-off rate | 0.03 | 0.03 | **0.25** | **0.25** |
| insured, with a 5 percent run-off rate | 0.05 | 0.05 | **0.25** | **0.25** |
| Uninsured | 0.25 | 0.25 | **0.50** | **0.50** |
| provided by sovereigns, central banks, public sector entities (PSEs), and multilateral development banks (MDBs) | | | | |
| insured, with a 3 percent run-off rate | 0.03 | 0.03 | 0.03 | 0.03 |
| insured, with a 5 percent run-off rate | 0.05 | 0.05 | 0.05 | 0.05 |
| Uninsured | 0.25 | 0.25 | 0.25 | 0.25 |
| provided by banks | | | | |
| insured, with a 3 percent run-off rate | 0.03 | 0.03 | **0.25** | **0.25** |
| insured, with a 5 percent run-off rate | 0.05 | 0.05 | **0.25** | **0.25** |
| Uninsured | 0.25 | 0.25 | **0.50** | **0.50** |
| provided by other financial institutions and other legal entities | | | | |
| insured, with a 3 percent run-off rate | 0.03 | 0.03 | **0.25** | **0.25** |
| insured, with a 5 percent run-off rate | 0.05 | 0.05 | **0.25** | **0.25** |
| Uninsured | 0.25 | 0.25 | **0.50** | **0.50** |

| | Scenario | ST Scenarios | | |
|---|---|---|---|---|
| | 1 - Regulatory | 2 - ST Retail | 3 - ST Wholesale | 4 - ST Combined |
| Total non-operational deposits, of which | | | | |
| provided by non-financial corporates, of which: | | | | |
| where entire amount is fully covered by an effective deposit insurance scheme | 0.20 | 0.20 | **0.50** | **0.50** |
| where entire amount is not fully covered by an effective deposit insurance scheme | 0.40 | 0.40 | **0.50** | **0.50** |
| provided by sovereigns, central banks, PSEs, and MDBs, of which: | | | | |
| where entire amount is fully covered by an effective deposit insurance scheme | 0.20 | 0.20 | **0.50** | **0.50** |
| where entire amount is not fully covered by an effective deposit insurance scheme | 0.40 | 0.40 | **0.50** | **0.50** |
| provided by other banks | 1.00 | 1.00 | 1.00 | 1.00 |
| provided by other financial institutions and other legal entities | 1.00 | 1.00 | 1.00 | 1.00 |
| Unsecured debt issuance | 1.00 | 1.00 | 1.00 | 1.00 |
| Additional balances required to be installed in central bank reserves | 1.00 | 1.00 | 1.00 | 1.00 |
| **Total unsecured wholesale funding run-off** | | | | |

**2.1.3. Secured Funding Run-off**

| | Weight | | | |
|---|---|---|---|---|
| Transactions maturing ≤ 30 days conducted with the bank's domestic central bank, of which: | | | | |
| Backed by Level 1 assets, of which: | | | | |
| Transactions involving eligible liquid assets | 0.00 | 0.00 | 0.00 | 0.00 |
| Transactions not involving eligible liquid assets | 0.00 | 0.00 | 0.00 | 0.00 |
| Backed by Level 2A assets, of which: | | | | |
| Transactions involving eligible liquid assets | 0.00 | 0.00 | 0.00 | 0.00 |
| Transactions not involving eligible liquid assets | 0.00 | 0.00 | 0.00 | 0.00 |
| Backed by Level 2B RMBS assets, of which: | | | | |
| Transactions involving eligible liquid assets | 0.00 | 0.00 | 0.00 | 0.00 |
| Transactions not involving eligible liquid assets | 0.00 | 0.00 | 0.00 | 0.00 |
| Backed by Level 2B non-RMBS assets, of which: | | | | |
| Transactions involving eligible liquid assets | 0.00 | 0.00 | 0.00 | 0.00 |
| Transactions not involving eligible liquid assets | 0.00 | 0.00 | 0.00 | 0.00 |
| Backed by other assets | 0.00 | 0.00 | 0.00 | 0.00 |
| Transactions maturing ≤ 30 days not conducted with the bank's domestic central bank and backed by Level 1 assets, of which: | | | | |
| Transactions involving eligible liquid assets | 0.00 | 0.00 | 0.00 | 0.00 |
| Transactions not involving eligible liquid assets | 0.00 | 0.00 | 0.00 | 0.00 |
| Transactions maturing ≤ 30 days not conducted with the bank's domestic central bank and backed by Level 2A assets, of which: | | | | |
| Transactions involving eligible liquid assets | 0.15 | 0.15 | 0.15 | 0.15 |
| Transactions not involving eligible liquid assets | 0.15 | 0.15 | 0.15 | 0.15 |

| | Scenario | ST Scenarios | | |
|---|---|---|---|---|
| | 1 - Regulatory | 2 - ST Retail | 3 - ST Wholesale | 4 - ST Combined |
| Transactions maturing ≤ 30 days not conducted with the bank's domestic central bank and backed by Level 2B RMBS assets, of which: | | | | |
| Transactions involving eligible liquid assets | 0.25 | 0.25 | 0.25 | 0.25 |
| Transactions not involving eligible liquid assets | 0.25 | 0.25 | 0.25 | 0.25 |
| Transactions maturing ≤ 30 days not conducted with the bank's domestic central bank and backed by Level 2B non-RMBS assets, of which: | | | | |
| Counterparties are domestic sovereigns, MDBs or domestic PSEs with a 20 percent risk weight, of which: | | | | |
| Transactions involving eligible liquid assets | 0.25 | 0.25 | 0.25 | 0.25 |
| Transactions not involving eligible liquid assets | 0.25 | 0.25 | 0.25 | 0.25 |
| Counterparties are not domestic sovereigns, MDBs or domestic PSEs with a 20 percent risk weight, of which: | | | | |
| Transactions involving eligible liquid assets | 0.50 | 0.50 | 0.50 | 0.50 |
| Transactions not involving eligible liquid assets | 0.50 | 0.50 | 0.50 | 0.50 |
| Transactions maturing ≤ 30 days not conducted with the bank's domestic central bank and backed by other assets (non-HQLA), of which: | | | | |
| Counterparties are domestic sovereigns, MDBs, or domestic PSEs with a 20 percent risk weight | 0.25 | 0.25 | 0.25 | 0.25 |
| Counterparties are not domestic sovereigns, MDBs or domestic PSEs with a 20 percent risk weight | 1.00 | 1.00 | 1.00 | 1.00 |
| **Total secured wholesale funding run-off** | | | | |

**2.1.4. Additional Requirements**

| | Weight | | | |
|---|---|---|---|---|
| Derivatives cash outflow | 1.00 | 1.00 | 1.00 | 1.00 |
| Increased liquidity needs related to downgrade triggers in derivatives and other financing transactions | 1.00 | 1.00 | 1.00 | 1.00 |
| Increased liquidity needs related to the potential for valuation changes on posted collateral securing derivative and other transactions: | | | | |
| Cash and Level 1 assets | 0.00 | 0.00 | 0.00 | 0.00 |
| For other collateral (i.e., all non-Level 1 collateral) | 0.20 | 0.20 | 0.20 | 0.20 |
| Increased liquidity needs related to excess non-segregated collateral held by the bank that could contractually be called at any time by the counterparty | 1.00 | 1.00 | 1.00 | 1.00 |
| Increased liquidity needs related to contractually required collateral on transactions for which the counterparty has not yet demanded the collateral be posted | 1.00 | 1.00 | 1.00 | 1.00 |
| Increased liquidity needs related to contracts that allow collateral substitution to non-HQLA assets | 1.00 | 1.00 | 1.00 | 1.00 |
| Increased liquidity needs related to market valuation changes on derivative or other transactions | 1.00 | 1.00 | 1.00 | 1.00 |

| | Scenario | ST Scenarios | | |
|---|---|---|---|---|
| | 1 - Regulatory | 2 - ST Retail | 3 - ST Wholesale | 4 - ST Combined |
| Loss of funding on ABS and other structured financing instruments issued by the bank, excluding covered bonds | 1.00 | 1.00 | 1.00 | 1.00 |
| Loss of funding on covered bonds issued by the bank | 1.00 | 1.00 | 1.00 | 1.00 |
| Loss of funding on asset-backed commercial paper (ABCP), conduits, SIVs, and other such financing activities, of which: | | | | |
| debt maturing ≤ 30 days | 1.00 | 1.00 | 1.00 | 1.00 |
| with embedded options in financing arrangements | 1.00 | 1.00 | 1.00 | 1.00 |
| other potential loss of such funding | 1.00 | 1.00 | 1.00 | 1.00 |
| Undrawn committed credit and liquidity facilities to retail and small business customers | 0.05 | 0.05 | 0.05 | 0.05 |
| Undrawn committed credit facilities to | | | | |
| non-financial corporates | 0.10 | 0.10 | 0.10 | **0.25** |
| sovereigns, central banks, PSEs, and MDBs | 0.10 | 0.10 | 0.10 | 0.10 |
| Undrawn committed liquidity facilities to | | | | |
| non-financial corporates | 0.30 | 0.30 | 0.30 | **0.50** |
| sovereigns, central banks, PSEs, and MDBs | 0.30 | 0.30 | 0.30 | 0.30 |
| Undrawn committed credit and liquidity facilities provided to banks subject to prudential supervision | 0.40 | 0.40 | 0.40 | 0.40 |
| Undrawn committed credit facilities provided to other Fis | 0.40 | 0.40 | 0.40 | 0.40 |
| Undrawn committed liquidity facilities provided to other Fis | 1.00 | 1.00 | 1.00 | 1.00 |
| Undrawn committed credit and liquidity facilities to other legal entities | 1.00 | 1.00 | 1.00 | 1.00 |
| **Other contractual obligations to extend funds to** | | **Weight** | | |
| financial institutions | 1.00 | 1.00 | 1.00 | 1.00 |
| retail clients | | | | |
| small business customers | | | | |
| non-financial corporates | | | | |
| other clients | | | | |
| retail, small business customers, non-financials and other clients | 1.00 | 1.00 | 1.00 | 1.00 |
| **Total contractual obligations to extend funds in excess of 50 percent roll-over assumption** | | | | |
| **Total additional requirements run-off** | | | | |
| **Other contingent funding obligations** | | **Weight** | | |
| Non-contractual obligations related to potential liquidity draws from joint ventures or minority investments in entities | 1.00 | 1.00 | 1.00 | 1.00 |

| | Scenario | ST Scenarios | | |
|---|---|---|---|---|
| | 1 - Regulatory | 2 - ST Retail | 3 - ST Wholesale | 4 - ST Combined |
| Unconditionally revocable "uncommitted" credit and liquidity facilities provided to retail and small business customers | 0.02 | 0.02 | 0.02 | **0.05** |
| Unconditionally revocable "uncommitted" credit and liquidity facilities provided to all other customers | 0.05 | 0.05 | 0.05 | **0.10** |
| Trade finance-related obligations (including guarantees and letters of credit) | 0.03 | 0.03 | 0.03 | 0.03 |
| Guarantees and letters of credit unrelated to trade finance obligations | 0.05 | 0.05 | 0.05 | **0.10** |
| Non-contractual obligations: | | | | |
| Debt-buy back requests (including related conduits) | 0.00 | 0.00 | 0.00 | 0.00 |
| Structured products | 0.05 | 0.05 | 0.05 | 0.05 |
| Managed funds | 0.00 | 0.00 | 0.00 | 0.00 |
| Other non-contractual obligations | 0.05 | 0.05 | 0.05 | 0.05 |
| Outstanding debt securities with remaining maturity > 30 days | 0.00 | 0.00 | 0.00 | 0.00 |
| Non-contractual obligations where customer short positions are covered by other customers' collateral | 0.50 | 0.50 | 0.50 | **0.75** |
| Bank outright short positions covered by a collateralized securities financing transaction | 0.00 | 0.00 | 0.00 | 0.00 |
| Other contractual cash outflows (including those related to unsecured collateral borrowings and uncovered short positions) | 1.00 | 1.00 | 1.00 | 1.00 |
| **Total run-off on other contingent funding obligations** | | | | |

## 2.2. Cash Inflows

### 2.2.1. Secured Lending Including Reverse Repo and Securities Borrowing

| | Weight | | | |
|---|---|---|---|---|
| Reverse repo and other secured lending or securities borrowing transactions maturing ≤ 30 days | | | | |
| Of which collateral is not re-used (i.e., is not rehypothecated) to cover the reporting institution's outright short positions | | | | |
| Transactions backed by Level 1 assets, of which: | | | | |
| Transactions involving eligible liquid assets | 0.00 | 0.00 | 0.00 | 0.00 |
| Transactions not involving eligible liquid assets | 0.00 | 0.00 | 0.00 | 0.00 |
| Transactions backed by Level 2A assets, of which: | | | | |
| Transactions involving eligible liquid assets | 0.15 | 0.15 | 0.15 | 0.15 |
| Transactions not involving eligible liquid assets | 0.15 | 0.15 | 0.15 | 0.15 |
| Transactions backed by Level 2B RMBS assets, of which: | | | | |
| Transactions involving eligible liquid assets | 0.25 | 0.25 | 0.25 | 0.25 |

| | Scenario | ST Scenarios | | |
|---|---|---|---|---|
| | 1 - Regulatory | 2 - ST Retail | 3 - ST Wholesale | 4 - ST Combined |
| Transactions not involving eligible liquid assets | 0.25 | 0.25 | 0.25 | 0.25 |
| Transactions backed by Level 2B non-RMBS assets, of which: | | | | |
| Transactions involving eligible liquid assets | 0.50 | 0.50 | 0.50 | 0.50 |
| Transactions not involving eligible liquid assets | 0.50 | 0.50 | 0.50 | 0.50 |
| Margin lending backed by non-Level 1 or non-Level 2 collateral | 0.50 | 0.50 | 0.50 | 0.50 |
| Transactions backed by other collateral | 1.00 | 1.00 | 1.00 | 1.00 |
| Of which collateral is re-used (i.e., is rehypothecated) in transactions to cover the reporting institution's outright short positions | | | | |
| Transactions backed by Level 1 assets | 0.00 | 0.00 | 0.00 | 0.00 |
| Transactions backed by Level 2A assets | 0.00 | 0.00 | 0.00 | 0.00 |
| Transactions backed by Level 2B RMBS assets | 0.00 | 0.00 | 0.00 | 0.00 |
| Transactions backed by Level 2B non-RMBS assets | 0.00 | 0.00 | 0.00 | 0.00 |
| Margin lending backed by non-Level 1 or non-Level 2 collateral | 0.00 | 0.00 | 0.00 | 0.00 |
| Transactions backed by other collateral | 0.00 | 0.00 | 0.00 | 0.00 |
| **Total inflows on reverse repo and securities borrowing transactions** | | | | |

**2.2.2. Other Inflows by Counterparty**

| | Weight | | | |
|---|---|---|---|---|
| Contractual inflows due in ≤ 30 days from fully performing loans, not reported as secured lending, from: | | | | |
| Retail customers | 0.50 | 0.50 | 0.50 | 0.50 |
| Small business customers | 0.50 | 0.50 | 0.50 | 0.50 |
| Non-financial corporates | 0.50 | 0.50 | 0.50 | 0.50 |
| Central banks | 1.00 | 1.00 | 1.00 | 1.00 |
| Financial institutions, of which | | | | |
| operational deposits related to clearing activities placed by indirect clearers with an OSFI-regulated direct clearer | 0.25 | 0.25 | 0.25 | 0.25 |
| other operational deposits | 0.00 | 0.00 | 0.00 | 0.00 |
| non-operational demand deposits placed by indirect clearers with an OSFI-regulated direct clearer | 1.00 | 1.00 | 1.00 | 1.00 |
| all payments on other loans and deposits due in ≤ 30 days | 1.00 | 1.00 | 1.00 | 1.00 |
| Other entities | 0.50 | 0.50 | 0.50 | 0.50 |
| **Total of other inflows by counterparty** | | | | |

**2.2.3. Other Cash Inflows**

| | Weight | | | |
|---|---|---|---|---|
| Other cash inflows | | | | |
| Derivatives cash inflow | 1.00 | 1.00 | 1.00 | 1.00 |

| | Scenario | ST Scenarios | | |
|---|---|---|---|---|
| | 1 - Regulatory | 2 - ST Retail | 3 - ST Wholesale | 4 - ST Combined |
| Contractual inflows from securities maturing ≤ 30 days, not included anywhere above | 1.00 | 1.00 | 1.00 | 1.00 |
| Other contractual cash inflows | 1.00 | 1.00 | 1.00 | 1.00 |
| **Total of other cash inflows** | | | | |

**2.2.4. Total Cash Inflows**

| | Weight | | | |
|---|---|---|---|---|
| Total cash inflows before applying the cap | | | | |
| Cap on cash inflows | 0.75 | 0.75 | 0.75 | 0.75 |
| Total cash inflows after applying the cap | | | | |

**3. Collateral Swaps**

| | Weight Outflows | | | |
|---|---|---|---|---|
| Collateral swaps maturing ≤ 30 days: | | | | |
| Of which the borrowed assets are not re-used (i.e., are not rehypothecated) to cover short positions | | | | |
| Level 1 assets are lent and Level 1 assets are borrowed, of which: | | | | |
| Involving eligible liquid assets | 0.00 | 0.00 | 0.00 | 0.00 |
| Not involving eligible liquid assets | 0.00 | 0.00 | 0.00 | 0.00 |
| Level 1 assets are lent and Level 2A assets are borrowed, of which: | | | | |
| Involving eligible liquid assets | | | | |
| Not involving eligible liquid assets | | | | |
| Level 1 assets are lent and Level 2B RMBS assets are borrowed, of which: | | | | |
| Involving eligible liquid assets | | | | |
| Not involving eligible liquid assets | | | | |
| Level 1 assets are lent and Level 2B non-RMBS assets are borrowed, of which: | | | | |
| Involving eligible liquid assets | | | | |
| Not involving eligible liquid assets | | | | |
| Level 1 assets are lent and other assets are borrowed, of which: | | | | |
| Involving eligible liquid assets | | | | |
| Not involving eligible liquid assets | | | | |
| Level 2A assets are lent and Level 1 assets are borrowed, of which: | | | | |
| Involving eligible liquid assets | 0.15 | 0.15 | 0.15 | 0.15 |
| Not involving eligible liquid assets | 0.15 | 0.15 | 0.15 | 0.15 |
| Level 2A assets are lent and Level 2A assets are borrowed, of which: | | | | |
| Involving eligible liquid assets | 0.00 | 0.00 | 0.00 | 0.00 |
| Not involving eligible liquid assets | 0.00 | 0.00 | 0.00 | 0.00 |
| Level 2A assets are lent and Level 2B RMBS assets are borrowed, of which: | | | | |
| Involving eligible liquid assets | | | | |

| | Scenario | ST Scenarios | | |
|---|---|---|---|---|
| | 1 - Regulatory | 2 - ST Retail | 3 - ST Wholesale | 4 - ST Combined |
| Not involving eligible liquid assets | | | | |
| Level 2A assets are lent and Level 2B non-RMBS assets are borrowed, of which: | | | | |
| Involving eligible liquid assets | | | | |
| Not involving eligible liquid assets | | | | |
| Level 2A assets are lent and other assets are borrowed, of which: | | | | |
| Involving eligible liquid assets | | | | |
| Not involving eligible liquid assets | | | | |
| Level 2B RMBS assets are lent and Level 1 assets are borrowed, of which: | | | | |
| Involving eligible liquid assets | 0.25 | 0.25 | 0.25 | 0.25 |
| Not involving eligible liquid assets | 0.25 | 0.25 | 0.25 | 0.25 |
| Level 2B RMBS assets are lent and Level 2A assets are borrowed, of which: | | | | |
| Involving eligible liquid assets | 0.10 | 0.10 | 0.10 | 0.10 |
| Not involving eligible liquid assets | 0.10 | 0.10 | 0.10 | 0.10 |
| Level 2B RMBS assets are lent and Level 2B RMBS assets are borrowed, of which: | | | | |
| Involving eligible liquid assets | 0.00 | 0.00 | 0.00 | 0.00 |
| Not involving eligible liquid assets | 0.00 | 0.00 | 0.00 | 0.00 |
| Level 2B RMBS assets are lent and Level 2B non-RMBS assets are borrowed, of which: | | | | |
| Involving eligible liquid assets | | | | |
| Not involving eligible liquid assets | | | | |
| Level 2B RMBS assets are lent and other assets are borrowed, of which: | | | | |
| Involving eligible liquid assets | | | | |
| Not involving eligible liquid assets | | | | |
| Level 2B non-RMBS assets are lent and Level 1 assets are borrowed, of which: | | | | |
| Involving eligible liquid assets | 0.50 | 0.50 | 0.50 | 0.50 |
| Not involving eligible liquid assets | 0.50 | 0.50 | 0.50 | 0.50 |
| Level 2B non-RMBS assets are lent and Level 2A assets are borrowed, of which: | | | | |
| Involving eligible liquid assets | 0.35 | 0.35 | 0.35 | 0.35 |
| Not involving eligible liquid assets | 0.35 | 0.35 | 0.35 | 0.35 |
| Level 2B non-RMBS assets are lent and Level 2B RMBS assets are borrowed, of which: | | | | |
| Involving eligible liquid assets | 0.25 | 0.25 | 0.25 | 0.25 |
| Not involving eligible liquid assets | 0.25 | 0.25 | 0.25 | 0.25 |
| Level 2B non-RMBS assets are lent and Level 2B non-RMBS assets are borrowed, of which: | | | | |
| Involving eligible liquid assets | 0.00 | 0.00 | 0.00 | 0.00 |
| Not involving eligible liquid assets | 0.00 | 0.00 | 0.00 | 0.00 |
| Level 2B non-RMBS assets are lent and other assets are borrowed, of which: | | | | |

| | Scenario | ST Scenarios | | |
|---|---|---|---|---|
| | 1 - Regulatory | 2 - ST Retail | 3 - ST Wholesale | 4 - ST Combined |
| Involving eligible liquid assets | | | | |
| Not involving eligible liquid assets | | | | |
| Other assets are lent and Level 1 assets are borrowed, of which: | | | | |
| Involving eligible liquid assets | 1.00 | 1.00 | 1.00 | 1.00 |
| Not involving eligible liquid assets | 1.00 | 1.00 | 1.00 | 1.00 |
| Other assets are lent and Level 2A assets are borrowed, of which: | | | | |
| Involving eligible liquid assets | 0.85 | 0.85 | 0.85 | 0.85 |
| Not involving eligible liquid assets | 0.85 | 0.85 | 0.85 | 0.85 |
| Other assets are lent and Level 2B RMBS assets are borrowed, of which: | | | | |
| Involving eligible liquid assets | 0.75 | 0.75 | 0.75 | 0.75 |
| Not involving eligible liquid assets | 0.75 | 0.75 | 0.75 | 0.75 |
| Other assets are lent and Level 2B non-RMBS assets are borrowed, of which: | | | | |
| Involving eligible liquid assets | 0.50 | 0.50 | 0.50 | 0.50 |
| Not involving eligible liquid assets | 0.50 | 0.50 | 0.50 | 0.50 |
| Other assets are lent and other assets are borrowed | 0.00 | 0.00 | 0.00 | 0.00 |
| Of which the borrowed assets are re-used (i.e., are rehypothecated) in transactions to cover short positions | | | | |
| Level 1 assets are lent and Level 1 assets are borrowed | 0.00 | 0.00 | 0.00 | 0.00 |
| Level 1 assets are lent and Level 2A assets are borrowed | | | | |
| Level 1 assets are lent and Level 2B RMBS assets are borrowed | | | | |
| Level 1 assets are lent and Level 2B non-RMBS assets are borrowed | | | | |
| Level 1 assets are lent and other assets are borrowed | | | | |
| Level 2A assets are lent and Level 1 assets are borrowed | 0.15 | 0.15 | 0.15 | 0.15 |
| Level 2A assets are lent and Level 2A assets are borrowed | 0.00 | 0.00 | 0.00 | 0.00 |
| Level 2A assets are lent and Level 2B RMBS assets are borrowed | | | | |
| Level 2A assets are lent and Level 2B non-RMBS assets are borrowed | | | | |
| Level 2A assets are lent and other assets are borrowed | | | | |
| Level 2B RMBS assets are lent and Level 1 assets are borrowed | 0.25 | 0.25 | 0.25 | 0.25 |
| Level 2B RMBS assets are lent and Level 2A assets are borrowed | 0.10 | 0.10 | 0.10 | 0.10 |
| Level 2B RMBS assets are lent and Level 2B RMBS assets are borrowed | 0.00 | 0.00 | 0.00 | 0.00 |

| | Scenario | ST Scenarios | | |
|---|---|---|---|---|
| | 1 - Regulatory | 2 - ST Retail | 3 - ST Wholesale | 4 - ST Combined |
| Level 2B RMBS assets are lent and Level 2B non-RMBS assets are borrowed | | | | |
| Level 2B RMBS assets are lent and other assets are borrowed | | | | |
| Level 2B non-RMBS assets are lent and Level 1 assets are borrowed | 0.50 | 0.50 | 0.50 | 0.50 |
| Level 2B non-RMBS assets are lent and Level 2A assets are borrowed | 0.35 | 0.35 | 0.35 | 0.35 |
| Level 2B non-RMBS assets are lent and Level 2B RMBS assets are borrowed | 0.25 | 0.25 | 0.25 | 0.25 |
| Level 2B non-RMBS assets are lent and Level 2B non-RMBS assets are borrowed | 0.00 | 0.00 | 0.00 | 0.00 |
| Level 2B non-RMBS assets are lent and other assets are borrowed | | | | |
| Other assets are lent and Level 1 assets are borrowed | 1.00 | 1.00 | 1.00 | 1.00 |
| Other assets are lent and Level 2A assets are borrowed | 0.85 | 0.85 | 0.85 | 0.85 |
| Other assets are lent and Level 2B RMBS assets are borrowed | 0.75 | 0.75 | 0.75 | 0.75 |
| Other assets are lent and Level 2B non-RMBS assets are borrowed | 0.50 | 0.50 | 0.50 | 0.50 |
| Other assets are lent and other assets are borrowed | 0.00 | 0.00 | 0.00 | 0.00 |

# Appendix VIII. Cash Flow-based Analysis—Stress Test Haircuts and Run-Off Rates

| A. **Liability Segments - Run off rates** (In percent) | **Mild Scenario SL1** | **Severely Adverse Scenario SL 21** |
|---|---|---|
| LIABILITIES—DEPOSITS | | |
| Retail and Small Business Demand / Notice Deposits | | |
| - Type 1 insured, stable demand deposits | 2.5 | 7.5 |
| - Type 2 insured, stable demand deposits | 2.5 | 10.0 |
| - Insured, less stable demand deposits | 5.0 | 15.0 |
| - Unaffiliated third-party sourced demand deposits | 5.0 | 15.0 |
| - Uninsured demand deposits | 5.0 | 15.0 |
| Retail and Small Business Cashable Term Deposits | | |
| - Type 1 insured, stable | 2.5 | 7.5 |
| - Type 1 insured, less stable | 2.5 | 10.0 |
| - Type 2 insured, stable | 5.0 | 15.0 |
| - Type 2 insured, less stable | 5.0 | 15.0 |
| - Uninsured | 5.0 | 15.0 |
| - Unaffiliated third-party sourced | 5.0 | 15.0 |
| Retail and Small Business Fixed Term Deposits | | |
| - Type 1, insured, stable - (30-day) | 1.5 | 5.0 |
| - Type 1, insured, stable - (60-day) | 1.5 | 5.0 |
| - Type 1, insured, stable - (90-day) | 1.5 | 5.0 |
| - Type 1, insured, stable - (180-day) | 1.5 | 5.0 |
| - Type 1, insured, stable - (1 year) | 1.5 | 5.0 |
| - Type 1, insured, stable - (>1 year) | 1.5 | 5.0 |
| - Type 1, insured, less stable - (30-day) | 2.5 | 7.5 |
| - Type 1, insured, less stable - (60-day) | 2.5 | 7.5 |
| - Type 1, insured, less stable - (90-day) | 2.5 | 7.5 |
| - Type 1, insured, less stable - (180-day) | 2.5 | 7.5 |
| - Type 1, insured, less stable - (1 year) | 2.5 | 7.5 |
| - Type 1, insured, less stable - (>1 year) | 2.5 | 7.5 |
| - Type 2, insured, stable - (30-day) | 1.5 | 5.0 |
| - Type 2, insured, stable - (60-day) | 1.5 | 5.0 |
| - Type 2, insured, stable - (90-day) | 1.5 | 5.0 |
| - Type 2, insured, stable - (180-day) | 1.5 | 5.0 |
| - Type 2, insured, stable - (1 year) | 1.5 | 5.0 |
| - Type 2, insured, stable - (>1 year) | 1.5 | 5.0 |
| - Type 2, insured, less stable - (30-day) | 2.5 | 7.5 |
| - Type 2, insured, less stable - (60-day) | 2.5 | 7.5 |
| - Type 2, insured, less stable - (90-day) | 2.5 | 7.5 |

| A. **Liability Segments - Run off rates** (In percent) | **Mild Scenario SL1** | **Severely Adverse Scenario SL 21** |
|---|---|---|
| - Type 2, insured, less stable - (180-day) | 2.5 | 7.5 |
| - Type 2, insured, less stable - (1 year) | 2.5 | 7.5 |
| - Type 2, insured, less stable - (>1 year) | 2.5 | 7.5 |
| - Uninsured - (30-day) | 5.0 | 15.0 |
| - Uninsured - (60-day) | 5.0 | 15.0 |
| - Uninsured - (90-day) | 5.0 | 15.0 |
| - Uninsured - (180-day) | 5.0 | 15.0 |
| - Uninsured - (1 year) | 5.0 | 15.0 |
| - Uninsured - (>1 year) | 5.0 | 15.0 |
| - Unaffiliated third-party sourced - (30-day) | 5.0 | 15.0 |
| - Unaffiliated third-party sourced - (60-day) | 5.0 | 15.0 |
| - Unaffiliated third-party sourced - (90-day) | 5.0 | 15.0 |
| - Unaffiliated third-party sourced - (180-day) | 5.0 | 15.0 |
| - Unaffiliated third-party sourced - (1 year) | 5.0 | 15.0 |
| - Unaffiliated third-party sourced - (>1 year) | 5.0 | 15.0 |
| - Structured Notes - No Cust Call | 5.0 | 15.0 |
| - Structured Notes - Cust Call | 5.0 | 15.0 |
| Commercial, Corporate and Wholesale Demand Deposits | | |
| - Operational - insured, within approved jurisdiction | 10.0 | 30.0 |
| - Operational - insured, outside of approved jurisdiction | 10.0 | 30.0 |
| - Operational - not Insured | 10.0 | 25.0 |
| - Non-Operational - insured (FI) | 30.0 | 100.0 |
| - Non-Operational - uninsured (FI) | 50.0 | 100.0 |
| - Non-Operational - insured (Corp, Sovereigns central banks, PSE, MDB) | 30.0 | 50.0 |
| - Non-Operational - uninsured (Corp, Sovereigns, central banks, PSE, MDB) | 50.0 | 100.0 |
| Commercial, Corporate and Wholesale Term Demands | | |
| - Operational term, original term <30 days, insured, within approved Jurisdiction | 5.0 | 15.0 |
| - Operational term, original term <30 days, insured, outside of approved jurisdiction | 10.0 | 30.0 |
| - Operational term, original term <30 days, not Insured | 15.0 | 30.0 |
| - Operational term, original term >30 days and non-operational term | 10.0 | 30.0 |
| - Wholesale term | 10.0 | 30.0 |
| Other Deposits/Guarantees | | |
| - Customers' Bankers acceptances issued - 1 month | 75.0 | 100.0 |
| - Customers' Bankers acceptances issued - 2 month | 75.0 | 100.0 |
| - Customers' Bankers acceptances issued - 3 month | 75.0 | 100.0 |
| - Other deposits - Swapped intrabank deposits | 10.0 | 20.0 |
| - Other deposits - Deposits from affiliates | 10.0 | 30.0 |
| LIABILITIES—OTHER LIABILITIES | | |
| Cash Collateral Received | | |
| - Cash collateral received for exchange-traded derivatives | | |

| A. **Liability Segments - Run off rates** (In percent) | Mild Scenario SL1 | Severely Adverse Scenario SL 21 |
|---|---|---|
| - Cash collateral received for OTC derivatives | | |
| - Cash collateral received for short sales | | |
| Commodities Short | | |
| - Precious metal short | | |
| - Precious metal deposits | | |
| - Other commodities short | | |
| Derivative Related Liabilities (DRL) | | |
| - FX and cross currency swap liabilities | | |
| - Other DRL | | |
| Other Liabilities | | |
| LIABILITIES—REPO AND SECURITIES LENT | | |
| Asset Backed Securities (ABS) and Asset Backed Commercial Paper (ABCP) | | |
| - Non-FI Issued ABS (High rated) | 15.0 | 40.0 |
| - Non-FI Issued ABCP (High rated) | 15.0 | 40.0 |
| - FI Issued ABS (High rated) | 15.0 | 40.0 |
| - FI Issued ABCP (High rated) | 15.0 | 40.0 |
| - Non-FI Issued ABS (Medium rated) | 15.0 | 40.0 |
| - Non-FI Issued ABCP (Medium rated) | 15.0 | 40.0 |
| - FI Issued ABS (Medium rated) | 15.0 | 40.0 |
| - FI Issued ABCP (Medium rated) | 15.0 | 40.0 |
| - Non-FI Issued ABS (Low/not rated) | 15.0 | 40.0 |
| - Non-FI Issued ABCP (Low/not rated) | 15.0 | 40.0 |
| - FI Issued ABS (Low/not rated) | 15.0 | 40.0 |
| - FI Issued ABCP (Low/not rated) | 15.0 | 40.0 |
| Bank's Own Securities | | |
| - Bank's own debt not eliminated | 15.0 | 40.0 |
| - Bank's own equity not eliminated | 15.0 | 40.0 |
| Corporate Bonds and Paper | | |
| - Non-FI issued unsecured bonds and paper (High rated) | 15.0 | 40.0 |
| - Non-FI issued covered bonds (High rated) | 15.0 | 40.0 |
| - FI issued unsecured bonds and paper (High rated) | 15.0 | 40.0 |
| - FI issued covered bonds (High rated) | 15.0 | 40.0 |
| - FI issued jumbo covered bonds (High rated) | 15.0 | 40.0 |
| - Non-FI issued unsecured bonds and paper (Medium rated) | 15.0 | 40.0 |
| - Non-FI issued covered bonds (Medium rated) | 15.0 | 40.0 |
| - FI issued unsecured bonds and paper (Medium rated) | 15.0 | 40.0 |
| - FI issued covered bonds (Medium rated) | 15.0 | 40.0 |
| - FI issued jumbo covered bonds (Medium rated) | 15.0 | 40.0 |
| - Non-FI issued unsecured bonds and paper (Low/not rated) | 15.0 | 40.0 |
| - Non-FI issued covered bonds (Low/not rated) | 15.0 | 40.0 |

| A. Liability Segments - Run off rates (In percent) | Mild Scenario SL1 | Severely Adverse Scenario SL 21 |
|---|---|---|
| - FI issued unsecured bonds and paper (Low/not rated) | 15.0 | 40.0 |
| - FI issued covered bonds (Low/not rated) | 15.0 | 40.0 |
| - FI issued jumbo covered bonds (Low/not rated) | 15.0 | 40.0 |
| Equities | | |
| - Eligible Non-Financial Common Equity shares | 15.0 | 40.0 |
| - Eligible Financial Common Equity | 15.0 | 40.0 |
| - Other Equities | 15.0 | 40.0 |
| Government Securities | | |
| - Sovereign | 15.0 | 40.0 |
| - State, Provincial (High rated) | 15.0 | 40.0 |
| - State Municipal Government Securities (High rated) | 15.0 | 40.0 |
| - Supranational and Multilateral Development Bank (High rated) | 15.0 | 40.0 |
| - Sovereign (Medium rated) | 15.0 | 40.0 |
| - State, Provincial (Medium rated) | 15.0 | 40.0 |
| - State Municipal Government Securities (Medium rated) | 15.0 | 40.0 |
| - Supranational and Multilateral Development Bank (Medium rated) | 15.0 | 40.0 |
| - Sovereign (Low/not rated) | 15.0 | 40.0 |
| - State, Provincial (Low/not rated) | 15.0 | 40.0 |
| - State Municipal Government Securities (Low/not rated) | 15.0 | 40.0 |
| - Supranational and Multilateral Development Bank (Low/not rated) | 15.0 | 40.0 |
| Mortgage Backed Securities (MBS) | | |
| - Agency MBS (High rated) | 15.0 | 40.0 |
| - Agency MBS (Medium rated) | 15.0 | 40.0 |
| - Agency MBS (Low/not rated) | 15.0 | 40.0 |
| - Non-Agency Commercial MBS (High rated) | 15.0 | 40.0 |
| - Non-Agency Commercial MBS (Medium rated) | 15.0 | 40.0 |
| - Non-Agency Commercial MBS (Low/not rated) | 15.0 | 40.0 |
| - Non-Agency Residential MBS (High rated) | 15.0 | 40.0 |
| - Non-Agency Residential MBS (Medium rated) | 15.0 | 40.0 |
| - Non-Agency Residential MBS (Low/not rated) | 15.0 | 40.0 |
| LIABILITIES—SECURITIES SOLD SHORT | | |
| Asset Backed Securities (ABS) and Asset Backed Commercial Paper (ABCP) | | |
| - Non-FI Issued ABS (High rated) | 15.0 | 40.0 |
| - Non-FI Issued ABCP (High rated) | 15.0 | 40.0 |
| - FI Issued ABS (High rated) | 15.0 | 40.0 |
| - FI Issued ABCP (High rated) | 15.0 | 40.0 |
| - Non-FI Issued ABS (Medium rated) | 15.0 | 40.0 |
| - Non-FI Issued ABCP (Medium rated) | 15.0 | 40.0 |
| - FI Issued ABS (Medium rated) | 15.0 | 40.0 |
| - FI Issued ABCP (Medium rated) | 15.0 | 40.0 |

| A. Liability Segments - Run off rates (In percent) | Mild Scenario SL1 | Severely Adverse Scenario SL 21 |
|---|---|---|
| - Non-FI Issued ABS (Low/not rated) | 15.0 | 40.0 |
| - Non-FI Issued ABCP (Low/not rated) | 15.0 | 40.0 |
| - FI Issued ABS (Low/not rated) | 15.0 | 40.0 |
| - FI Issued ABCP (Low/not rated) | 15.0 | 40.0 |
| Bank's Own Securities | | |
| - Bank's own debt not eliminated | 15.0 | 40.0 |
| - Bank's own equity not eliminated | 15.0 | 40.0 |
| Corporate Bonds and Paper | | |
| - Non-FI issued unsecured bonds and paper (High rated) | 15.0 | 40.0 |
| - Non-FI issued covered bonds (High rated) | 15.0 | 40.0 |
| - FI issued unsecured bonds and paper (High rated) | 15.0 | 40.0 |
| - FI issued covered bonds (High rated) | 15.0 | 40.0 |
| - FI issued jumbo covered bonds (High rated) | 15.0 | 40.0 |
| - Non-FI issued unsecured bonds and paper (Medium rated) | 15.0 | 40.0 |
| - Non-FI issued covered bonds (Medium rated) | 15.0 | 40.0 |
| - FI issued unsecured bonds and paper (Medium rated) | 15.0 | 40.0 |
| - FI issued covered bonds (Medium rated) | 15.0 | 40.0 |
| - FI issued jumbo covered bonds (Medium rated) | 15.0 | 40.0 |
| - Non-FI issued unsecured bonds and paper (Low/not rated) | 15.0 | 40.0 |
| - Non-FI issued covered bonds (Low/not rated) | 15.0 | 40.0 |
| - FI issued unsecured bonds and paper (Low/not rated) | 15.0 | 40.0 |
| - FI issued covered bonds (Low/not rated) | 15.0 | 40.0 |
| - FI issued jumbo covered bonds (Low/not rated) | 15.0 | 40.0 |
| Equities | | |
| - Eligible Non-Financial Common Equity shares | 15.0 | 40.0 |
| - Eligible Financial Common Equity | 15.0 | 40.0 |
| - Other Equities | 15.0 | 40.0 |
| Government Securities | | |
| - State, Provincial (High rated) | 15.0 | 40.0 |
| - State Municipal (High rated) | 15.0 | 40.0 |
| - Supranational and Multilateral Development Bank (High rated) | 15.0 | 40.0 |
| - Sovereign (Medium rated) | 15.0 | 40.0 |
| - State, Provincial (Medium rated) | 15.0 | 40.0 |
| - State Municipal (Medium rated) | 15.0 | 40.0 |
| - Supranational and Multilateral Development Bank (Medium rated) | 15.0 | 40.0 |
| - Sovereign (Low/not rated) | 15.0 | 40.0 |
| - State, Provincial (Low/not rated) | 15.0 | 40.0 |
| - State Municipal (Low/not rated) | 15.0 | 40.0 |
| - Supranational and Multilateral Development Bank (Low/not rated) | 15.0 | 40.0 |
| Mortgage Backed Securities (MBS) | | |

| A. **Liability Segments - Run off rates** (In percent) | **Mild Scenario SL1** | **Severely Adverse Scenario SL 21** |
|---|---|---|
| - Agency MBS (High rated) | 15.0 | 40.0 |
| - Agency MBS (Medium rated) | 15.0 | 40.0 |
| - Agency MBS (Low/not rated) | 15.0 | 40.0 |
| - Non-Agency Commercial MBS (High rated) | 15.0 | 40.0 |
| - Non-Agency Commercial MBS (Medium rated) | 15.0 | 40.0 |
| - Non-Agency Commercial MBS (Low/not rated) | 15.0 | 40.0 |
| - Non-Agency Residential MBS (High rated) | 15.0 | 40.0 |
| - Non-Agency Residential MBS (Medium rated) | 15.0 | 40.0 |
| - Non-Agency Residential MBS (Low/not rated) | 15.0 | 40.0 |
| LIABILITIES—WHOLESALE ISSURANCE | | |
| Wholesale Secured Debt Issuance | | |
| - Bank's ABCP | 15.0 | 30.0 |
| - Bank's Covered Bonds | 15.0 | 30.0 |
| - Bank's ABS and MBS | 30.0 | 50.0 |
| - Agency MBS and Bonds | 30.0 | 50.0 |
| - Other FI-owned securitizations | 75.0 | 100.0 |
| Wholesale Unsecured Debt Issuance | | |
| - Bankers' acceptances (BAs) | 30.0 | 65.0 |
| - Commercial Paper issued | 50.0 | 65.0 |
| - Certificates of Deposit and Bearer Deposit Notes issued | 30.0 | 65.0 |
| - Wholesale/Commercial Structured Notes | 30.0 | 65.0 |
| - Senior Unsecured Debt issued | 50.0 | 100.0 |
| - Subordinated Debt issued | 50.0 | 100.0 |

| **B. Asset Classes—Haircuts and price shocks** (In percent) | Market Shock Mild SL1 | Market Shock Sev Adverse SL 21 | Haircut Mild SL 1 | Haircut Sev Adverse SL21 |
|---|---|---|---|---|
| ASSETS—CASH RESOURCES | | | | |
| Coins and Bank Notes | 0.00 | 0.00 | 0.00 | 0.00 |
| Deposits with Central Banks - Mandatory | 0.00 | 0.00 | 0.00 | 0.00 |
| Deposits with Central Banks- Unencumbered | 0.00 | 0.00 | 0.00 | 0.00 |
| Deposits with FIs - Demand Deposits at FIs | 0.00 | 0.00 | 0.00 | 0.00 |
| Deposits with FIs - Term Deposits at FIs | 0.00 | 0.00 | 0.00 | 0.00 |
| ASSETS—LOANS | | | | |
| Business and Government Loans | | | | |
| - Fixed Maturity | | | | |
| - Open maturity (with minimum payment) | | | | |
| - Open maturity (with no minimum payment) | | | | |
| Call Loans | | | | |
| - Call Loans (with minimum payment) | | | | |
| - Call Loans (with no minimum payment) | | | | |
| Commercial Mortgages | | | | |
| - EULA Securitized Commercial Mortgages (Balance at maturity) | | | | |
| - EULA Securitized Commercial Mortgages (Payments) | | | | |
| - Encumbered Securitized Commercial Mortgages (Balance at Maturity) | | | | |
| - Encumbered Securitized Commercial Mortgages (Payments) | | | | |
| - Commercial Mortgage - Insured (Balance at Maturity) | | | | |
| - Commercial Mortgage - Insured (Payments) | | | | |
| - Commercial Mortgage - Not Insured (Balance at Maturity) | | | | |
| - Commercial Mortgage - Not Insured (Payments) | | | | |
| Other Loans | | | | |
| - Credit Cards | | | | |
| - Swapped Intrabank Loans | | | | |
| - Loans to Affiliates | | | | |
| - Customer's Liability under Acceptance | | | | |
| Personal Loans | | | | |
| - Fixed Maturity | | | | |
| - Open maturity (with minimum payment) | | | | |
| - Open maturity (with no minimum payment) | | | | |
| Residential Mortgages | | | | |
| - EULA Securitized Residential Mortgages - (Balance at Maturity) | | | | |
| - EULA Securitized Residential Mortgages - (Payments) | | | | |
| - Encumbered Securitized Residential Mortgages - (Balance at Maturity) | | | | |
| - Encumbered Securitized Residential Mortgages - (Payments) | | | | |
| - Residential Mortgage - Insured - (Balance at Maturity) | | | | |
| - Residential Mortgage - Insured - (Payments) | | | | |

| **B. Asset Classes—Haircuts and price shocks** (In percent) | Market Shock Mild SL1 | Market Shock Sev Adverse SL 21 | Haircut Mild SL 1 | Haircut Sev Adverse SL21 |
|---|---|---|---|---|
| - Residential Mortgage - Not Insured - (Balance at Maturity) | | | | |
| - Residential Mortgage - Not Insured - (Payments) | | | | |
| ASSETS—OTHER ASSETS | | | | |
| Cash Collateral Pledged | | | | |
| - Cash collateral pledged for exchange-traded derivatives | 0.00 | 0.00 | 100.00 | 100.00 |
| - Cash collateral pledged for OTC derivatives | 0.00 | 0.00 | 100.00 | 100.00 |
| - Cash collateral pledged for short sales | 0.00 | 0.00 | 100.00 | 100.00 |
| Commodities | | | | |
| - Precious Metals | 0.00 | 0.00 | 100.00 | 100.00 |
| - Precious Metal Loans | 0.00 | 0.00 | 100.00 | 100.00 |
| - Other Commodities Held | 0.00 | 0.00 | 100.00 | 100.00 |
| Derivative Related Assets (DRA) | | | | |
| - FX and Cross Currency Swap Assets | 0.00 | 0.00 | 100.00 | 100.00 |
| - Other DRA | 0.00 | 0.00 | 100.00 | 100.00 |
| Other Assets - Other Assets | 0.00 | 0.00 | 100.00 | 100.00 |
| ASSETS—REVERSE REPO AND SECURITIES BORROWED | | | | |
| Asset Backed Securities (ABS) and Asset Backed Commercial Paper (ABCP) | | | | |
| - Non-FI Issued ABS and ABCP (High rated) - Non-FI Issued ABS (High rated) | | | | |
| - Non-FI Issued ABS and ABCP (High rated) - Non-FI Issued ABCP (High rated) | | | | |
| - FI Issued ABS and ABCP (High rated) - FI Issued ABS (High rated) | | | | |
| - FI Issued ABS and ABCP (High rated) - FI Issued ABCP (High rated) | | | | |
| - Non-FI Issued ABS and ABCP (Medium rated) - Non-FI Issued ABS (Medium rated) | | | | |
| - Non-FI Issued ABS and ABCP (Medium rated) - Non-FI Issued ABCP (Medium rated) | | | | |
| - FI Issued ABS and ABCP (Medium rated) - FI Issued ABS (Medium rated) | | | | |
| - FI Issued ABS and ABCP (Medium rated) - FI Issued ABCP (Medium rated) | | | | |
| - Non-FI Issued ABS and ABCP (Low/not rated) - Non-FI Issued ABS (Low/not rated) | | | | |
| - Non-FI Issued ABS and ABCP (Low/not rated) - Non-FI Issued ABCP (Low/not rated) | | | | |
| - FI Issued ABS and ABCP (Low/not rated) - FI Issued ABS (Low/not rated) | | | | |
| - FI Issued ABS and ABCP (Low/not rated) - FI Issued ABCP (Low/not rated) | | | | |
| Bank's Own Securities | | | | |
| - Not Eliminated - Bank's own debt not eliminated | | | | |
| - Not Eliminated - Bank's own equity not eliminated | | | | |
| Corporate Bonds and Paper | | | | |
| - Non-FI issued unsecured bonds and paper (High rated) | | | | |
| - Non-FI issued covered bonds (High rated) | | | | |
| - FI issued unsecured bonds and paper (High rated) | | | | |
| - FI issued covered bonds (High rated) | | | | |
| - FI issued jumbo covered bonds (High rated) | | | | |
| - Non-FI issued unsecured bonds and paper (Medium rated) | | | | |

| B. **Asset Classes—Haircuts and price shocks** (In percent) | Market Shock Mild SL1 | Market Shock Sev Adverse SL 21 | Haircut Mild SL 1 | Haircut Sev Adverse SL21 |
|---|---|---|---|---|
| - Non-FI issued covered bonds (Medium rated) | | | | |
| - FI issued unsecured bonds and paper (Medium rated) | | | | |
| - FI issued covered bonds (Medium rated) | | | | |
| - FI issued jumbo covered bonds (Medium rated) | | | | |
| - Non-FI issued unsecured bonds and paper (Low/not rated) | | | | |
| - Non-FI issued covered bonds (Low/not rated) | | | | |
| - FI issued unsecured bonds and paper (Low/not rated) | | | | |
| - FI issued covered bonds (Low/not rated) | | | | |
| - FI issued jumbo covered bonds (Low/not rated) | | | | |
| Equities | | | | |
| - Eligible Non-Financial Common Equity shares | | | | |
| - Eligible Financial Common Equity | | | | |
| - Other Equities | | | | |
| Government Securities | | | | |
| - Sovereign (High rated) | | | | |
| - State, Provincial (High rated) | | | | |
| - State Municipal (High rated) | | | | |
| - Supranational and Multilateral Development Bank (High rated) | | | | |
| - Sovereign (Medium rated) | | | | |
| - State, Provincial (Medium rated) | | | | |
| - State Municipal (Medium rated) | | | | |
| - Supranational and Multilateral Development Bank (Medium rated) | | | | |
| - Sovereign (Low/not rated) | | | | |
| - State, Provincial (Low/not rated) | | | | |
| - State Municipal (Low/not rated) | | | | |
| - Supranational and Multilateral Development Bank (Low/not rated) | | | | |
| Mortgage Backed Securities (MBS) | | | | |
| - Agency MBS (High rated) | | | | |
| - Agency MBS (Medium rated) | | | | |
| - Agency MBS (Low/not rated) | | | | |
| - Non-Agency Commercial MBS (High rated) | | | | |
| - Non-Agency Commercial MBS (Medium rated) | | | | |
| - Non-Agency Commercial MBS (Low/not rated) | | | | |
| - Non-Agency Residential MBS (High rated) | | | | |
| - Non-Agency Residential MBS (Medium rated) | | | | |
| - Non-Agency Residential MBS (Low/not rated) | | | | |
| ASSETS—SECURITIES | | | | |
| Asset Backed Securities (ABS) and Asset Backed Commercial Paper (ABCP) | | | | |
| - Non-FI Issued ABS (High rated) | 0.00 | 5.00 | 5.00 | 10.00 |

| **B. Asset Classes—Haircuts and price shocks** (In percent) | Market Shock Mild SL1 | Market Shock Sev Adverse SL 21 | Haircut Mild SL 1 | Haircut Sev Adverse SL21 |
|---|---|---|---|---|
| - Non-FI Issued ABCP (High rated) | 0.00 | 5.00 | 5.00 | 10.00 |
| - FI Issued ABS (High rated) | 0.00 | 5.00 | 15.00 | 30.00 |
| - FI Issued ABCP (High rated) | 0.00 | 5.00 | 15.00 | 30.00 |
| - Non-FI Issued ABS (Medium rated) | 2.50 | 7.50 | 15.00 | 30.00 |
| - Non-FI Issued ABCP (Medium rated) | 2.50 | 7.50 | 15.00 | 30.00 |
| - FI Issued ABS (Medium rated) | 2.50 | 7.50 | 25.00 | 50.00 |
| - FI Issued ABCP (Medium rated) | 2.50 | 7.50 | 25.00 | 50.00 |
| - Non-FI Issued ABS (Low/not rated) | 5.00 | 10.00 | 25.00 | 50.00 |
| - Non-FI Issued ABCP (Low/not rated) | 5.00 | 10.00 | 25.00 | 50.00 |
| - FI Issued ABS (Low/not rated) | 5.00 | 10.00 | 50.00 | 100.00 |
| - FI Issued ABCP (Low/not rated) | 5.00 | 10.00 | 50.00 | 100.00 |
| Bank's Own Securities | | | | |
| - Not Eliminated - Bank's own debt not eliminated | 10.00 | 40.00 | 100.00 | 100.00 |
| - Not Eliminated - Bank's own equity not eliminated | 10.00 | 40.00 | 100.00 | 100.00 |
| Corporate Bonds and Paper | | | | |
| - Non-FI issued unsecured bonds and paper (High rated) | 0.00 | 5.00 | 10.00 | 20.00 |
| - Non-FI issued covered bonds (High rated) | 0.00 | 5.00 | 5.00 | 10.00 |
| - FI issued unsecured bonds and paper (High rated) | 0.00 | 10.00 | 10.00 | 20.00 |
| - FI issued covered bonds (High rated) | 0.00 | 10.00 | 5.00 | 15.00 |
| - FI issued jumbo covered bonds (High rated) | 0.00 | 5.00 | 5.00 | 15.00 |
| - Non-FI issued unsecured bonds and paper (Medium rated) | 0.00 | 7.50 | 10.00 | 20.00 |
| - Non-FI issued covered bonds (Medium rated) | 0.00 | 7.50 | 5.00 | 10.00 |
| - FI issued unsecured bonds and paper (Medium rated) | 0.00 | 7.50 | 25.00 | 40.00 |
| - FI issued covered bonds (Medium rated) | 5.00 | 10.00 | 10.00 | 20.00 |
| - FI issued jumbo covered bonds (Medium rated) | 5.00 | 10.00 | 10.00 | 20.00 |
| - Non-FI issued unsecured bonds and paper (Low/not rated) | 5.00 | 10.00 | 20.00 | 40.00 |
| - Non-FI issued covered bonds (Low/not rated) | 5.00 | 10.00 | 10.00 | 20.00 |
| - FI issued unsecured bonds and paper (Low/not rated) | 5.00 | 15.00 | 50.00 | 100.00 |
| - FI issued covered bonds (Low/not rated) | 5.00 | 15.00 | 20.00 | 40.00 |
| - FI issued jumbo covered bonds (Low/not rated) | 5.00 | 15.00 | 20.00 | 40.00 |
| Equities | | | | |
| - Eligible Non-Financial Common Equity shares | 10.00 | 40.00 | 30.00 | 50.00 |
| - Eligible Financial Common Equity | 10.00 | 40.00 | 100.00 | 100.00 |
| - Other Equities | 10.00 | 40.00 | 50.00 | 100.00 |
| Government Securities | | | | |
| - Sovereign (High rated) | 0.00 | 2.50 | 2.50 | 5.00 |
| - State, Provincial (High rated) | 0.00 | 5.00 | 5.00 | 10.00 |
| - State Municipal (High rated) | 0.00 | 5.00 | 10.00 | 20.00 |
| - Supranational and Multilateral Development Bank (High rated) | 0.00 | 3.00 | 5.00 | 10.00 |

| **B. Asset Classes—Haircuts and price shocks** (In percent) | Market Shock Mild SL1 | Market Shock Sev Adverse SL 21 | Haircut Mild SL 1 | Haircut Sev Adverse SL21 |
|---|---|---|---|---|
| - Sovereign (Medium rated) | 0.00 | 2.50 | 10.00 | 10.00 |
| - State, Provincial (Medium rated) | 0.00 | 5.00 | 15.00 | 25.00 |
| - State Municipal (Medium rated) | 0.00 | 5.00 | 20.00 | 30.00 |
| - Supranational and Multilateral Development Bank (Medium rated) | 0.00 | 2.50 | 5.00 | 10.00 |
| - Sovereign (Low/not rated) | 0.00 | 10.00 | 20.00 | 30.00 |
| - State, Provincial (Low/not rated) | 0.00 | 5.00 | 50.00 | 60.00 |
| - State Municipal (Low/not rated) | 5.00 | 15.00 | 100.00 | 100.00 |
| - Supranational and Multilateral Development Bank (Low/not rated) | 5.00 | 15.00 | 40.00 | 60.00 |
| Mortgage Backed Securities (MBS) | | | | |
| - Agency MBS (High rated) | 2.50 | 7.50 | 5.00 | 10.00 |
| - Agency MBS (Medium rated) | 5.00 | 10.00 | 10.00 | 20.00 |
| - Agency MBS (Low/not rated) | 5.00 | 15.00 | 20.00 | 40.00 |
| - Non-Agency Commercial MBS (High rated) | 0.00 | 5.00 | 10.00 | 20.00 |
| - Non-Agency Commercial MBS (Medium rated) | 0.00 | 5.00 | 30.00 | 50.00 |
| - Non-Agency Commercial MBS (Low/not rated) | 0.00 | 5.00 | 50.00 | 100.00 |
| - Non-Agency Residential MBS (High rated) | 0.00 | 5.00 | 10.00 | 20.00 |
| - Non-Agency Residential MBS (Medium rated) | 0.00 | 5.00 | 30.00 | 50.00 |
| - Non-Agency Residential MBS (Low/not rated) | 0.00 | 5.00 | 50.00 | 75.00 |

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