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SWITZERLAND

FINANCIAL SECTOR ASSESSMENT PROGRAM

June 2019

TECHNICAL NOTE—STRESS TESTING THE BANKING SECTOR

This Technical Note on Stress Testing the Banking Sector for the Switzerland 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 May 2019.

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June 12, 2019

TECHNICAL NOTE

STRESS TESTING THE BANKING SECTOR

Prepared By
Monetary and Capital Markets Department

This Technical Note was prepared by IMF staff in the context of the Financial Sector Assessment Program in Switzerland. 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

CONTENTS

FIGURES

TABLES

APPENDICES

Glossary

ABS	Asset backed securities
AFS	Available for sale
ALM	Asset and liability management
BBA	Building Block Analysis
bps	Basis Points
BS	Balance Sheet
BU	Bottom-up (stress test)
CCAR	Comprehensive Capital Analysis and Review
CCB	Capital Conservation Buffer
CCF	Credit Conversion Factor
CCR	Counterparty Credit Risk
CDS	Credit Default Swap
CET1	Common Equity Tier 1
CHF	Swiss francs
CoVaR	Conditional Value at Risk
CPBP	Clients, Products and Business Processes
CVA	Credit Valuation Adjustment
DFBs	Domestically Focused Banks
D-SIB	Domestic Systemically Important Bank
ECB	European Central Bank
EAD	Exposure at Default
EDF	Expected Default Frequency
EM	Emerging Market
ES	Expected Shortfall
EU	European Union
EUR	euro
F&C	Fees and Commissions
FINMA	Swiss Financial Market Supervisory Authority
FMOLS	Fully modified ordinary least square
FRTB	Fundamental Review of the Trading Book
FSAP	Financial Sector Assessment Program
FSR	Financial Stability Report
FVO	Fair Value Option
FX	Foreign Exchange
GAAP	Generally Accepted Accounting Principles
GDP	Gross domestic product
GFC	Global Financial Crisis
GFM	Global Macrofinancial Model
GMM	Generalized Method of Moments
GP	General Provisions

G-SIB	Global Systemically Important Bank
HFT	Held for trading
HQLA	High-quality liquid assets
HTM	Held to maturity
HY	High-yield
IB	Investment Banking
IG	Investment-grade
IMF	International Monetary Fund
IFRS	International Financial Reporting Standards
IRB	Internal ratings-based (approach)
IRR	Interest Rate Risk
IRRBB	Interest Rate Risk in the Banking Book
LCR	Liquidity coverage (ratio)
LGD	Loss-given default
LMT	Liquidity Monitoring Templates
LPA	Loss Potential Analysis
LRD	Leverage Ratio Denominator
LTI	Loan-to-Income
LTV	Loan-to-Value
MBS	Mortgage backed securities
MiFID II	Markets and Financial Instruments Directive II
MiFIR	Markets and Financial Instruments Regulation
NII	Net interest income
nim	Net interest margin
NPL	Nonperforming loan
P&L	Profit and Loss
PD	Probability of Default
PiT	Point-in-time
RAM	Risk Assessment Matrix
RMBS	Residential Mortgage-backed Securities Business
ROA	Return on Assets
RWA	Risk-Weighted Assets
SFTs	Securities Financing Transactions
SME	Small- and Medium-sized Enterprise
SNB	Swiss National Bank
SP	Specific Provisions
STA	Standardized (approach)
STeM	Stress Test Matrix (for FSAP stress tests)
TBTF	Too Big to Fail
TD	Top-down (stress test)
TTC	Through-the-cycle

USD	U.S. dollar
VaR	Value at Risk
VIX	Volatility Index
WEO	World Economic Outlook
YTM	Yield to Maturity

EXECUTIVE SUMMARY[1]

The Swiss banking system is large and highly concentrated. Banking system total assets reached about 470 percent of nominal gross domestic product (GDP) in 2018, representing over 50 percent of total financial sector assets. The two largest banks (UBS and Credit Suisse)—both global systemically important banks (G-SIBs) and domestic systemically important banks (D-SIBs)—account for about one half of banking assets. Switzerland has three other D-SIBs and a large private banking industry. With one-quarter of global assets under management, Switzerland remains one of the biggest global cross-border financial centers for private banking.

Switzerland's banking sector landscape has changed since the global financial crisis (GFC). The aggregate balance sheet (BS) for all banks in Switzerland fell sharply in 2008–09 from a peak of 600 percent of nominal GDP in 2007, mainly attributable to lower G-SIBs' foreign assets and liabilities. The two G-SIBs have strengthened their resilience by exiting non-core activities and shifting their focus away from investment banking (IB) to wealth management. Also, they have settled some litigation charges and significantly reduced costs.

The Financial Sector Assessment Program (FSAP) stress testing exercise comprises a comprehensive analysis of solvency and liquidity risks in the Swiss banking sector. Macroprudential stress tests were conducted to assess the banking system's ability to withstand losses without amplifying shocks to the real economy. One set of tests used macroeconomic scenarios to capture the impact of a drastic deterioration in macrofinancial conditions on the solvency of banks. A second batch of tests used hypothetical deteriorations in liquidity and equity markets to gauge the impact of these developments on individual entities as well as on the risk of interbank contagion.

Access to confidential firm-specific supervisory data (a first for Switzerland) allowed the FSAP team to take account of key risks exposed during the global financial crisis. One of the most important lessons of the financial crisis for the Swiss banks was the fall in profits owing to the negative results obtained in trading operations, commission business and services, and litigation provisions. Access to supervisory data allowed the FSAP team to assess latent risks related to the structure of the mortgage portfolio, risks from maturity transformation, and the exposure to complex products including securitized products, and underwriting exposures to leverage loans. The IMF stress test captures additional innovations relative to previous FSAPs including the quantification of basis risk for cash and derivative positions, operational risk, and solvency and liquidity interactions from contingent liquidity-at-risk.

The financial sector remains resilient in the face of the rising cyclical vulnerabilities, but there is a need to closely monitor risks. The banking stress test analysis shows that the resilience of

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[1] This Technical Note was prepared by Laura Valderrama (Monetary and Capital Markets Department, IMF).

Swiss banks has improved. Capital buffers are in aggregate sizeable relative to immediate threats. Macroeconomic shocks and market risks deplete capital ratios by 440 basis points at the low point of stress. In the specific adverse scenario considered, domestically-oriented banks are relatively more resilient than the G-SIBs and Private banks on the back of their lower exposure to market risk, business risk, and operational risk. Comparable, if more favorable, results were obtained by the Swiss National Bank (SNB) Top-Down stress test and the bottom-up (BU) exercise run by the G-SIBs based on a stress scenario provided by the IMF.[2] The banking system as a whole has ample liquidity in total currency, but some banks are vulnerable to a shortage of U.S. dollar (USD) liquidity and to sustained stressful conditions in wholesale markets. While Dollar liquidity poses a potential challenge for some banks, the banks with a deficit in USD have excess in euro (EUR) liquidity and could use both the Swiss francs (CHF)/USD and EUR/USD swap markets to tap USD funding. The network analysis suggests that the risk of contagion through interbank exposures within the Swiss interbank market is currently low and banks' systemic risk, measured by the delta Conditional Value at Risk (CoVaR) of the most systemic bank, has halved in 2018 relative to the financial crisis.

To facilitate the monitoring of financial stability risks, the Swiss authorities are encouraged to secure availability of more timely and granular data to minimize risks going undetected. Increasing granularity in supervisory returns would allow the SNB and FINMA to leverage, to a greater extent, banks' regular supervisory reporting into their stress testing framework. This would also support the consistency of data sources when aggregating data within supervisory stress tests and when developing quantitative and qualitative indicators of systemic risk.

The Swiss authorities' stress testing framework could be enhanced along several dimensions. The analysis of risk interactions could also be deepened, particularly regarding the interaction between solvency and liquidity risks and the modeling of feedback loops between banks. The Swiss authorities should also consider including major private banks in the stress testing frameworks. The failure of a major private bank would expose the Swiss banking system to significant reputational risk, could spread to other Swiss banks through their wealth management activities and lead to potential contagion in funding markets.

FINMA is encouraged to remain vigilant on liquidity pressures. This includes from non-maturing liabilities, intragroup transactions, cross-border operations, and contingent flows linked to changes in market prices, a downgrade in the bank's credit rating, and margin calls in derivative positions and securities financing transactions (SFTs), as well as to sudden changes in market haircuts particularly on other than high-quality liquid assets (HQLA). This will be supported by the continued monitoring of liquidity coverage ratio (LCR) pressures in USD and the drivers of asset encumbrance.

[2] Additional stress scenarios explored by Swiss authorities indicate that domestically oriented banks would be vulnerable to harsher interest rate shocks, leading to a sharp decline in net interest income due to maturity mismatches, in combination with a surge in write-downs on domestic mortgages.

Table 1. Switzerland: Main Recommendations on Stress Testing

Recommendations and Responsible Authorities	Timing*	Priority**
Data Infrastructure		
(General Recommendation) Secure the availability of more timely, consistent, and granular data, supported by user-friendly IT systems (SNB/FINMA).	MT	H
Enhance the granularity of regular reporting with respect to banks' securities and investment portfolios (breakdowns by products, accounting categories, counterparty categories, regions, remaining maturities) (SNB).	MT	H
Enhance the Interest Rate Risk report by including a breakdown of Instruments by residual maturity and increasing the granularity of Category I and II by product and counterparty as envisaged in the revised reporting starting in March 2019 (FINMA/SNB).	ST	H
Report geographical breakdown of material exposures by residence of the obligor (internal ratings-based (IRB), STA exposures) (FINMA).	MT	M
Analytical Infrastructure		
Further develop analysis on risk interaction, particularly the interaction between solvency and liquidity risks and the modeling of feedback loops between banks (SNB).	MT	M
Stress Testing Framework		
Increase the granularity of stress tests for other D-SIBs, commensurate with their specific risk profiles (FINMA/SNB).	MT	M
Expand perimeter of top-down stress test analysis to large private banks (SNB).	MT	M

***** Timing: C: Continuous; I: Immediate (<1 year); ST: Short Term (1–2 years); MT: Medium Term (3–5 years)
****** Priority: H: High; M: Medium; L: Low

AN EVOLVING BANKING SECTOR

A. Challenging Macrofinancial Environment

1. The Swiss economy is slowing, global growth forecasts for 2019–20 have been revised down slightly, while interest rates are forecasted to remain exceptionally low. A growth slowdown in Swiss GDP is expected this year, close to potential, as world trade cools, and inflation is forecasted to decline. Policy interest rates of major central banks are expected to stay historically low and Swiss policy rates to remain close to their current level.

2. The SNB's decision in January 2015 to reduce the interest rate on sight deposits to -75 basis points, has put pressure on profitability of domestic banks. The direct costs incurred by the negative rates are limited by the exemption threshold.[3] However, the return on other short-term liquid assets in CHF has turned negative, and interest margins have narrowed, pushing down profitability. Competition between the banks and the decision not to pass-through negative rates to retail customers has reduced banks' interest margin by about one-third since 2008 to 1.21 percent in 2017. The prolonged period of low interest rates, which markets expect to continue, has encouraged risk taking. With a positive credit gap since 2009, and private sector leverage and banks' real estate exposure already high, macrofinancial risks will need to be monitored carefully.

B. Banking Sector Trends

3. The banking system is large and highly concentrated (Figure 1). Banking system total assets reached about 470 percent of nominal GDP in 2018, representing over 50 percent of total financial sector assets.[4] The two largest banks (UBS and Credit Suisse)—both G-SIBs—account for about half of banking assets. Switzerland has significant cantonal banks, Raiffeisen cooperative banks, private banks, and some regional banks. In addition to the two G-SIBs, the Swiss authorities have designated three other D-SIBs: PostFinance; Raiffeisen; and Zürcher Kantonalbank.[5]

4. Swiss banks follow different business models with respect to the activities that they undertake. While G-SIBs' strategic focus includes global wealth management, universal banking in Switzerland, competitive investment banking and asset management business, cantonal banks' mandates focus on their contribution to the economic development of their home region, including through the provision of mortgage financing.[6] Raiffeisen banks' core activities include mortgage and savings business across Swiss regions, while private banks concentrate on wealth management activities with a global footprint and focus on recurring fee generation from services linked to

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[3] The exemption threshold is set at a level of 20 times the minimum reserve requirements.

[4] Additionally, off-balance sheet items managed by banks are reported by the bankers' association to total some CHF 6.6 trillion (about 950 percent of GDP).

[5] PostFinance is the state-owned financial services arm of Swiss Post. The government has proposed to partially privatize PostFinance and provide it with a full range banking license.

[6] Some large cantonal banks are also engaged in corporate banking, wealth management, and select trade-financing operations.

investment advisory and succession planning. Asset management and technology services are also meaningful profit contributors for some private banks.

5. While the two G-SIBs have deleveraged and de-risked their balance sheets, they still represent over 250 percent of GDP. The aggregate balance sheet for all banks in Switzerland fell sharply in 2008–09 from a 600 percent peak of nominal GDP in 2007, mainly attributable to lower G-SIBs' foreign assets and liabilities. The two G-SIBs have strengthened their resilience by exiting non-core activities and shifting their focus away from investment banking to wealth management. Also, they have settled some litigation charges and significantly reduced costs. Consequently, their balance sheet has downsized from a peak of over 400 percent of GDP in 2008 while their capital base has strengthened to an average 13.1 percent Common Equity Tier 1 (CET1).

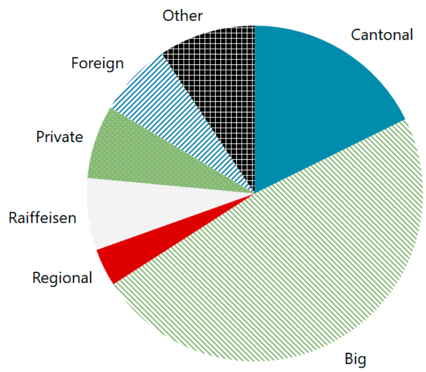
Figure 1. Switzerland: Banking System Overview

The Swiss banking sector is large, diverse, and highly concentrated despite G-SIBs' post-crisis deleveraging.

The Swiss banking sector is highly concentrated with the two G-SIBs accounting for about half of banking sector assets.

Banking Sector Structure, 2017

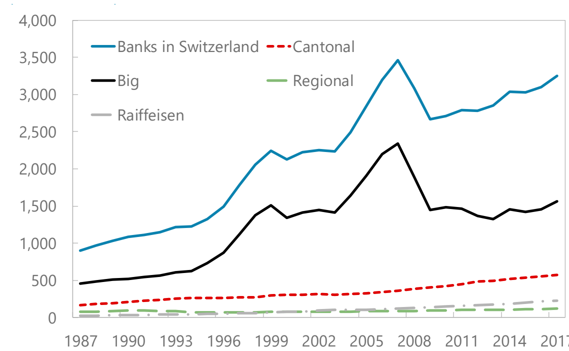
(Fraction of Total Assets)



The aggregate balance sheet of the banking system fell sharply in 2008–09 from 600 percent of nominal GDP in 2007 to 470 percent in 2018.

Banking Sector Assets

(In billions of CHF)



Source: SNB Surveys and IMF estimates.

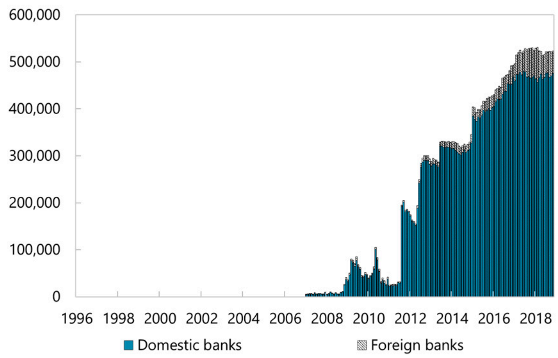
6. The global footprint of the G-SIBs is reflected in a cross-jurisdictional activity of 60 percent of assets. At the same time, their interconnectedness, measured by their intra-financial claims (liabilities) reached 20 percent (25 percent) of assets in 2018. The two G-SIBs are also domestically important with a 33 percent share in corporate loans, 27 percent share in the mortgage market (down from 35 percent in 2008), and 33 percent in customer deposits. Employment by the two G-SIBs has dropped to 35 percent of total banking system staff from a peak of 50 percent in 2007; has happened on the back of a 20 percent overall contraction relative to pre-crisis employment in the banking industry.

Figure 2. Switzerland: Banking Sector Developments

Banks have de-risked and profits have stabilized, despite pressures from narrow margins.

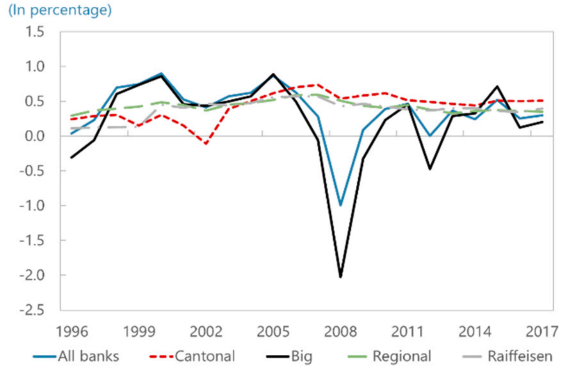
A quarter of unconsolidated banking system assets, reaching CHF 460 million, are invested in sight deposits at the SNB at -75 basis points (bps), although negative rates only apply to deposits above the exemption threshold…

Sight Deposits at SNB
(In million CHF)



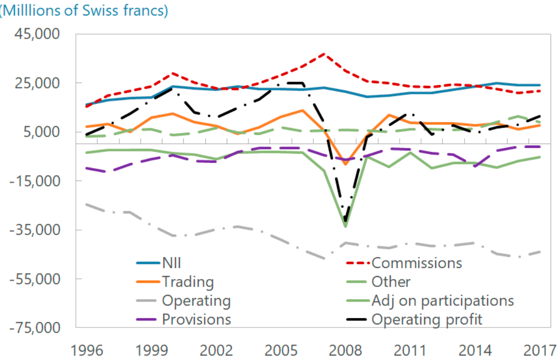
…despite the drag on profitability from negative rates, return on assets (ROA) has stabilized at 0.3 percent.

Return on Assets
(In percentage)



Over one third of operating income is generated by commissions mainly from securities trading and investment banking…

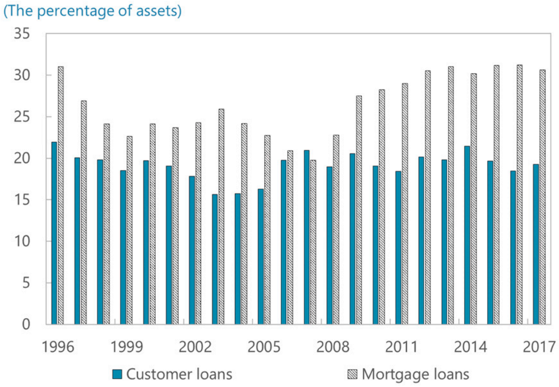
Breakdown of Profits
(Milllions of Swiss francs)



Sources: Segoe UI - Size 18

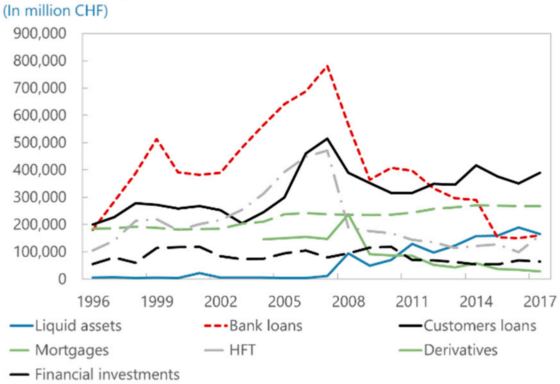
…with one third of total assets allocated to mortgage loans and over half of customer loans being secured.

Loan Allocation
(The percentage of assets)



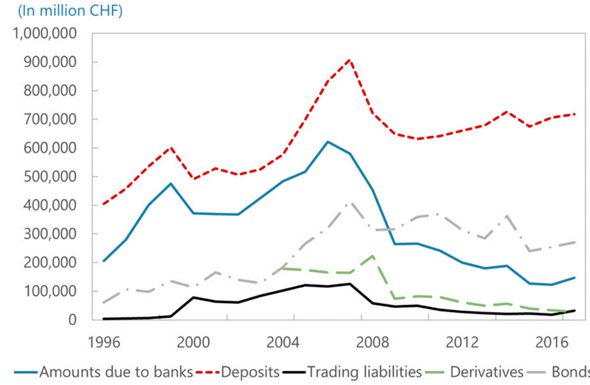
G-SIBs have deleveraged by one-third their balance sheet driven by a collapse of bank loans and trading assets…

Assets of Big Banks
(In million CHF)



…mirrored by a drop in funding from banks and a contraction of customer deposits.

Liabilities of Big Banks
(In million CHF)



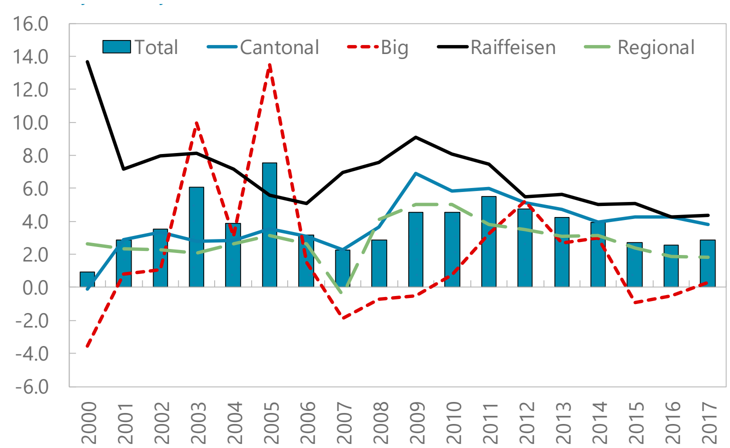
Source: SNB and IMF staff estimates.

7. **While the G-SIBs' profitability has improved gradually since 2008, it remains below pre-financial crisis levels (Figure 2).** In 2017, excluding one-off tax effects from the U.S. tax reform, the G-SIBs showed a stronger operating performance, reflecting progress made in executing the post-crisis strategic plans to transform and shrink the investment banks' asset base and unwind non-core business. The G-SIBs' focus is now gradually shifting away from downsizing and reducing legacy assets, and toward new growth strategies and business initiatives, including in warehouse lending and securities-based lending.

8. **The exceptionally low level of mortgage rates has encouraged mortgage lending, mainly in fixed rate loans (Figure 3).** Domestic mortgage loans continued to rise and in 2017 stood at CHF 975 billion, an increase of 2.7 percent, representing under 30 percent of total assets. The growth rate has been uneven across bank categories. While Raiffeisen banks' mortgage portfolio grew at 4.4 percent, cantonal banks posted a 3.8 percent growth rate, and G-SIBs' mortgage portfolio remained flat in 2017. Fixed interest rates account for at least 75 percent of total domestic mortgage loans, while the rest corresponds to money market mortgages linked to Libor and redeemable mortgages with adjustable rates ('variable' mortgages), are estimated to represent about 15 percent and less than 10 percent of outstanding mortgages, respectively.

Figure 3. Switzerland: Mortgage Lending Growth
(In percent; year-on-year)

Low mortgage rates have encouraged sustained lending growth in mortgages, particularly among Raiffeisen banks.



Source: SNB Surveys and IMF estimates.

9. **The risk weight density for the largest banking groups has increased notwithstanding an improvement in regulatory capital ratios.** During the last 3 years, the aggregate risk-weighted assets (RWA) density of the G-SIBs increased from 24 to 29 percent in 2018: Q1 driven by the phase-in of FINMA regulatory multipliers on several credit internal ratings-based (IRB) portfolios mainly linked to real estate, and investment banking (IB) corporate portfolios. The decrease in the leverage ratio denominator (LRD) was due to a compression of leverage exposures from derivatives,

SFTs, and off-balance sheet positions. For domestically focused commercial banks[7] (DFBs), the risk-weight density reached 41.4 percent in 2018: Q1 with some large banks increasing the STA risk weights on the mortgage lending portfolio particularly for income-producing real estate loans. At the same time, capital ratios have increased to 13.1 percent CET1 for the G-SIBs and 16.4 percent CET1 for the DFBs.

KEY RISK FACTORS

A. Risks and Vulnerabilities

10. Banking system soundness indicators have been improving, but key challenges remain. For the aggregate banking system, Tier 1 capital has risen to 17 percent of risk-weighted assets, and asset quality remains strong with 0.7 percent of nonperforming loans (NPLs). Bank liquidity has improved significantly, and the LCR stands at about 160 percent. Despite the drag on profitability from negative interest rates, banks' return on assets has stabilized at 0.3 percent due to an improvement in trading revenues, a shift towards wealth management activities, increased cost efficiency, and a reduction in provisions. Notwithstanding recent improvements:

- While the G-SIBs are more diversified than other banks in terms of business activities, regions, and currencies, they are relatively more vulnerable under stressed conditions to corporate defaults, stressed leveraged and securitized products, lack of hedge effectiveness and basis risk, volatile IB sales, low performance fees, and reduced net new money inflows in wealth management;

- Domestic banks are mainly exposed to a sudden and abrupt correction in the Swiss real estate market and to a sharp snapback in interest rates on the back of their exposure to the mortgage business and to maturity transformation risk; and

- Private banks show high sensitivity to stressed earnings from reduced performance fees in asset management and wealth management activities, some market risk in fair-valued portfolios, adverse regulatory changes and competitive pressures in financial markets that could impair the advisory business. They are also exposed to operational risks linked to fraud, and clients, products, and business practices.

11. The mission's Risk Assessment Matric (RAM) (Appendix I) identified the following key macrofinancial risks for the banking sector:

- **Tighter financial conditions and volatile trading business.** This would generate a generalized sell-off in stock markets, and the reemergence of sovereign stress in the Euro Area. Money market pressures would push up funding costs and lending rates would surge. Higher debt service would risk affordability risk for leveraged firms, stretched households, and vulnerable

[7] DBFs include banks whose domestic credit exposure amounts to at least 50 percent of their total balance sheet. They represent one third of total banking system assets.

sovereigns. Trading business would suffer as volatile markets would push clients to seek shelters in cash hurting transaction-driven capital market revenue and lowering performance fees.

- **Severe global recession and low net new money.** A hard Brexit without a deal in place, a U.S. trade war against Europe or China, concerns over public debt sustainability in Europe, or a credit cycle downturn in emerging markets (EMs) would undermine global medium-term growth, resulting in a considerable increase in default rates on claims against corporates and financial institutions. Global private banking would be hit by additional external risks in emerging markets, such as the inability to exchange currency, risk of capital controls, restrictions to capital transfers, political risk, or inability to enforce the right to sell collateral due to legal prescriptions. Net new money outflows would surge hurting the wealth and asset management industry.

- **Regional tensions and regulatory pressures.** A significant deterioration of bilateral relations with the European Union (EU) would impact Switzerland’s externally-oriented economy eroding competitiveness and weighing on economic growth in Switzerland. Marked changes in tax and regulatory requirements would impact the wealth-management industry's putting pressure on Swiss banks’ business models and feeding adverse feedback loops.

- **Large correction in real estate prices.** A sharp reversal of historically high house prices in Switzerland would pose material credit risks, due to domestic banks' high exposure to real estate markets. Falls in asset prices would widen loan-to-value (LTV) ratios, trigger margin calls, and increase borrowers’ amortization schedules. Affordability risk would surge and default events would spread to the nonbank financial industry exposed to real estate fueling amplification mechanisms.

B. Macroeconomic Scenarios for Stress Testing

12. To project the impact on profitability and regulatory capital of adverse macrofinancial conditions, the IMF developed two macroeconomic scenarios over five years in consultation with SNB and FINMA. The scenarios cover forty countries and include macroeconomic variables such as GDP, inflation, unemployment, output gap, foreign exchange, asset prices, credit growth, benchmark curves, spreads, commodity prices, and global economic developments. The scenarios cover five years, starting from the first quarter of 2019 and ending in the last quarter of 2023.

13. The baseline scenario is based on the October 2018 IMF World Economic Outlook (WEO). GDP growth in Switzerland slows down from 3 percent to 1.7 percent by 2023 while the positive output gap closes gradually, and inflation remains stable at about 1 percent by the end of the horizon. In line with interest rate developments in advanced countries, the short-term rate normalizes from -75 basis points to 1.25 percent, and long-term yields rise from -40 basis points to 1.9 percent.

14. The adverse scenario assumes the materialization of the system-wide risks identified in the RAM (Figure 4). The narrative consists of a global financial cycle downturn with abrupt and sizeable repricing of risk premia in global financial markets triggering a housing price correction and a balance-sheet recession in Switzerland. The tightening of financial conditions leads to global asset price adjustments, a credit crunch, consumption contraction, reduction and business investment, sovereign stress, and output losses. Conventional monetary policy responds with the policy rate in Switzerland reaching -275 basis points in 2020: Q4 before normalizing to 30 basis points by 2023. The scenario is calibrated using IMF's in-house Global Macrofinancial Model (GFM).[8] Scenario design follows a conservative layers-of-shocks approach with compounding shocks rather than separate scenarios focusing on different risk factors yielding a lower level of severity. Additional scenarios assuming a sharp snap back in interest rates were assessed in the sensitivity analysis.

15. The severity of the adverse macro-financial scenario lies within the range of severities explored by the SNB in the adverse FSR scenarios, but exceeds that of recent FSAPs. Macrofinancial stress triggers a recession in Switzerland with GDP growth in negative territory for seven quarters and a peak decline of -4.75 percent in 2019. The scenario implies a deviation of real GDP from its baseline level by 7.7 percent in 2020, with a 3.3 standard deviation move in two-year cumulative real GDP growth rate,[9] and a 35 percent peak-to-trough decline in real estate prices.

16. The international component of the scenario reflects additional stress in core markets for Swiss internationally active banks (Figure 5). This is captured through a regional layer of shocks in material geographies for Swiss large banks including the Euro Area, the United Kingdom, the United States, China, and other Emerging Markets. On aggregate, output falls between 5.8 to 8.5 percent below baseline in advanced economies by 2020, and by 4.8 to 5.8 percent in emerging economies. Overall, world output falls 6.3 percent below baseline by 2020, while energy and non-energy commodity prices fall over 50 and 30 percent below baseline, respectively.

17. The macroeconomic scenario is expanded to include a traded risk component that is likely to influence banks' resilience to market shocks. The market risk scenario includes stressed paths for swap curves by currency, yield curves by issuer, corporate spreads by index, and volatility shocks in a way that is consistent with the core macroeconomic projections. To capture basis risk the scenario includes differentiated shocks for cash and derivative indices. The calibration of the traded risk component of the scenario is sector-specific and is described in more detail in the market risk modeling section.

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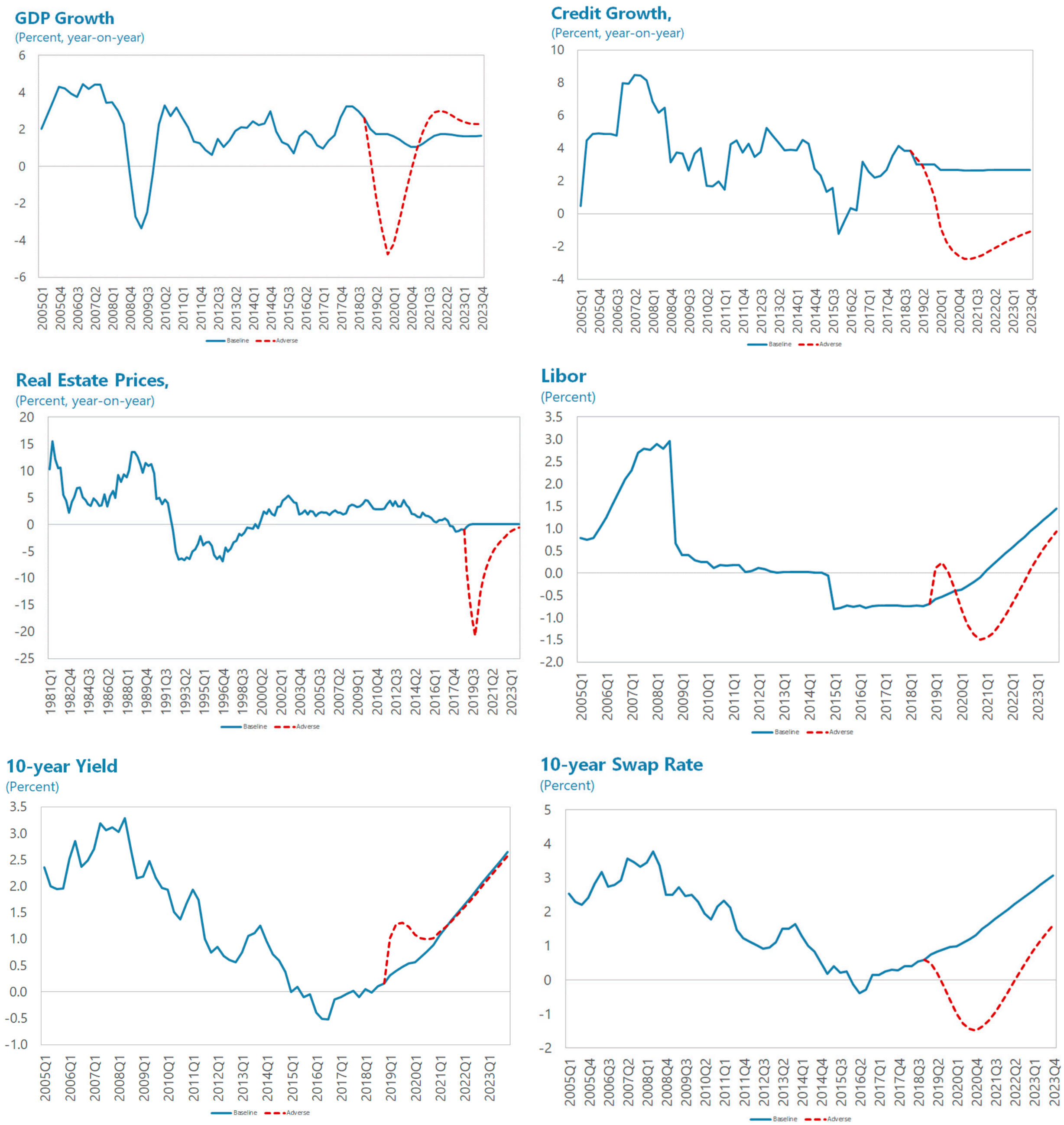
[8] See Vitek, F. (2018), The Global Macrofinancial Model, *International Monetary Fund Working Paper*, 81.

[9] This is larger than the severity benchmark used in other FSAPs defined as two standard deviations move in two-year cumulative real GDP growth rate relative to baseline forecast (e.g., 2018 Euro Area FSAP). Historical volatility was computed over the unconditional distribution of GDP growth given the accommodative stance of current financial conditions.

Figure 4. Switzerland: Macroeconomic Scenario

The severity of the adverse scenario lies within the range of severities explored by the SNB in the adverse FSR scenarios. It represents a 3.3 standard deviation move in two-year cumulative real GDP growth rate, and a 35 percent peak-to-trough decline in real estate prices.



Source: IMF estimates.

Figure 5. Switzerland: International Macroeconomic Scenario

Real GDP growth paths in material geographies for Swiss large internationally active banks. Output falls between 5.8 to 8.5 percent below baseline in other advanced economies by 2020, and by 4.8 to 5.8 percent in emerging economies.

Source: IMF estimates.

Table 2. Switzerland: Key Scenario Assumptions for Adverse Scenario

IMF scenario design followed a layers-of-shocks approach. The resulting paths for core variables reflect both exogeneous shocks as well as the endogenous behavior reflected in the structural macro model.

Layer 1: Global capital market disruptions, 2019Q1 – 2019Q4	
Real equity price; Equity risk premium shocks	
Advanced economies	−40.0 percent
Emerging economies	−30.0 percent
Term premium; Duration risk premium shocks	
Euro Area periphery	+300 basis points
Euro Area core	+150 basis points
Other advanced economies	+200 basis points
Emerging economies	+120 basis points
Layer 2: Global interbank market stress, 2019Q1 – 2019Q4	
Interbank spread; Liquidity risk premium shocks	
Advanced economies	+100 basis points
Emerging economies	+50 basis points
Layer 3: Global housing market downturn, 2019Q1 – 2020Q4	
Real house price; Housing risk premium shocks	
Advanced economies	−10.0 percent
Emerging economies	−5.0 percent
Layer 4: Global credit cycle downturn, 2019Q1 – 2021Q4	
Mortgage loan default rate; Mortgage loan default shocks	
Advanced economies	+1.0 percentage points
Emerging economies	+2.0 percentage points
Corporate loan default rate; Corporate loan default shocks	
Advanced economies	+2.0 percentage points
Emerging economies	+4.0 percentage points
Layer 5: Global confidence losses, 2019Q1 – 2021Q4	
Business investment; Business investment demand shocks	−5.0 percent
Layer 6: Interbank market stress in Switzerland, 2019Q1 – 2019Q4	
Interbank spread; Liquidity risk premium shocks	+50 basis points
Layer 7: Housing market downturn in Switzerland, 2019Q1 – 2020Q4	
Real house price; Housing risk premium shocks	−10.0 percent
Layer 8: Confidence losses in Switzerland, 2019Q1 – 2021Q4	
Business investment; Business investment demand shocks	−5.0 percent

Note: All scenario assumptions are expressed as deviations from the April 2018 World Economic Outlook baseline. Those endogenous variable adjustments that peak in 2019Q4/2020Q4/2021Q4 60/40/20 percent dissipate by 2023Q4.

Source: IMF estimates.

STRESS TESTING THE BANKING SECTOR

A. Benefits from Accessing Supervisory Data

18. Stress testing has become a cornerstone of post-crisis FSAPs to promote the stability of the banking system as a whole. Stress testing, unlike capital requirements, provides a forward-looking assessment of losses that would be suffered under adverse economic scenarios. The simultaneous stress test of the largest Swiss banks lends a perspective on a large part of the banking system and facilitates identification of common exposures and risks.

19. For the 2019 Switzerland FSAP, access to confidential firm-specific supervisory data (a first) allowed the FSAP team to take account of key risks exposed during the global financial crisis. One of the most important lessons of the financial crisis for the Swiss banks was the fall in profits owing to the negative results obtained in trading operations, commission business and services, and litigation provisions. Losses in trading operations were due to valuation losses as a result of the sharp drop in the prices of securities. Net income from commission business and services decreased in 2008 by 18.5 percent, and by a further 13.9 percent in 2009. This was due to a decline in commission income from securities trading and investment business to CHF 26.0 billion, which was partly attributable to falling securities sales. Litigation charges mainly linked to Residential Mortgage-backed Securities Business (RMBS), Libor and foreign exchange (FX) litigation items contributed further to the losses of internationally active Swiss banks. Potential losses from these risks could be better assessed using granular supervisory data.

20. It also allowed the FSAP team to assess latent risks related to the mortgage portfolio, derivative books, interest rate shifts, and complex products, linked to banks' portfolio characteristics. Mortgage lending can pose risks to financial stability as it is the largest asset class on Swiss banks' balance sheets. To understand the conditions under which mortgages can become distressed, data on borrowers' characteristics (e.g., loan-to-income (LTI)), and loan characteristics at origination as well as over the loans' lifetime (e.g., LTV) are required. Another key risk for Swiss banks is hedge effectiveness and basis risk for both interest rate risk in the banking book (IRRBB) as well as for market risk on the back of complex trading positions hedge by index derivative contracts. To evaluate basis risk, data on market risk sensitivities for cash and derivative positions are required. For the calculation of IRRBB, supervisory data on repricing gaps and maturity breakdowns linked to banks' structural balance sheet positions are needed to perform the analysis. Credit risk assessment from Lombard loans, securitized products, and underwriting exposures to leverage loans requires detailed data on product characteristics of underlying exposures.

21. Another refinement in the Switzerland stress test is the assessment of solvency/liquidity interactions drawing on supervisory data.[10] Another key lesson of the financial crisis is that stress testing had been predominantly microprudential in nature, applying idiosyncratic risks faced by a bank in isolation and adding the effects of risk factors, without regard

[10] The desire for additional macroprudential elements in the stress test is one of the key aspects of the 2016 of the U.S. CCAR (Tarullo, 2016).

to the interaction among risks across financial institutions, which are known to exacerbate losses under stressed conditions creating adverse spirals. Combining FINMA supervisory data with Liquidity Monitoring Templates (LMT), the FSAP team was able to examine risk interactions between credit risk, market risk, and liquidity risk arising from the default of banks' financial counterparties.

22. However, in the absence of a dedicated IT data infrastructure for stress testing, the IMF granular approach required substantial efforts in data gathering and spreadsheet modeling to build a consistent database. The IMF stress test data infrastructure required highly granular balance sheet and income statement information from SNB surveys, FINMA Basel III risk surveys, G-SIBs' supervisory BBA of banks' risk profile, and segmentation of risks and exposures extracted from banks' annual reports and Pillar 3 disclosures.[11] Efforts included the development of a synthesis tool for aggregating analytical results to produce consolidated future balance sheets, income statements, and capital ratios.

23. IMF stress test results should be interpreted with caution. Despite the FSAP team's best efforts to build a consistent database, the matching and reconciliation of risk data extracted from multiple data sources is a complex exercise. Additional challenges are posed by the use of proxy variables and the nature of tail risk events. Some risk parameters were projected using proxy variables on the back of data availability constraints, adding challenges to the quantitative impact of the stress testing exercise. For instance, the duration of the fixed income portfolio was proxied by remaining maturity of outstanding traded bonds. Probability of default (PD) estimates for selected portfolios were projected drawing on expected default frequency (EDFs) which display greater volatility than regulatory PDs. A broader caveat is that stress test scenarios are calibrated using historical data which identify extreme 'tail events' based on a historical distribution, even though it is well known that the nature of crises is to have unanticipated shocks and unexpected interrelationships where the past offers limited guidance.

24. The FSAP stress test should be seen in conjunction with regular tests undertaken by SNB. To assess the resilience of the Swiss banking system to adverse shocks, SNB conducts a semi-annual stress test of the banking system on four adverse scenarios including macrofinancial, financial and, for the two G-SIBs, operational risks. The test covers the two G-SIBs and most DFBs.[12] The 2018 SNB's Financial Stability Report (FSR) notes that the loss potential for G-SIBs is highest under a U.S. recession scenario, stemming from credit losses in Switzerland and the US, counterparty exposures from derivatives and SFTs, and equity and bond positions. By contrast, DFBs are most vulnerable to an interest rate scenario with sharp rises in interest rates increasing default risk in mortgage loans and net interest income (NII) losses from high level of maturity transformation risk.

25. SNB concurrent stress test complements FINMA's regulatory stress scenario analysis on the G-SIBs. FINMA introduce IRB multipliers as Pillar 1 add-ons in 2012. IRB multipliers are

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[11] Bank reports were used mainly to map geographical segmentation of credit exposures and issuer breakdown of financial instruments booked in the trading portfolio and available-for-sale regulatory books.

[12] The DFB sample includes 95 banks which represents about 35 percent and 61 percent of the Swiss banks balance sheet and domestic credit respectively.

based on benchmarking via stress testing and a gap analysis to standardized approach RWAs. Stress testing is used to ensure that minimum capital requirements of IRB portfolios can cover potential losses during a stress period. Banks perform loss potential analysis (LPA) calculations based on FINMA scenarios. Bank results, benchmarked, challenged and eventually adjusted (add-ons) by FINMA, feed into banks' capital planning process to guide dividend payout rules and share buy-backs.

B. FSAP Stress Testing Strategy

26. The resilience of the Swiss banking system is assessed under a comprehensive range of stress tests run by the IMF (Figure 6). The assessment follows a four-pronged approach (Appendix VII)[13]:

- *A solvency stress test including a fully-fledged scenario-based test and a range of sensitivity tests to assess the system's capital adequacy.* The macrofinancial scenario explored domestic as well as global risks. It also included a traded risk scenario to capture business risk from tighter financial conditions, changes in market valuations, and vulnerabilities from asset liability management (ALM) operations. A range of sensitivity tests was conducted to further explore the resilience of the Swiss banking system to wider shifts to risk factors.

- *A wide range of liquidity stress tests to assess bank resilience to sudden, sizable withdrawals of funding. The* analysis was based on two complementary liquidity frameworks: (i) a LCR-based approach implemented under two additional scenarios by currency; and (ii) two implied cash-flow tests over 5-day of consecutive stress and a 30-day of cumulative stress drawing on Basel Liquidity Monitoring Templates.

- *A contagion module to shed light on the potential for the interbank market to spread stress across banking institutions.* The transmission of shocks in the interbank market ("bilateral exposure channel") was examined drawing on Swiss banks' bilateral matrix of large exposures, including intragroup transactions. [14]

- *A systemic risk module to assess contagion through equity markets.* Systemic risk and cross-border spillovers were assessed using a market-based CoVaR approach. This methodology ("market contagion channel") allows evaluating correlated losses through equity markets which might be unrelated to credit or funding exposures (i.e., due to common exposures, similarities in banks' business models or investors' correlated strategies).

27. IMF tests were complemented by SNB' s Top-down (TD) stress tests on the two G-SIBs and all DFBs and BU test run by the G-SIBs. For FSAP purposes, all tests were run on the IMF

[13] Appendix VII details the solvency tests' specifications and methodology.

[14] The stress test assessed the potential impact from credit risk from exposures to other credit institutions as well as from funding concentration to large counterparties. Amplification mechanisms through fire sales and cascading defaults were assessed using a network analysis on the Swiss interbank market.

scenario. In addition, authorities' stress test results were benchmarked against supervisory stress tests conducted on SNB scenarios (for systemic risk analysis) and FINMA scenarios to identify key drivers of stress.

Figure 6. Switzerland: Overview of Stress Testing of the Banking Sector

The resilience of the Swiss banking system is assessed under 3 complementary Pillars.

Solvency Stress Test			Liquidity Stress Test	Interconnectedness	
TD IMF	TD SNB	BU Banks	TD IMF/FINMA	TD IMF	
				Network Analysis	CoVaR Methodology
12 Banks, including 4 Private Banks	Big Banks; Domestic Banks	Big Banks	12-30 banks (TBD)	12 Banks, including 4 Private Banks	5 listed Swiss Banks
• Full macroeconomic stress test: balance-sheet regulatory approach; • Two scenarios: baseline and adverse; • Reference date: June 2018; Stress test horizon: 2019-23 • Scope: credit risk; market risk; business risk; operational risk, RWAs			Wide range of stress test scenarios, liquidity risk drivers, and approaches	• Exposure-based • Bilateral matrix: "large exposures" template • Transmission of credit and funding shocks throughout the network • Identification of systemic banks and vulnerable banks	• Market-based • Contagion through equity markets • Time-varying effects throughout the cycle • Measure of systemic risk • Banks' marginal contribution to systemic risk
Projection of banks' capital ratios using IMF models; Funding-Solvency nexus	Projection of banks' capital ratios using SNB team models	Projection of banks' capital ratios using banks' internal models	LCR Test: Swiss Basel LCR by currency Swiss retail scenario Swiss wholesale scenario		
Battery of sensitivity tests: • Widening of credit spreads • Credit rating downgrade • Mortgage risk (FINMA pilot mortgage stress test) • Solvency-liquidity interaction in derivative markets.			Cash-flow based stress tests, using maturity ladder (5-day; 30-day test)		

Source: IMF staff.

SOLVENCY STRESS TEST

A. Scope of the Stress Test

28. **Banking sector risks are assessed through a wide range of stress tests conducted in cooperation with the SNB and FINMA, using confidential firm-specific supervisory data.**[15] IMF TD stress tests are carried out on a sample of banks covering broadly 80 percent of the Swiss banking sector, in terms of consolidated assets as of June 2018, run at the highest level of consolidation. It covers twelve major banks including the two Big banks, six large domestically focused banks, and the four largest private banks.

29. **The exercise is carried out on the basis of mid-year 2018 figures, and scenarios are applied using a range of methodologies to allow benchmarking**. IMF tests are carried out over a period of 5 years through 2023. SNB TD tests are performed over two years for the G-SIBs and five years for domestic banks. IMF models and methodologies used to derive stress estimates and impacts were calibrated to the Swiss banking sector. Models were developed to fit the segmentation and granularity of supervisory data and the materiality of the banks' portfolios.

[15] Details on specification and methodology of the solvency tests are contained in the Stress Testing Matrix (Technical Note).

30. The stress testing framework captured all relevant risks determined by a sound risk identification process. The risk identification process included a comprehensive assessment of risks reflected in the RAM (Appendix I) and SNB's 2018 FSR, including those deriving from both on- and off-balance sheet exposures related to private banking. Given Swiss banks' business models and risk exposures, IMF modeling efforts focused on:

- Projecting IRRBB using maturity breakdowns from SNB surveys and repricing gaps from the Interest Rate Risk report at the portfolio level;
- Estimating business risk from commission income from securities trading, investment activities, and managed assets; income from trading activity and the fair value option; funding cost by instrument; and, operational risk linked to litigation charges, and private clients;
- Considering interactions between risk types, including links between credit and market risk from Lombard facilities, and solvency and liquidity interactions from counterparty risk in derivative markets; and
- Assessing market risk impact by risk factor, region, counterparty type, and rating class, covering cash and derivative positions separately to evaluate basis risk.

31. In addition, the FSAP team developed a structural approach on mortgage risk calibrated to the Swiss real estate market. Stressed losses on the owner occupied and investment-led portfolios are linked to banks' LTI and LTV mortgage distribution, and stressed affordability risk from a snapback in lending rates and a housing price correction tightening the amortization rule of second mortgages. Results are comparable to the 2018 FINMA's pilot enhanced mortgage stress test exercise conducted over 18 banks in parallel.[16]

32. The assessment criteria ("hurdle rate") include the too-big-too-fail (TBTF2) provisions under baseline conditions and Basel III's minimum capital requirements under the adverse scenario.[17] The going concern requirements under the TBFT2 provisions that entered into force on July 2016 for the D-SIBs consist of a basic requirement as well as a progressive component depending on the degree of systemic importance. The basic requirement for risk-weighted assets is 12.9 percent and 4.5 percent for the leverage ratio. Adding the expected progression based on benchmarks results in going concern requirements for the G-SIBs of 14.3 percent for risk-weighted assets and 5 percent for the leverage ratio.

[16] While FINMA takes into account demographic effects, and a sharp rise in lending rates of 500 bps, the IMF approach includes tighter amortization schedules from a rise in LTV ratios on second mortgages, and a lending rate increase of 300 bps.

[17] This hurdle rate was applied to determine the pass/failure nature of D-SIBs (Figure 15). For non-D-SIBs, Basel minimum capital requirements were applied under the adverse scenario. Basel requirements were augmented by the CCyB and the CCB buffer under baseline conditions.

B. Credit Risk Modelling Approach

33. The IMF stress test was conducted at the highest level of consolidation in Switzerland. This includes the consolidation of banking associates, and foreign subsidiaries SNB surveys on balance sheet data are available at yearly frequency for banking groups. Data was extrapolated to June 2018 for the five banking groups included in the sample. [18]

34. The credit risk analysis covered all material geographies of Swiss banks. For the G-SIBs, the geographical segmentation in the supervisory BBA was used to map banks' Basel credit exposures. For DFBs and private banks, annual reports and Pillar 3 disclosures were used to map credit exposures to the geographical breakdown of macrofinancial drivers projected in the IMF country-based scenario. Overall, material geographies included twelve countries, namely Australia, China, Germany, Ireland, Italy, the Netherlands, Singapore, Switzerland, Turkey, the United Kingdom, the United States, and other advanced and emerging economies.

35. The FSAP scenario assumed constrained dynamic balance sheets by geography, excluding banks' management actions. Under the FSAP scenario, credit growth is determined by credit demand shocks triggered by negative consumption and investment shocks that lead to a slowdown of credit under the adverse scenario. On the other hand, credit supply effects or banks' management actions to restore capital ratios were disallowed. Given the geographic footprint of Swiss banks, the growth rate of credit varies across banks. It was computed as the EAD-weighted nominal GDP growth across relevant jurisdictions. To capture FX structural risk, valuation effects on capital ratios were calculated under the assumptions that loans are denominated in the domestic currency of the geographical exposure. To calibrate the EAD shock linked to triggered credit lines and guarantees, the FSAP team used the maximum increase in the off-balance sheet exposures to EAD ratio for corporates reported by banks in their Pillar 3 disclosures.

36. In the IMF stress test, credit risk was assessed by asset class following Basel definitions of exposures booked under the IRB and standardized (STA) approach. Basel asset classes were grouped into six portfolios: retail secured by immovable property; financial institutions; corporate specialized lending; corporate other; retail unsecured; and, sovereign and public institutions.

37. Loan losses were computed over non-defaulted exposures under reporting accounting standards. Basel exposure data is broken down by obligor grade. For IRB exposures, removing exposures with obligor grade PD=1 (defaulted) yields a non-defaulted PDs and loss-given defaults (LGDs) by portfolio. STA exposures are broken down between defaulted and non-defaulted. Expected and unexpected losses were calculated for non-defaulted exposures under current accounting standards. For the sample of banks, only one bank publishes its consolidated financial statements in accordance with International Financial Reporting Standards (IFRS).[19] The expected impact of the implementation of IFRS 9 was included in its financial statement of 2017 showing a

[18] SNB balance sheet survey data is only available at annual frequency for consolidated groups.

[19] Other IFRS banks include some rather smaller banks mainly active in the private banking / asset management business.

low expected impact with no material effect on capital ratios. About half of the impact was related to changes in classification and measurement and the other half was related to the introduction of the expected credit loss approach. Another bank reports consolidated statements under U.S. Generally Accepted Accounting Principles (GAAP) with the scheduled implementation of the expected credit loss approach in 2020. The remaining Swiss banks report under local GAAP using the incurred credit loss approach.

38. A different modeling strategy was applied by asset class:

- A structural approach for mortgage lending risk in exposures secured by immovable property;
- An econometric approach for exposures to financial institutions; corporate specialized lending; corporate other; and, retail unsecured; and
- A Merton-based approach for sovereign exposures and exposures to public institutions.

39. The FSAP team used a two-step process to generate bank-specific parameters:

- Based on the stress test scenario, top-down default risk and loss-given default rates are projected by asset class and geography; and
- The top-down projected paths are applied to banks' starting points to derive bank-specific credit risk parameters. For IRB exposures these include regulatory PDs and LGDs. For STA exposures, these include newly created adjustments in provisions for default risk charged to income statement, and rating migration of performing exposures to substandard categories.

A Structural Model for Mortgage Risk

40. The mortgage and real estate markets are a key source of risk for financial stability on the back of rising imbalances and increasing affordability risk. On the one hand, strong growth in real estate prices have resulted in imbalances on the residential real estate market, with an estimated accumulated growth rate of 150 percent in the investment-led segment and 75 percent for owner-occupied property over 2000: Q1–2018: Q3. On the other hand, there are signs of increased affordability risk with the share of new mortgages where imputed costs would exceed one-third of income at an interest rate of 5 percent at about 50 percent.

41. In addition, Swiss banks are heavily exposed to mortgage loans. About three quarters in Swiss banks' lending portfolio are mortgage loans (excluding amounts due to banks and SFTs). This share increases for DFBs, reaching 95 percent for Raiffeisen and regional and savings banks, and 87 percent for cantonal banks. DFBs in turn account for 64 percent of the CHF 980 billion domestic mortgage market in Switzerland in 2018: Q1. By contrast, the weight of the mortgage portfolio for the Swiss legal entities of the G-SIBs is lower at 62 percent of total loans,[20] whereas for other banks, including private banks, mortgage loans account for 40 percent of the loan portfolio.

42. The limited data from actual tail events in Switzerland and structural changes in the mortgage market, makes statistical approaches to estimate mortgage loan loss events unreliable. While Switzerland experienced a surge in loss rates in mortgage claims in the early 1990s this event was triggered by default rates in commercial real estate rather than in the residential segment. Also, the structure of the mortgage market has changed markedly since 2010 when borrowers were allowed to use contributions to retirement benefits in the 2nd Pillar to cover part of the cash down payment to finance the loan.[21]

43. Statistical approaches are also hindered by the current benign cycle. Observed default rates in mortgage portfolios have been about 0.15 percent in the last three years which makes the statistical analysis unsuitable to deal with far tail events. At the same time, low observed default rates in benign times can be consistent with a risky portfolio under stress.

44. The IMF's modeling approach projects the structure of the loan default process with estimates of behavioral and macroeconomic drivers linked to the scenario. The model builds on TUI, a structural model of the residential housing loan default process and incorporates idiosyncratic features of the Swiss mortgage market.[22] The model assumes that borrowers will continue to service a loan if they can afford to pay off the scheduled interest and principal payments, even when they have negative equity. The drivers include idiosyncratic demographic events as well as systematic factors generated by the scenario related to changes in house prices, unemployment rate, and mortgage interest rates.

45. The structural approach is calibrated on banks' total mortgage portfolio. While the calibration is applied jointly to all portfolio segments in banks' mortgage portfolio, the path for housing prices reflects the composition of the mortgage book across residential (owner-occupied and investment-led) and commercial real estate sectors. On average, the share of residential mortgage loans is about 80 percent (of which 50 percent for owner-occupied property), and 20 percent for commercial real estate.

46. The model assumes that default occurs if two conditions are satisfied:

- The borrower is in distress: he is unable to repay the debt on time due financial difficulties; and
- The net value of the collateral, after disposable costs, is less than the value of the loan: the borrower cannot sell the collateral to service the loan.

[20] At the consolidated level, mortgage loans account for 40 percent of total customer loans for G-SIBs.

[21] Swiss banks usually offer a mortgage of up to 80 percent of the current market value of the property, which requires a down payment of 20 percent. At least 10 percent must be put down in cash while the other 10 percent can be arranged using Pillar 2 or 3 pension fund retirement benefits.

[22] TUI stands for Tool for Unobserved-event Investigation, which focuses on tail risk events where there is little information available and was developed by the Reserve Bank of New Zealand (2008).

47. To capture Swiss regulatory rules, borrowers' debt service ratio includes the amortization schedule as well as in interest payments. Swiss banks have the option to request a margin call if the value of the collateral (after a housing correction) is insufficient to meet self-regulation rules, tightening the debt servicing ratio. Specifically, the current self-regulation rules stipulate a mandatory amortization (second mortgage) to two-thirds of the value of the collateral at origination over a 15-year period. Before the revision in 2014, self-regulation stipulated that mortgages had to be amortized to two-thirds of the collateral value within 20 years.

48. Affordability risk under stressed conditions depends crucially on the mortgage vintage. Shocks to lending rates (interest payment), and the additional margin that Swiss banks might require if the Point-in-Time (PiT) LTV that exceeds two thirds of the outstanding value of the loan cannot be amortized over the remaining tenor of the mortgage, depend critically on the initial interest rate, housing price, LTV ratio, mortgage tenor, and self-regulation rules at origination.

49. The FSAP team reconstructed outstanding vintages using supervisory data. As vintage information was not available, the FSAP team used data on the average mortgage tenor, binding self-regulation rules, and data on inflow and outflow of mortgages to segment banks' outstanding portfolio by vintage. The caveats of this approach relate primarily to the third step, as mortgage flows could be related to the refinancing of different tranches of the loan rather than to full amortization. Another caveat of this approach is that these data do not include material "indirect amortization" flows which are collected on a tax privileged Pillar 3a account pledged to the bank, but do not reduce the outstanding of the mortgage.

50. The probability that a borrower gets into distress (PSS) is specified as follows:

$$PSS_t = \beta_0(DSR_t^\gamma)\cdot D + \beta_1 \cdot \Delta DSR_t^\gamma\left(i_t, \frac{L_t}{V_t}(P_t)\right) + \beta_3 \cdot \left(\beta_4 \cdot u_t + \beta_5 \cdot (\Delta u_t)^\alpha\right)$$

Borrower affordability rises with the following factors: (i) a demographic event D which impacts affordability provided the debt service ratio exceeds a given threshold; (ii) the tightening of income gearing ΔDSR_t^γ which is linked to the interest path i_t, and the Point-in-time LTV ratio which depends on the outstanding value of the loan L_t and the real estate price P_t; and, (iii) a decrease in the borrower's income proxied by the starting level of unemployment u_t, and a non-linear function of the shock to unemployment Δu_t, with the sensitivity parameter β_3 increasing with DSR_t^γ. The model has been calibrated initially on data from New Zealand supported by an estimation approach that replicates the observed loans loss rates in Switzerland in the early 1990s.

51. Default occurs when the borrower is in distress and the current value of the house net of transaction costs is lower than the value of the loan:

$$PD_t = PSS_t \cdot \left\{ \# L \middle| \tilde{P}_t - C < (1 - t\rho)\cdot L + \sum_{j=1,T-t} i_{t+j} \cdot (1-(t+j)\cdot\rho)\cdot L / (1+i_{t+j})^j \right\} / \# iterations$$

Where the first term PSS_t denotes the borrower's capacity to service the loan, and the second term captures the condition that the net value of the collateral $\tilde{P}_t - C$, where $\tilde{P}_t$ is the market value of the house and C the transaction costs, is lower than the value of the loan at time t. The value of the loan includes the outstanding principal L (amortized at an annual rate ρ over t periods) and the present value of future interest payments until the maturity of the loan at time T discounted at market rate i_{t+j}. The default rate is generated using a draw from the stochastic house price index with mean linked to the scenario and repeated 10,000 times to generate an array of iterations.

52. **The conditional LGD is driven by the discounted sale price of the house**. The model assumes that the sale occurs at time *t+s* (where s denotes the time to sell the collateral currently calibrated at 2 years) and the sale proceeds are net of transaction costs discounted at a rate reflecting the risk premium of the foreclosed asset (linked to the spreads projected in the scenario). For each draw of the house prices used to determine the default rate (systematic risk), the model generates 2,000 draws to generate individual house prices (idiosyncratic risk). For each of these house prices the model determines whether the value of the loan is greater than the net proceeds of selling the house. The average of the 2,000 losses is the LGD for the risk bucket.

$$LGD_t = (1-\rho t)L + C - (1-\delta)P_{t+s}/(1+r_t+cs_t)^s$$

53. **Bank-specific forecasts for stressed PDs and LGDs are built by risk bucket over the horizon period**. The model calculates PDs and LGDs for specified risk buckets defined by LTV tranche and vintage. Outputs for a given portfolio are calculated by combining separately estimated outputs of all the portfolio's risk buckets and weighting them by their share in the bank's portfolio. The data for the initial distribution of outstanding mortgages across risk buckets are sourced from the BBA templates for large banks are applied to the remaining banks of the sample. The model acknowledges that loan losses take time to realize and projects cumulative forecasts of PDs and LGDs by bank over 2018–20 and 2020–2023. It generates annualized rates by dividing accumulated losses over the number of years.

54. **A key component to the implementation of IMF's model-based credit risk assessment is model validation**. The aim is to ensure that the model chosen is accurate and perform consistently. This is performed in two stages. First, the model is subject to stress testing under baseline and adverse conditions, examining the model's expected outcome under normal and stress conditions. Second, the model is subject to backtesting. Observed outcomes in a relevant historical period are compared against the model's expected outcomes. This process enables forecast evaluation of the model.

55. **The model was simulated to a replication of 'benign' conditions, 'good time' conditions, and 'bad time' conditions (Figure 7).** The 'benign' conditions' simulation is captured by the baseline scenario with a gradual improvement of macroeconomic conditions; the 'good time' scenario replicates the improvement in loan loss rates observed in Switzerland in 1999; and the 'bad time' scenario reproduces the Swiss housing mortgage default experience of the early 1990s. A caveat of this approach is that there is no data on the historical structure of banks' mortgage portfolio by LTV/LTI bucket. The working assumption is that it replicates the current distribution.

56. **Under current 'benign' conditions, the expected loss rate of the portfolio reaches 0.13 percent.** The model is simulated under the baseline scenario whereby unemployment rate

improves by 10 basis points to 2.6 percent, mortgage rates increase gradually from 1.5 percent to 2.8 percent over two years, and house prices remain stable. The 0.13 percent expected loss rate for the average bank mortgage portfolio compares against the latest observed default rate 0.014 percent which is supported by the extraordinary low interest rate environment.

57. For the 'good time' conditions observed during the late 1990s' housing market recovery, the model replicates accurately the observed default rate. After the housing crash and sharp increase in mortgage rates in the early 1990s, the observed loan loss rate in Switzerland halved over 1997–99 from 1.32 percent to 0.61 percent. The model simulates the macroeconomic conditions prevailing in 1997 and produces a forecast for 1999 whereby unemployment rate decreased by 250 basis points to 2.7 percent, interest rates contracted by 50 basis points to 3.9 percent, and housing prices remained stable at about -0.3 percent. Applying the LGD projected by the model on observed loan losses in 1999 yields a default rate of 1.30 percent against the default rate simulated by the model of 1.28 percent.

58. The model is able to reproduce the Switzerland mortgage default event of the early 1990s which experienced the largest relative increase in default rates. Loss rates on mortgage claims doubled in 1991 from 0.53 percent in 1989 to 1.03 percent. The model is fed with the inputs as of 1989 and simulates the macroeconomic recession of 1991 including a 50 basis points increase in the unemployment rate to 1.1 percent, the 180 basis points increase in mortgage rates to 7.8 percent, and the sharp fall in real estate of 20 percent.[23] Using the LGD estimated by the model on observed loan losses in 1991 delivers a observed default rate of 1.90 percent with matches the 1.91 percent default rate projected by the model.

59. The back-testing exercise suggests that the model is a useful diagnostic tool, however, results are subject to caveats. The caveats of this approach relate primarily to assumptions over time to repricing of outstanding mortgages, the construction of vintages using inflow/outflow data, and assumptions on the LTV/LTI distribution of historical vintages. At the same time, this model has clear strengths related to the transparency, precision, and flexibility of the tool which outperforms statistical analysis which depend critically on the estimation period, are limited to deal with far tail events, and apply judgments related to the application of past experiences to the future despite structural changes in the mortgage market.

60. Results suggest that default rates are particularly sensitive to lending rates, margin calls, and the vintage distribution. The adverse scenario includes rises to mortgage lending rates from 1.5 to 5 percent on the back of a widening of credit risk premia.[24] The vintage of the portfolio is constructed using the self-regulation rules which after 2014 stipulate a maximum amortization period of 15 years for the second mortgage. Default rates increase to 4.9 percent if the portfolio is more heavily weighted to more recent originations under a 5-year amortization rule. Similarly, default rates increase to 6.2 percent under a 470 basis points increase in mortgage rates.

[23] This housing price decline materialized through 1996.

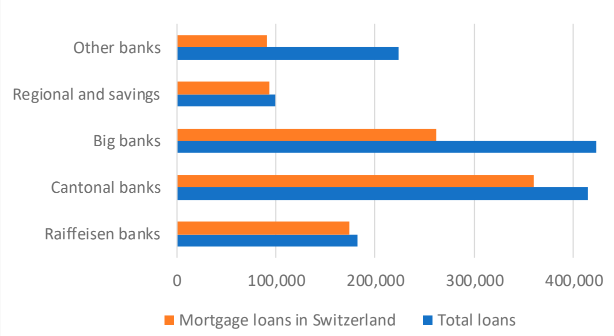
[24] The average mortgage lending rate is 1.5 percent for a 10-year fixed rate mortgage.

Figure 7. Switzerland: Credit Risk for Housing Loans

Stressed affordability of borrowers and triggered margin calls on the back of a sharp fall in real estate prices leads to a deterioration in the quality of the mortgage portfolio with PDs increasing to 2.7 percent by 2020. Results are highly sensitivities to shocks to mortgage rates, and LTV/LTI distributions.

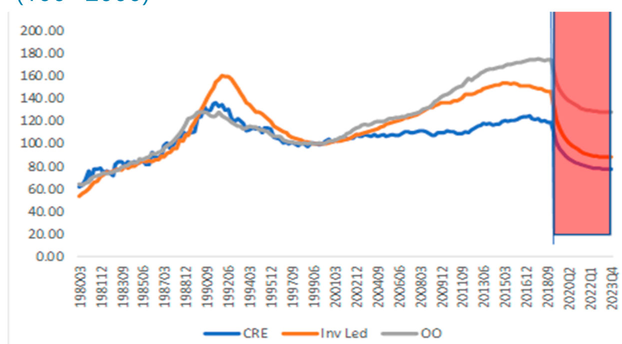
About three quarters in Swiss banks' lending portfolio are mortgage loans (excluding amounts due to banks and SFTs).

Loan Structure Swiss Banks
(In millions of CHF)



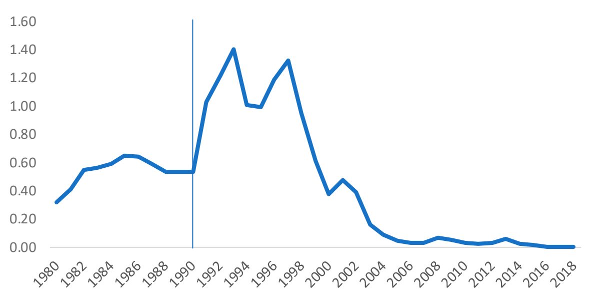
The adverse scenario projects a peak-to-trough average decline in real estate prices of 32 percent with a differential impact across mortgage objects.

Real Estate Price Index
(100=2000)



The model is optimized to back-test tail events including peak-to-trough crisis and recovery period in mortgage loss rates

Loss Rates Mortgages
(In percent)



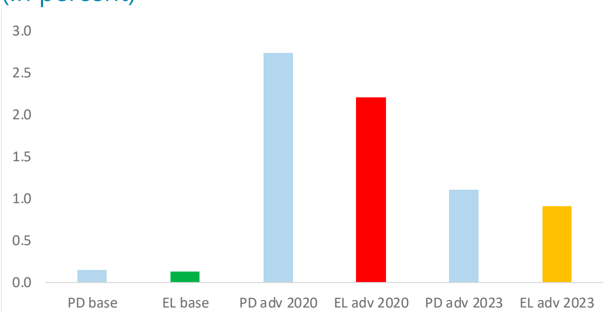
The model is able to replicate Switzerland historical episodes of 'crisis', 'recovery', and 'benign' conditions.

Backtesting the Model
(In percent)

Conditions	Crisis	Recovery	Benign
Period	1989-1991	1997-1999	Current
PD observed	1.90	1.30	
PD projected	1.01	1.28	
EL observed 2017			0.014
EL projected 2020			0.130

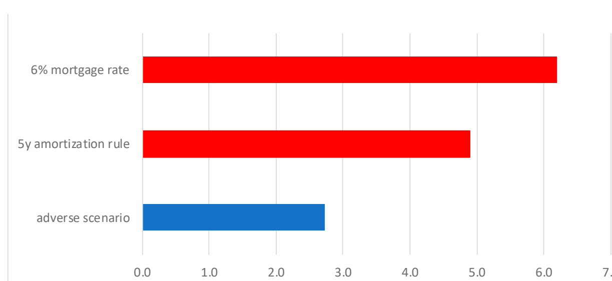
Under adverse conditions including a snap back in mortgage rates to 5 percent, the average PD rises to 2.7 percent by 2020.

Average Annualized Projections
(In percent)



Results are very sensitive to shocks to mortgage rates and vintage distribution with higher distress for portfolios heavily weighted to more recent originations.

Sensitivity Test—PD Annualized Projections
(In percent)



Source: IMF staff estimates.

An Econometric Approach for Other Credit Exposures

61. Default risk in retail unsecured and corporate exposures by geography and asset class was proxied by the average one-year EDF extracted from Moody's Analytics. For each geography, the following portfolios were used: the corporate group, the construction and real estate development group, the financials group, and the consumer nondurables and services group. These categories were mapped to Basel credit portfolios, i.e., corporate and small- and medium-sized enterprise (SME) exposures, specialized lending exposures, exposures to financial institutions, and retail unsecured, respectively. The econometric analysis was conducting using quarterly data over 2002: Q2 through 2018: Q4. Bank specific PDs were generated by attaching top-down parameter paths to bank starting points with a locational and portfolio perspective.[25]

62. To address the truncated distribution nature of default rates, a logit transformation was applied before conducting the analysis. The logit transformation addressed biases generated by the truncated distribution of default rates and ensures that the projected rate is contained within the 0–1 bound once the logit forward path is applied on the forecast.

63. Credit risk was linked to a set of local drivers, regional variables, and global factors. Arguably, credit risk, particularly for wholesale clients, is not only a country-specific type of risk but it is also driven by regional macroeconomic forces external to the country as well as by global funding conditions. To estimate credit risk, a statistical-type model was developed by country and portfolio level using the following set of drivers:

- *Local variables*: there are a number of macroeconomic and financial variables that can impact the risk profile of a credit portfolio including real GDP growth, a GDP-based recession indicator (to capture non-linear effects from negative rates), inflation, unemployment, output gap, credit growth, equity prices, housing prices, FX rates, 3-month T-bill, 10-year yield, 3-month libor rate, the slope of the yield curve, real long-term rate, the swap rate, and the spread of the 10-year yield over the swap rate. Local drivers were forecasted for the twelve geographies included in the geographical breakdown of the lending portfolio;

- *Regional variables* to capture information about developments in the euro area, and emerging markets. Regional factors include GDP growth and inflation in the euro area and emerging economies, developments in the euro swap curve, 3-month euro repo rates, 3-month euro Libor, European corporate spreads, Emerging market bond index spreads, Eurostoxx 50, and structural challenges from debt sustainability concerns (measured by sovereign debt spreads of the Italian 10-year yield over the Bund);

- *Global financial market variables*: the ability of wholesale clients to repay also depends on the state of the global economy; in addition, shifts to global liquidity are likely to trigger default risk shocks. Global variables include world GDP growth, developments in commodity prices (fuel,

[25] This econometric strategy was preferred over a bank panel regression approach given that bank credit risk parameters are not segmented by geography in Basel templates or SNB survey data.

non-fuel), changes in 3-month U.S. dollar Libor, TED spread, changes in U.S. investment-grade (IG) and high-yield (HY) corporate bond spreads, volatility index (VIX), and U.S. equity prices.

64. Given the uncertainty associated to tail risk predictions, a robust econometric framework was implemented using a variety of approaches:

- A time series econometric technique using Newey-West HAC-robust standard errors to obtain consistent estimators when the error term is heteroskedastic, autocorrelated, or both, once the regressors are proved stationary;

- A quantile regression approach to address the concern that the drivers of the conditional mean might be different in the higher tail of the credit risk distribution. The distribution was divided in quartiles (four segments). Robustness of the results was checked using a distribution based on deciles (ten segments) to explore cliff-effects far in the tail;

65. The quantile approach was used to benchmark the econometric model against severe credit risk in the upper quantiles of the default rate distribution. The empirical specification of the PD level of portfolio j in geography i is as follows:

$$PD_{\lambda,t}^{i,j} = Z_{t-1}^{i} \cdot \beta_{\lambda}^{i,j} + u_{\lambda,t}^{i,j}$$

where Z_{t-1}^{i} · is the set of lagged determinants including the country, regional, and global factors specified above, and λ · denotes the quantile of the conditional distribution.

66. The Newey-West HAC time series approach suggests that credit risk in domestic non-financial corporate exposures increases with deflationary pressures, a widening in the output gap, and the tightening of financial conditions. Table 3 shows that low inflation, negative output gap, a dummy variable capturing negative economic growth, contribute to a rise in default rates. A tightening of financial conditions reflecting low equity prices, low fuel prices, rises in the T-bill, a steepening of the yield curve, and sovereign stress in the Euro Area also contribute to a worsening in the outlook of Swiss corporates.

67. The determinants of credit risk in foreign exposures differ across geographies. Appendices II and III show key drivers for corporate default rates in the United Kingdom and the United States. By contrast to the determinants of corporate default risk in Switzerland, a rise in inflation, lower credit growth, a slowdown in global growth, and a widening on money market spreads in the U.S. are key drivers of corporate credit risk for U.K. firms (Appendix II). In the United States, a flattening of the yield curve, a rise in long-term real interest rates and a slowdown in emerging markets also contribute to corporate distress (Appendix III).

68. Quantile results suggest that credit risk projections are more severe using estimated coefficients from the upper quantiles of the EDF distribution. Figure 8 shows quantile regression projections for default risk in corporate exposures in Switzerland. Under the baseline scenario, credit risk increases from the 0.9 percent value observed in 2018 to 1.6 percent (50th percentile) and jumps

Table 3. Switzerland: EDF Projections for Non-Financial Corporates

VARIABLES	(1) 1	(2) 2	(3) 3	(4) 1	(5) 2	(6) 3
L.inf	0.010	0.157	-0.073	-0.019	0.044	-0.090
	(0.149)	(0.130)	(0.216)	(0.144)	(0.161)	(0.170)
L2.inf		0.150	0.146		0.184	0.064
		(0.169)	(0.237)		(0.176)	(0.358)
L.g_nom	-0.136	-0.026	-0.265*	-0.200**	-0.127	-0.401**
	(0.083)	(0.122)	(0.130)	(0.086)	(0.183)	(0.183)
L2.g_nom		-0.318*	0.203		-0.381	0.106
		(0.183)	(0.175)		(0.236)	(0.248)
L.gap	-0.038	-1.878**	-0.719	-0.008	-2.764***	0.216
	(0.068)	(0.821)	(1.183)	(0.072)	(0.838)	(1.583)
L.tb	0.016	0.563*	0.574	0.044	0.899*	0.823
	(0.124)	(0.324)	(0.349)	(0.119)	(0.453)	(0.467)
L.ltr	0.040	-0.251	-0.980	0.062	-0.284	-0.813
	(0.152)	(0.374)	(0.594)	(0.176)	(0.358)	(0.497)
L2.ltr		0.030	0.033		-0.474	-0.356
		(0.251)	(0.363)		(0.368)	(0.539)
L.slope	0.408**	0.592	0.784*	0.393**	0.594	0.853
	(0.154)	(0.371)	(0.449)	(0.159)	(0.444)	(0.494)
L.credit	-0.015	0.004	0.027	-0.018	0.004	0.036
	(0.040)	(0.045)	(0.044)	(0.045)	(0.051)	(0.057)
L.equity	-0.011**	-0.012	0.005	-0.008	-0.006	0.008
	(0.004)	(0.007)	(0.013)	(0.006)	(0.007)	(0.009)
L2.equity		-0.001	-0.008		0.014	0.005
		(0.009)	(0.006)		(0.011)	(0.013)
L.g_w	-0.015	0.200	-0.316*	0.011	0.440**	-0.162
	(0.077)	(0.130)	(0.168)	(0.097)	(0.162)	(0.226)
L.g_oil	0.003	0.001	0.003	0.004	0.008*	0.010*
	(0.002)	(0.003)	(0.005)	(0.003)	(0.004)	(0.005)
L2.g_oil		-0.010**	-0.013***		-0.013**	-0.011***
		(0.004)	(0.004)		(0.005)	(0.004)
L.spread_IT	0.173***	0.500***	0.546*	0.159***	0.567**	0.561*
	(0.045)	(0.152)	(0.271)	(0.050)	(0.211)	(0.306)
1.stress_g#cL.g	0.095	0.171	0.229	0.122*	0.239*	0.173
	(0.074)	(0.123)	(0.152)	(0.072)	(0.125)	(0.145)
Constant	-4.877***	-6.867***	-8.411***	-4.974***	-6.633***	-7.165***
	(0.423)	(0.837)	(1.395)	(0.413)	(0.871)	(1.796)
Observations	66	66	66	59	59	59

Standard errors in parentheses

Sources: Moody's KMV, WEO, Bloomberg, and IMF estimates.

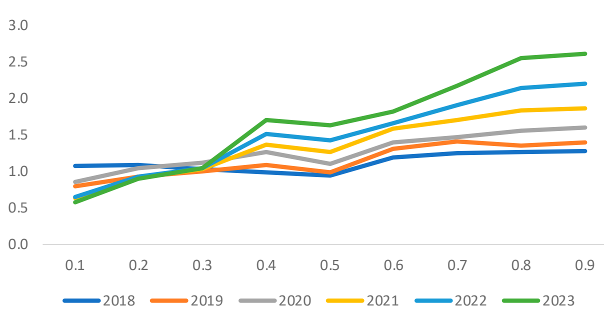
Note: The estimation period is 2002: Q2 through 2018: Q4. The dependent variable is Moody's 1-year average EDF for the corporate portfolio (i.e,. "1-Yr EDF 9 Average") in Switzerland. Regressors include: inf (inflation rate), g_nom (nominal GDP rate), gap (output gap), tb (3-month T-bill), ltr (10-year real interest rate), slope (10-year over 3-month sovereign yield), credit (credit growth to the private sector), equity (equity price growth), g_w (global GDP growth), g_oil (spot fuel price growth), spread_IT (10-year Italy sovereign minus 10-year Bund yield), and stress_g#cL.g (a dummy variable taking the lagged GDP rate when it's negative).

Three specifications are shown for each corporate portfolio for the full sample period (66 observations) and a truncated sample (59 observations) to conduct out-of-sample forecasting. L denotes 1 lag, L2 denotes 2 lags and L3 denotes 3 lags. The model is used for forecasting purposes rather than for the structural identification of shocks. Therefore, the forecasting ability of the specification is the relevant metric for model performance rather than the economic interpretation and magnitude of the drivers.

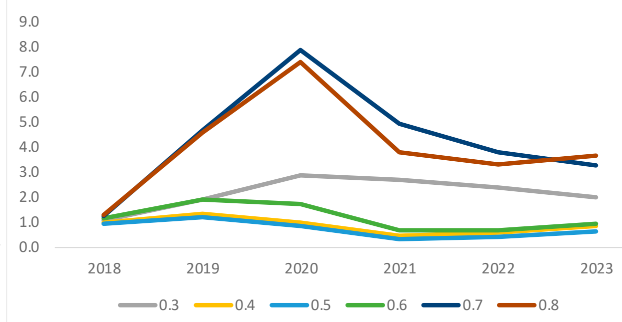
Figure 8. Switzerland: EDF Corporate Exposures, Quantile Approach

Credit risk projections are increasingly severe in the upper quantiles of the credit risk distribution for both baseline and adverse projections.

EDF Projections, Baseline
(In percent)

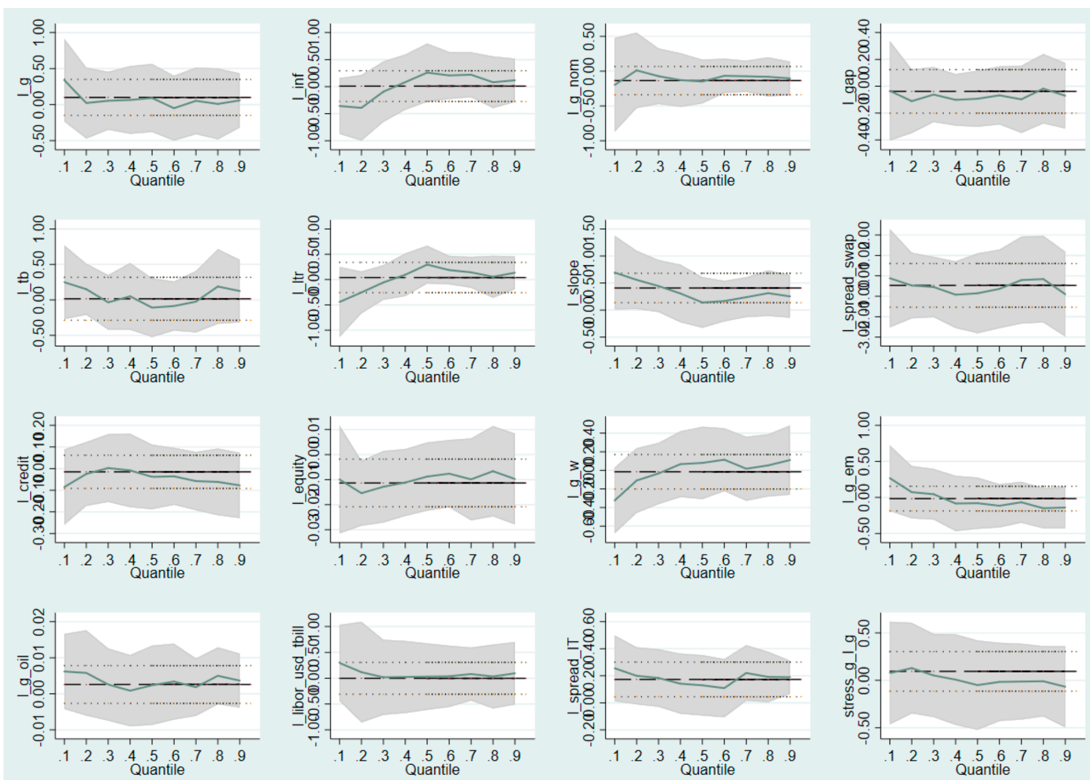


EDF Projections, Adverse
(In percent)



The impact of EDF determinants in Switzerland varies across quantiles of the credit risk distribution.

EDF Determinants



Source: IMF estimates. The panel shows the estimated coefficients across quantiles for key drivers. Estimated coefficients using quantile regressions are shown against linear-based coefficients including confidence intervals. *Regressors include: g (growth rate), inf (inflation rate), g_nom (nominal GDP rate), gap (output gap), tb (3-month T-bill), ltr (10-year real interest rate), slope (10-year over 3-month sovereign yield), spread_swap (10-year sovereign yield minus 10-year swap rate), credit (credit growth to the private sector), equity (equity price growth), g_w (global GDP growth), g_em (GDP growth of emerging markets), g_oil (spot fuel price growth), libor_usd_tbill (3m libor USD minus 3m U.S. T-bill), spread_IT (10-year Italy sovereign minus 10-year Bund yield), and stress_g_l_g (a dummy variable taking the lagged GDP rate when it's negative). Lagged variables are preceded by "l".*

to 2.6 percent (90th percentile). Under the adverse scenario, EDF increases to 2.8 percent (30th percentile) and to a peak of 7.4 percent in 2020 under the 80th percentile.[26] The chart also reports the estimates across quantiles benchmarked against a linear ordinary least squares-based specification. The impact is non-linear across quantiles, albeit with wide confidence intervals, suggesting cliff effects from a worsening of underlying risk factors.

69. **The final model selection was based on a combination of criteria.** This included goodness of fit of the regression, forecasting performance in-sample (2002: Q–2018: Q4) and out-of-sample (2016: Q4–2018: Q4), and expert judgment applied over the forecasted paths under baseline and adverse conditions based on the behavior observed during the 2008–09 global financial crisis. Estimated projections were applied over the forecast window 2019: Q1–2023: Q4 under each scenario.

A Merton-based Approach for Sovereign Exposures

70. **The FSAP team constructed a database of sovereign exposures by counterparty mapping SNB surveys, Basel data, and banks' annual reports.** The SNB 'Debt Securities' template was used to estimate the country shares of fixed income securities. The country breakdown was applied to the amount of IRB and STA sovereign and non-financial institutions' exposures reported in Basel templates.[27] As the 'Debt Securities' breakdown for foreign exposures does not include the breakdown by counterparty (counterparties are only available for domestic debt securities), the FSAP team extracted counterparty data from banks' annual reports and Pillar 3 to identify foreign sovereign and corporate debt securities.[28] Under the adverse scenario, the slope of the yield curve increase for most bond curves due to term premium (Table 4).

71. **A structural Merton-based model was used to extract PD estimates from the sovereign spreads projected under each scenario.** This approach assumes that the difference between a risk-free security and a risky security is the put option on the value of the assets defined as the expected loss under stressed conditions (i.e., PD*LGD). Using the credit spreads projected by the scenario for sovereign i, i.e., $S^i_{t,T}$, the residual maturity of security i (T-t), and assuming LGD=45 percent, the implied risk-neutral default rate for security i is computed as:

$$PD^i_{t,T} = \frac{1 - \exp^{-S^i_{t,T}} \cdot (T-t)}{LGD^i_t}$$

[26] EDF projections using estimates from higher quantiles capture amplification effects under stressed conditions from adverse moves to determinants and higher elasticities to regressors.

[27] In the Basel asset class of 'other institutions', most exposures are to sub-regional governments and municipalities.

[28] Another challenge posed by SNB 'Debt securities' breakdown is that data is reported at the parent-level. Pillar 3 data was used to reconstruct the holdings shares at the consolidated level.

Table 4. Switzerland: Slope Yield Curve Projections

While short-term yields decline in the adverse scenario as monetary policy reacts to the global recession, long-term yields increase due to the widening of credit spreads, leading to the steepening of the yield curve.

	Observed	Baseline					Adverse				
	2018	2019	2020	2021	2022	2023	2019	2020	2021	2022	2023
Switzerland	96	105	108	116	123	130	320	388	352	280	234
United States	49	24	-5	17	39	44	248	286	264	205	156
United Kingdom	84	68	59	55	50	44	290	349	301	215	154
China	69	69	69	69	69	69	217	277	236	169	130
Germany	130	150	159	163	163	168	324	410	378	304	258
Japan	33	40	46	68	77	87	131	89	83	79	84
Australia	106	91	86	81	64	64	319	380	331	234	181
Spain	225	256	276	292	314	319	580	654	606	531	469
Korea	118	118	118	118	118	118	348	416	363	279	224
Hong Kong	69	69	69	69	69	69	217	277	236	169	130
Italy	248	286	309	327	320	317	611	688	642	538	467
Netherlands	113	113	113	113	113	113	287	364	328	253	203
Ireland	168	182	197	210	221	229	357	449	426	361	319
Luxembourg	113	113	113	113	113	113	287	364	328	253	203
Canada	102	85	54	83	89	89	307	346	333	257	201
Sweden	160	154	146	135	71	107	378	440	384	236	215
Brazil	593	515	437	424	424	424	661	643	592	528	489
Thailand	148	128	138	148	158	158	273	348	319	261	220
Singapore	118	118	118	118	118	118	348	416	363	279	224
Malaysia	93	93	93	93	93	93	240	305	266	198	156
Belgium	199	224	238	247	253	263	399	490	462	393	353

Source: Bloomberg, WEO, IMF Staff estimates. The slope is measured as the 10-year sovereign yield over the 3-month Treasury bill.

72. **Impairments on sovereign exposures were calculated on claims not measured at fair value through profit and loss.** Newly created adjustments to provisions for default risk were projected for sovereign exposures booked in available-for sale, loans and receivables, and held-to-maturity investments. This contrast with the fair value assessment of sovereign positions booked in the held for trading category which were subject to market shocks (see market risk modelling section).

Stressing Complex Credit Risk Products

73. **Default risk for leverage loan exposures were estimated using G-SIBs' BBA templates.** Leveraged loan exposures include temporary exposures from syndicated underwriting activities, including syndicated loans, bridge loans, and equity bridges. These exposures cover facility type positions including term loans, revolving credit facilities, and loan commitments. The IMF team applied stressed PD and LGD parameters consistent with the credit risk paths for high-yield corporate indices in the scenario on banks' reported leverage loan exposures to estimate credit losses from these positions.

74. **Credit risk from banks' structured credit products was covered in the scope of credit risk loss estimates.** This category includes securitization products (e.g., asset backed securities (ABS), mortgage backed securities (MBS)) of financial assets including mortgages, credit card receivables, or auto loans, as well as structured credit derivatives. For the computation of the profit

and loss (P&L) impact, the amount of impairments was calculated on the carrying value for accrual positions and on net exposures for fair value positions. For each security, the underlying pool's credit and prepayment models was stressed under the IMF scenario to produce consistent impairment estimates, drawing on banks' estimates on stylized price shocks reported in BBA templates.

75. In addition, default risk from Lombard lending positions on uncovered exposures was also included in the analysis. The analysis drew on BBA reporting templates which include the exposures and losses of the entire Lombard portfolios.[29] To determine the size of uncovered exposures, the IMF scenario on market shocks was applied. The stress loss was computed by applying stressed PDs from retail exposures to the net exposures after applying the scenario shocks to market risk factors.

Impact of Credit Risk on Regulatory Capital

76. The impact of credit risk on banks' capital ratios depends on the regulatory approach used by banks to book credit exposures. For exposures booked under the IRB approach, credit risk evolves with the exposure at default (EaD), the PD, and the LGD. For exposures under the STA approach, credit risk is reflected in higher provisions for default risk and higher risk weights from a deterioration of the creditworthiness of underlying exposures. This is driven by higher LTVs in mortgage loans, credit risk migration to substandard categories for performing loans, and a rise in past due loans for non-performing loans.

77. At end-2018, there are four main IRB banks in the Swiss banking system. Main IRB banks include the two G-SIBs, and two of the largest cantonal banks. While the G-SIBs are A-IRB banks that book most credit exposures, including sovereign claims, under IRB (about 95 percent), the cantonal banks are F-IRB banks with very conservative F-IRB implementation, and RWA levels close to standardized values. For these banks a considerable part of the sovereign exposures are cash holdings at the SNB.

Credit Risk Model for IRB Exposures

78. The impact of macrofinancial conditions on provisions was calculated by estimating expected losses: $EL_{i,t}^{j} = PD_{i,t}^{j} * LGD_{i,t}^{j} * EAD_{i,t}^{j}$ where *i* denotes the bank, *j* denotes the asset class, and *t* is the time dimension. Credit risk parameters were estimated by asset class, geography, and scenario. The EaD evolves with the growth of the balance sheet and the migration of off-balance sheet exposures to on-balance sheet using credit conversion factors (CCF). Even if under current Swiss accounting standards, banks do not apply the expected credit loss approach, banks using IRB approaches need to deduct any "shortfall of provisions" from CET1 capital.

79. The regulatory credit risk parameters (PD, LGD, EaD) for Swiss banks' approved IRB models tend to be Through-the-Cycle (TTC). Switzerland adopted Basel Standards that required a

[29] Credit risk from concentration risk on individual exposures was excluded from the calculations.

calibration based on long-run averages and additionally a downturn calibration for CCF and LGD. Although credit risk parameters used to compute capital requirements are mostly TTC, there are some PiT components across portfolios.

80. To derive PD projections, a multiplier approach was applied on the paths generated by IMF credit risk models. The parameter paths, derived from the satellite models, form the basis for projecting bank loan losses conditional on the macro-financial scenario. To quantify the build-up of loan loss reserves, the estimated paths were applied on bank-level starting regulatory parameters using corresponding country-based default rate multipliers estimated by IMF models. These were applied on an exposure-weighted basis across the geographical breakdown of exposures.

81. For the LGD parameters, the structural model for mortgage risk was used for housing-related portfolio segments.[30] For other portfolios, the FSAP team used the multipliers calibrated by European Central Bank (ECB) staff for the Euro Area FSAP as well as on insights from the global financial crisis. Shifts to LGDs were calibrated by geography and portfolio. LGD projections were derived by bank, using estimated non-defaulted LGD ratios and shifts to LGD by portfolio as:

$$LGD^{j}_{i,t} = LGD^{j}_{i,t-1} + \Delta LGD^{j}_{t}$$

where $LGD^{j}_{i,t}$ is bank *i* post-credit risk mitigation LGD for portfolio *j* at time *t*, and ΔLGD^{j}_{t} is the aggregate LGD shift for portfolio *j* at time *t*.

82. The projection of EAD was driven by balance sheet assumptions, structural FX risk in foreign geographies, and triggered credit lines and guarantees. Specifically, changes to EAD in the IRB portfolio were governed by:

$$EAD^{j}_{i,t} = EAD^{j}_{i,t-1} \cdot \left(1 + g_{i,t} + f^{j}_{i,FX} \cdot \Delta FX_{t}\right) \cdot \left(1 - PD^{j}_{i,t-1}\right) + \Delta L^{j}_{i,t} \cdot UCL^{j}_{i,t-1}$$

where *i* denotes the bank, *j* denotes the asset class, and *t* is time, $g_{i,t}$ is the growth rate of the IRB portfolio, $f^{j}_{i,FX}$ is the fraction of foreign currency loans. ΔFX_{t} is the shock to foreign currency under the macro scenario, $\left(1 - PD^{j}_{i,t-1}\right)$ represents the non-defaulted portfolio, $\Delta L^{j}_{i,t}$ is the shock to triggered credit lines and guarantees, and $UCL^{j}_{i,t-1}$ is the amount of undrawn guarantees.

83. To compute capital requirements, regulatory risk parameters conditional on the scenario, were projected using the Basel III formula for IRB exposures. The derivation of RWAs is dependent on estimates of PD, LGD, EAD, correlation assumptions, and effective maturity for each exposure. According to the Basel III framework, RWAs were computed after applying the scaling factor of 1.06 to credit RWAs. Also, a multiplier of 1.25 was applied to the correlation parameter of all exposures to large regulated financial institutions and to all unregulated financial institutions.

84. An adjustment factor was applied on projected RWAs to account for idiosyncratic elements in banks' IRB modeling approach. While IMF projected paths are derived using

[30] These include retail loans secured by immovable property and corporate loans specialized lending.

credit risk proxies at the portfolio level, banks tend to use credit scoring models at the loan level in their estimation of credit risk. Although banks are expected to apply risk-weight functions provided by the Basel III regulatory framework, which maps the risk parameters to risk-weighted assets, the risk-weight function is concave on default risk which yields lower capital requirements when credit risk is estimated at the loan level. To address this bias, an adjustment factor calculated as the ratio between the projected RWA at the starting point and banks' reported RWA is applied over the estimated period.

Credit Risk Model for STA Exposures

85. To estimate loans loss provisions for STA exposures the FSAP team considered a range of approaches to compute the starting value of the risk parameters. Four approaches were used to construct the starting point of default rates:

- Compute the ratio of the stock of exposures in default over the amount of total exposures drawing on Basel templates.
- Calculate the share of impaired loans and non-performing loans over total receivables in the credit portfolio;
- Estimate the ratio of newly created adjustments to provisions for credit risk charged to income statement over gross loans, to exclude the impact of write-offs and recoveries;
- Use the 1-year expected default rate reported for IRB exposures for IRB banks and that of peer banks for STA banks.

86. Given the benign cyclical conditions of the Swiss economy, the FSAP team with decided to use the forward-looking IRB default rate in peer banks' portfolios as a starting point for STA exposures. The average NPL ratio in 2017 for the sample banks reached 0.5 percent for customer loans and 0.3 percent for mortgage loans. The amount of newly created provisions on the gross carrying amount of loans was even lower. Also, the available time series did not pick up sufficiently severe stress events making the statistical approach on these credit measures unsuitable. While the IRB default rate is a forward-looking measure rather than an incurred loss measure, it has the advantage of reporting a 1-year flow and therefore does not require additional assumptions on write-off rates and recoveries over the stress test horizon.

87. Currently, the Basel III regulatory treatment of credit losses for STA exposures allows a forward-looking concept in general provisions (GP) albeit this is added to Tier II capital. Under Basel regulatory framework, GP are defined as "provisions or loan-loss reserves held against future, presently unidentified losses which subsequently materialize" and while they are subtracted from CET1 capital, they are added to Tier II capital. By contrast, specific provisions (SP) include "provisions ascribed to identified deterioration of particular assets" and they are excluded from both regulatory capital and from RWAs for credit risk.

88. At the same time, the Basel Committee is considering creating a level-playing field in the capital regulatory treatment of provisions by adopting the expected loss approach for STA provisions. One of the options being considered is to fundamentally change the current regulatory treatment of provisions – remove the GP/SP distinction and introduce regulatory expected losses under SA. This is in line with the approach taken by the IMF team to project credit impairments for standardized exposures.

89. The coverage ratio for defaulted exposures was floored at the LGD rate reported for the same portfolio under the IRB approach.[31] Banks report the general and specific provisions computed on defaulted exposures in Basel templates. This measure captures the eligible collateral and guarantees on defaulted claims in line with credit risk mitigation techniques. Under the adverse scenario, a 65 percent estimated coverage ratio was applied subject to the following constraint:[32]

$$LGD_t^{c,i} = \max\left\{\max\left(\frac{general\ \ provision_t^{c,i} + specific\ \ provision_t^{c,i}}{\exp osure\ \ in\ \ default_t^{c,i}}, LGD_t^{c,i}\right)\cdot multiplier_t^{c,i}, 0.65\right\}$$

90. To forecast the flow of exposures in default, the default rate was multiplied by the amount of performing exposures projected each period. General and specific credit risk adjustments were projected by multiplying the flow of new impairments by the stressed LGD by geography and portfolio. The flow of new impairments was projected using the same econometric approach applied to IRB exposures. In line with balance sheet assumptions for the IRB portfolio, the stock of performing exposures was driven by the growth of the loan book, structural FX risk in foreign exposures, triggered credit lines and guarantees, and the flow of new impairments.

91. Regulatory capital requirements were computed using three steps:

- For the defaulted portfolio, the risk weight of exposures in default, excluding exposures at 0 percent risk weight, was computed for each portfolio drawing on Basel templates;

- The risk weight of exposures in default was set at an average 100 percent, following Basel III's regulatory framework which specified that a 100 percent risk weight should be applied on past-due loans when specific provisions are no less than 20 percent of the outstanding amount of the loan. The risk weight on the new flow of exposures in default was computed as:

$$RW_t^{c,i}\,\middle|\,default = \max\left\{RW_{2017}^{c,i}\,\middle|\,default, 100\%\right\}$$

[31] This floor covers all exposure classes except claims on central government, central banks, regional governments, public sector entities, multilateral development banks, and international organizations which were floored at 40 percent.

[32] This ratio was calibrated using Basel findings on NPL coverage ratios during the global financial crisis.

- For the non-defaulted portfolio, one-notch downgrade of the underlying exposure was assumed under the adverse scenario.[33] The initial risk-weight density reported by banks for non-defaulted exposures in Basel templates was mapped to the external rating by portfolio laid out by Basel, and one-notch downgrade was added to calculate the projected risk-weight density.[34]

92. Capital requirements for STA exposures were also driven by changes in provisioning rates, growth of EAD, structural FX risk, triggered credit lines and guarantees, and migration effects. There are four main components driving shifts to RWAs in the STA portfolio. The first component reflects the motion of RWAs generated by the flow of provisions, the growth rate of the portfolio, and FX effects. The second component shows the increase in risk weights resulting from triggered off-balance sheet credit lines and guarantees. The third component reflects the increase in risk density from the transition of loans from the performing to nonperforming category. Finally, the fourth component denotes the change in risk density from the transition matrix estimated for performing exposures.

93. To avoid a structural break in the loan loss impairment projections, an adjustment factor was applied based on the reported newly created provisions at the starting point. To address the IMF upward bias of a rise in provisions from the choice of the forward-looking approach relative to Swiss GAAP incurred loss accounting standards, an adjustment factor was computed as the ratio between the projected loan loss impairment charges at the starting point and banks' reported new inflows of provisions. This limited the contribution of credit losses to banks' capital shortfall under stress.

C. Market Risk Modelling Approach

94. The scope of the market risk assessment covers all fair value positions. This includes financial assets held for trading (HFT), financial assets designated at fair value through profit and loss, as well as available-for-sale financial assets (AFS) which impact regulatory capital through other comprehensive income (OCI). The scope excludes amortized cost positions held in a hedge-accounting relationship, as well as hedge accounting derivatives. The traded risk scenario had an impact on capital resources while capital requirements for market risk evolve with balance sheet assumptions. Changes in credit valuation adjustment (CVA) and counterparty credit risk (CCR) are excluded from the scenario-based analysis. Stressed CVA is assessed as a separate sensitivity test linked to solvency and liquidity interactions.

95. The market impact is computed using a combined approach of instantaneous and multi-year shocks. For the valuation impact of debt securities (repricing risk, credit spread risk) a

[33] This is informed by the revised standardized approach for credit risk under Basel III which recommends assigning a risk weight at least one bucket higher than the risk weight determined by the external rating when the due diligence analysis reflects higher risk characteristics than that implied by the external rating bucket of the exposure (BIS, 2017). We expect this to hold under stressed conditions.

[34] This amounts to an average increase in the risk weight density for STA exposures of about 8 percent. See Basel Committee on Banking Supervision (2017), 'Basel III: Finalizing post-crisis reforms', December. Section 'Standardized approach for credit risk'.

multi-year shock was applied in line with the 5-year scenario. Losses were absorbed the same year the shock hits. To assess the P&L impact of products sensitive to other market risk factors (e.g., equity risk, foreign exchange risk, commodity risk), an instantaneous shock was applied, and losses recognized in the first year of stress.

96. The IMF applies a multi-year approach for interest rate shocks and assesses basis risks. Under the IMF approach, fair valuation impact is computed separately on cash and derivative instruments for G-SIBs allowing the assessment of basis risk. By contrast, hedging instruments for interest rate risk and credit shocks are assumed to be ineffective under stress for DFBs and private banks. While this is a conservative approach, the traded risk losses are partially reversed as asset prices recover after a sharp correction assumed during the first year of stress.

97. Market risk factors include risk free curves, libor rates, sovereign and corporate credit spreads, equity prices, exchange rates, and commodity prices. Paths for sovereign spreads, libor rates, equity prices, exchange rates, and commodity prices were generated by the macrofinancial scenario. Scenario expansion was required for swap curves and corporate credit spreads. Figure 9 shows that, with SNB's introduction of negative rates in Dec 2014, the three-month Libor was taken into negative territory and the sovereign yield flattened posting yields at -64 bps, -34 bps, and +15 bps for 1-year, 5-year, and 10-year tenor, respectively, in Oct 2018. The path for swap curves was generated by modeling a cointegration equation on 3-month libor and sovereign yields estimated using a fully modified least square approach (FMOLS).

98. Traded shocks on corporate instruments were calibrated by index and credit rating class using an expected shortfall (ES) approach. The calibration approach is consistent with the minimum capital requirements for market risk under Basel's fundamental review of the trading book (FRTB) which includes a shift from Value-at-Risk (VaR) to an ES measure of market risk under stress. The use of ES helps to ensure a more prudent capture of 'tail risk' and capital adequacy during periods of significant financial market stress. To compute ES, daily yield to maturity (YTM) were computed over 2000–2018, taking a 99 percent threshold, and a 30-day holding period for the calculation of the market shock.[35]

99. Revenue and cost changes in banks' investment banking business were included in commission income. Client revenues of trading assets include bid/ask spread, fees and commissions, and investment banking fees. These revenues were projected as commission income by applying shocks to the effective implied rate at the starting date using the amount reported in Basel templates. Client revenues reported by banks under gains on financial assets and liabilities held for trading were excluded as they could not be differentiated from the valuation impact of the trading position.

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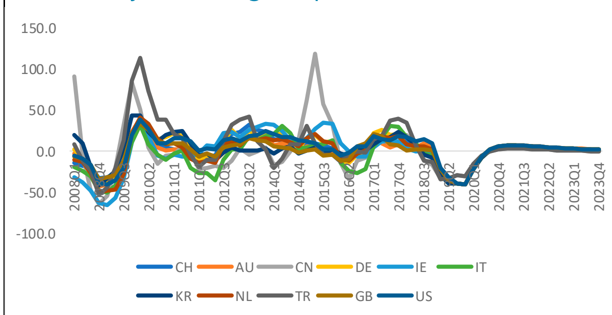
[35] The holding period for EM indices was set to 180 days as market liquidity tends to dry out during crisis in relatively illiquid securities.

Figure 9. Switzerland: Selected Market Risk Shocks

The scenario features a generalized sell-off in stock markets, a sharp correction in commodity prices, basis risk across cash and derivative positions, and an ES valuation approach for corporate shocks.

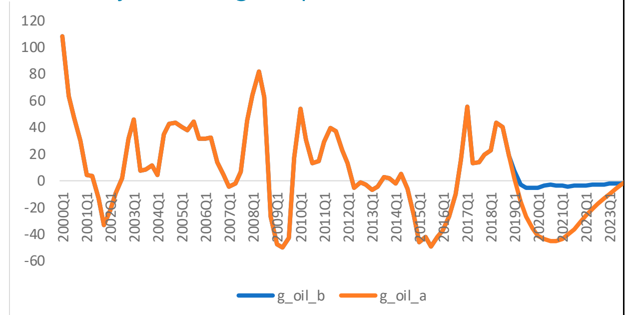
Equity prices fall by an average rate of 40 percent across major equity indexes.

Equity Prices
(Year-on-year Change in percent)



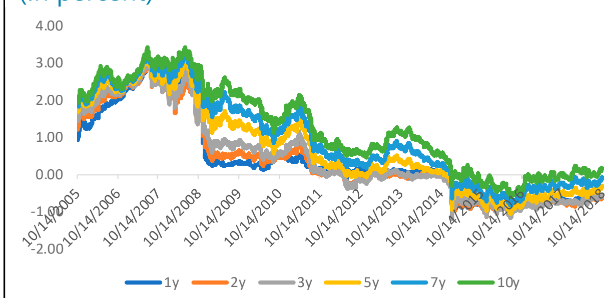
Commodity prices replicated the oil prices' plunge observed during the global financial crisis.

Oil Prices
(Year-on-year Change in percent)



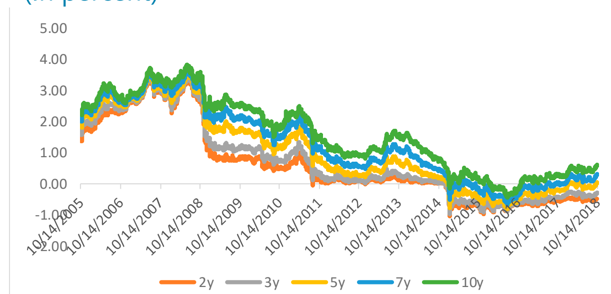
After SNB's introduction of negative rates in Dec 2014, sovereign yields have remained negative with a slight flattening of the yield curve posting -64 bps, -34 bps, and +15 bps for 1-year, 5-year, and 10-year tenor in Oct 2018.

Yield Curve Swiss Confederation
(In percent)



Swap rates on Swiss francs have gone down with average daily spreads of 5-year sovereign yields over swap rates at -31 bps over 2000-2018.

Swap Curve CHF
(In percent)



To assess basis risk in cash and derivative instruments, shocks were differentiated across curves using an ES measure.

Government Yield Curve

	1y	2y	3y	5y	7y	10y
99% VaR	9.6	11.1	10.0	8.5	7.9	7.9
99% Expected	12.9	15.8	14.4	11.8	10.7	10.5
shock holding 30d	**70.9**	**86.6**	**78.8**	**64.4**	**58.7**	**57.7**

Swap Rate Curve

	1m	2y	3y	5y	7y	10y
99% VaR	4.0	6.5	6.7	7.2	7.5	7.8
99% Expected shortfall	7.1	9.8	9.5	9.4	9.6	9.9
shock holding 10d	**22.4**	**31.0**	**30.1**	**29.8**	**30.2**	**31.3**

Corporate shocks were calibrated by major index and rating class using an ES measure.

	EA Financial BBB	UK Financial BBB	US Financial BBB	EA Non-Financial BBB	UK Non-Financial BBB	US Non-Financial BBB
99% VaR	22.208	17.8	21.2	11.8	11.1	13.2
99% Expected shortfall	68.6	43.7	36.7	16.1	13.9	18.5
shock holding 30d	**376**	**239**	**201**	**88**	**76**	**102**

	Euro Non Periphery Financial BBB	Euro Non Periphery Non-Financial BBB	Euro Periphery Financial BBB	Euro Periphery Non-Financial BBB	Japan Financial BBB	Japan Non-Financial BBB
Scaling factor	4	3	4	3	3	
shock scaling factor	**285**	**203**	**467**	**276**	**134**	**50**

	Australia Financial BBB	Australia Non-Financial BBB	CH - Global Financial BBB	CH - Global Non-Financial BBB	BBB EM Financial	BBB EM Non-Financial
Scaling factor	3		3		3	
shock scaling factor	**281**	**103**	**222**	**82**	**478**	**176**

Source: Bloomberg, IMF staff estimates, and IMF calculations.

100. Banks' securities portfolio evolves in line with the constrained balance sheet assumption for credit risk. The notional values of the securities portfolio grow according to:

$$B_{i,t}^{j} = \left(B_{i,t-1}^{j} - \mathrm{Pr}_{i,t}^{j}\right) * \left(1 + g_{i,t} + f_{i,EUR} \cdot \Delta FX_{EUR} + f_{i,USD} \cdot \Delta FX_{USD}\right)$$

where $\mathrm{Pr}_{i,t}^{j}$ is the level of provisions for asset class *j*, by bank *i*, at time *t*; $g_{i,t}$ is the growth of interest-bearing assets for bank *I*; $f_{i,EUR}$ ($f_{i,USD}$) is the fraction of bank's *i* portfolio denominated in EUR (USD), and ΔFX_{EUR} (ΔFX_{USD}) is the FX shock to EUR (USD). On the other hand, no portfolio rebalancing or liquidation of positions was allowed throughout the stress test horizon.

Data Granularity

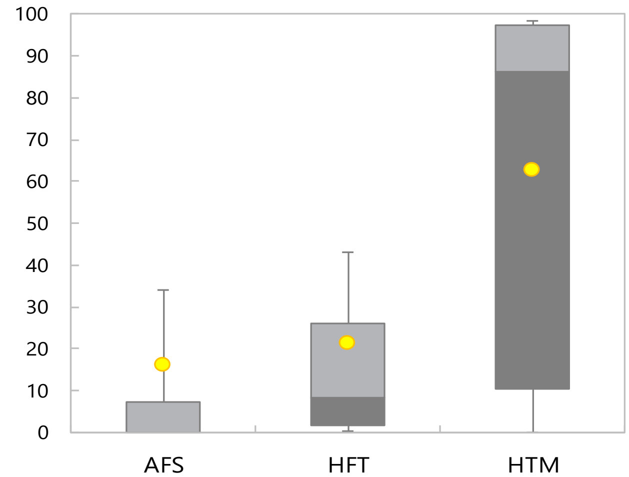
101. The FSAP team extracted data from SNB BS surveys, G-SIBs' BBA reporting, and banks' annual reports and Pillar 3 disclosures to build a granular database. Fair value positions were identified by issuer, regulatory book, and counterparty. SNB balance sheet surveys were used to identify the volume of trading portfolio, other financial investments at fair value, and financial investments. The latter groups AFS and held to maturity (HTM) positions. The breakdown by accounting category was achieved by combining information from banks' annual reports.

102. While SNB BS positions include fine breakdowns for some categories, supplementary information was required to identify the portfolio sensitivities to market shocks. SNB BS data includes breakdowns for domestic and foreign positions, material currencies, major counterparties for domestic portfolios, and geographies for foreign positions. However, additional data was extracted from banks' annual report identify the sensitivity of positions to market shocks, including reference equity indices, sovereign benchmark curves, and country corporate indices.

103. The analysis shows that sovereign exposures are booked mainly in HFT and HTM portfolios (Figure 10). On an asset-weighted basis, about 50 percent of sovereign exposures are booked under HTM portfolios, 40 percent in trading and fair value portfolios, and the remaining 10 percent in AFS portfolios. However, there is a large dispersion across banks with G-SIBs booking primarily in HFT, DFBs in HTM, and private banks either in AFS or HTM. In terms of issuers, sovereign exposures are predominantly to the United States, United Kingdom, Switzerland, and other foreign issuers given the insufficient supply of HQLA to meet the LCR requirements in CHF (excluding the current high levels of banks' sight deposits with the SNB). In Switzerland, banks are allowed to include additional HQLA in foreign currencies when calculating the LCR under the Alternative Liquidity Approaches options.

Figure 10. Switzerland: Sovereign Exposures by Accounting Category
(In percent)

Most exposures are booked under the HTM and HFT books with a large dispersion across banks.



Source: IMF Staff Estimates. The sample of banks included the twelve major Swiss banks. Boxplots include the mean (yellow dot), the 25th and 75th percentiles (boxes) and the 15th and 85th percentiles (whiskers).

Market Risk Approach for G-SIBs

104. To compute the P&L impact from shocks to market risk factors on G-SIBs, the FSAP team used data on banks' risk profile from BBA templates. The BBA templates group exposures in modules that represent the key drivers of banks' risk profile. The templates also collect delta sensitivities by major index/counterparty, with a breakdown of long vs. short positions, and cash vs. derivative positions. To account for non-linear valuation effects from large shocks, the report also collects fair value impact to severe shocks prescribed at two severity levels, i.e., 'severe event', and 'extreme event'.

105. FINMA reporting templates suggest that G-SIBs rely on delta hedging strategies to manage market risk. Delta hedging is an option-based strategy that aims to reduce, or hedge, the risk associated with price movements in the underlying asset, by offsetting long and short positions. The small net delta, with netting of long and short positions in cash and derivative positions, reported by banks for a 1-bp move to the price of the underlying, suggests that banks are, on aggregate, well hedged under normal market conditions.

106. Banks are, however, exposed to basis risk if correlations between cash and derivative positions break down under stress. Basis risk is the most important risk when trading in the derivative market. Since derivatives essentially are traded on the basis of the value of the underlying asset, any disproportionate fall in the value of the underlying asset would cause a crash in the derivatives designed for that purpose. If there is non-convergence of spot price and relative price on the offset date of trade, banks are exposed to adverse price shocks to the underlying.

107. To assess basis risk, the IMF team used differentiated shocks across the cash and derivative positions. Relative shocks to cash and derivative positions were informed by:

- *The financial crisis*. The implicit assumption is that to hedge sovereign bond curve risk in fair valued government securities, banks use derivatives priced against the swap curve. Figure 8 suggests that basis risk in fixed income markets widened during the global financial crisis, exposing banks to basis risk. While the daily spread between the 5-year sovereign yield and the swap rate hovered about -31 bps in 2000–2018, it tripled to over -100 bps in October 2008;

- *Market liquidity*. Differential impact in the fall of the underlying asset and its derivative can be triggered by the different degree of market liquidity that characterizes the trade risk scenario. This is associated to the liquidity horizon under which banks can exit positions in view of the likely market trade volumes under the stress scenario. For corporate bond curve risk, the IMF team assumed a 30-day holding period while for swap-referenced positions, the holding period is assumed to be 10-days (Figure 8).

- *The 2018 Comprehensive Capital Analysis and Review (CCAR) severely adverse market scenario.* For BBB corporate bonds, the relative shock to the bond position and the underlying derivative indexed by the Credit Default Swap Index-Investment Grade (on the run) was estimated at a scaling factor of 2.

108. The P&L fair valuation impact resulted from applying the corresponding shock to the cash and derivative position separately. BBA data includes the net delta on cash and derivative positions. For instance, for credit spread risk, net delta is reported by credit rating (IG, HY), counterparty (sovereign, public entities, financial, corporate), and region (Switzerland, North America, Asia…). This enabled the application of differentiated shocks calibrated in the IMF scenario on the fair value of the position to compute P&L impact. Information related to the valuation impact reported by banks on prescribed shocks was also used to account for non-linear effects in the size of the shock.

Market Risk Approach for DFBs and Private Banks

109. The valuation impact on debt securities was disaggregated into repricing risk and credit spread risk. The impact on P&L and capital is recognized over the stress test horizon. Although the notional value of exposures evolves with the balance sheet, banks are assumed to maintain the same structure of the portfolio throughout the stress testing horizon.

110. The impact of repricing risk depends on the shock to the risk-free curve and bond duration. Interest rate sensitivity is measured by the effective maturity of the bond proxied by duration. Duration is approximated by the residual maturity of the bond at the cut-off date. Under the full valuation approach, the change in the risk-free bond price is the result of multiplying modified duration by the shock to the risk-free rate:

$$\Delta P_t^i = -\frac{D^i}{\left(1 + r_t^i\right)} \cdot B_t \cdot \Delta r_t^i$$

where D^i denotes average duration of bond *i*, B_t denotes the carrying value of the debt security at time *t*, r_t^i captures the risk-free rate level and Δr_t^i the shock to the risk-free rate.

111. The risk-free curve is proxied by the Swiss bond curve. Term premium decompression in fixed income markets together with the absence of flight-to-quality effects contribute to steepen the Swiss bond curve with the 10-year rate rising by 100 bps in 2020: Q4 relative to 2018: Q2 despite the decrease in policy rates. A polynomial interpolation method is applied to span the term structure between the 3-month and the 10-year rate generated in the macroeconomic scenario.

112. Credit spread risk in other geographies depend on the re-emergence of sovereign stress and monetary policy space. For countries with sovereign distress (e.g., peripheral Europe, some emerging markets) and at the zero-lower bound, credit spreads widen significantly relative to the Swiss bond curve. For countries with monetary policy space, the expansionary policy response assumed in the adverse scenario makes the yield curve pivot downwards mitigating the pricing impact at the short-end (e.g., China, United States).

113. The credit spread impact on fair value depends on shocks to credit spreads and bond duration. Using the modified duration approach, the FSAP team calculated the haircut for each fixed income instrument under each scenario by multiplying modified duration by the shocks to credit spreads:

$$\Delta P_t^j = -\frac{D^j}{\left(1 + r_t^i + cs_t^j\right)} \cdot B_t^j \cdot \Delta cs_t^j$$

where D^j denotes average duration of bond *j*, B_t^j denotes the carrying value of security *j* at time *t*, r_t^i shows the risk-free rate, cs_t^j denotes the credit spread, and Δcs_t^j the shock to credit spreads.

114. Although duration (proxied by residual maturity) is typically low in the HFT portfolio, is larger in the AFS portfolio, exacerbating valuation impact in a few cases. Duration affects valuation through two channels. First, as the curve pivots downwards and steepens under stress, long-duration assets are hit by larger shocks. Second, the sensitivity of the portfolio to shocks increases with the duration of the portfolio. Relatively less monetary policy space in some jurisdictions (e.g., euro area) limits the downward shift of the yield curve increasing the relative impact of term premium decompression and sovereign stress.

115. For equities held with a trading intent, the fair value impact was floored using the 2018 EBA methodology. The market impact from full revaluation of equity holdings was floored using the following constraint:

$$\Delta Eq_t^j = 1.5 \cdot \left(-0.20\% \cdot \left(Equity_t^{long,j} + Equity_t^{short,j}\right)\right)$$

where the VaR scaling factor has been set to the upper bound of 1.5, and the trading position includes the fair value of equity instruments (assets) and the short positions in equity instruments (liabilities).

116. Hedges are assumed to be ineffective for DFBs and Private banks. Given data limitations, the FSAP team did not have access to market risk sensitives for DFBs and Private banks. Although DFBs typically carry small fair value positions, some private banks have larger sensitivity to market risk factors, particularly interest rate risk, credit spread risk, and equity risk. Under the assumption that Private banks hedge their position effectively (i.e., they do not take directional trades), the IMF approach was rather conservative.

D. Operational Risk

117. Operational risk is a major source of risk for Swiss banks. For G-SIBs and private banks operational risks are significantly given the sensitivity inherent in private banking business models to operational risk. Even for DFBs, capital requirements for operational risk almost triple that for market risk. From a total RWA of CHF 479 billion at end-2017, CHF 11.1 billion cover market risk, whereas about CHF 30 billion cover unexpected losses in operational risk.

118. In times of economic and financial turmoil, operational loss events like fraud, processing errors or lawsuits may be more likely and/or more severe. In fact, one point that has long been argued is that operational risk is idiosyncratic to the firm, and therefore not driven by macroeconomic conditions. A complicating factor is that, where such relationships exist, there may often be a delay between the deterioration of macroeconomic conditions and the occurrence and realization of operational losses (e.g., legal losses). Scenario assumptions can enter into the projection of operational losses under stress either in the frequency of the loss events, or in the loss severity distribution for each event drawing on far tail percentiles of historical realized loss data or on estimated losses per event.

119. Operational risk of Swiss banks is mainly linked to internal fraud, external frauds, execution, delivery and process management, and clients, products and business processes (CPBP).[36] Most of the losses expected under adverse macrofinancial conditions relate to clients, products, and business practices, and to a lower extent to internal fraud. Some losses for CPBP are related to potential delays in the execution of Lombard loans under stressed conditions. Together with financial risks related to securities-based lending (including market and collateral valuation risk), banks face additional risks linked to the execution of the collateral, particularly in emerging markets, related to potential capital controls, restrictions to capital transfers, or legal prescriptions limiting the enforcement of collateral sales. Other elements of CPBP relate to potential litigation charges associated to the underwriting and trading of securities, and to the mis-selling of complex products to investors given the implementation of substantial new conduct requirements for financial services when dealing with clients introduced in the EU.[37]

120. Operational costs are also linked to some open litigation items by Swiss banks. While most legacy litigation items from the global financial crisis were closed down (e.g., FX, Libor), there are some major cases still open. There are, however, challenges in the estimation of the amount of

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[36] The main categories of operational risk projected by banks include: business disruption and system failure; clients, products and business practices; damage to physical assets; employment practices and workplace safety; execution, delivery and process management; external fraud; and, internal fraud.

[37] Swiss implementation of investor protection legislation similar to MiFID II/MiFIR is expected over the stress test horizon. In the EU MiFID II/MiFIR was implemented in January 2018.

loss incurred when open legal cases (or future events) materialize into a loss which adds to the uncertainty over the timing of the settlement of future losses.

121. The potential shortfall of provisions in the balance sheets due to possible lenient accounting standards are partly compensated by the conservative calibration of the regulatory capital requirements for operational risks. In some instances, litigation reserves as well as possible losses have been underestimated at the lower end of the possible outcomes in banks' accounting reporting. At the same time, additional litigation stress analyses are performed as part of the capital exercise of G-SIBs to ensure adequate capitalization. Also, capital requirements for operational risk are calculated using advanced models which generate a conservative estimate given the size of on-balance sheet and off-balance sheet exposures of Swiss banks. In addition, FINMA has imposed institution-specific buffers with respect to the exposure towards litigation and reputational risks to ensure adequate capitalization.

122. The FSAP team used bottom-up projections of operational risk linked to the IMF scenario. To satisfy emerging regulatory expectations and ensure appropriate stress testing results, Swiss banks have been using a well-structured approach to link operational losses to macroeconomic conditions to develop credible results. Bottom-up results indicated that the cumulative capital impact from operational risk over the 5-year horizon account approximately for 8 percent of total impact against the 15 percent for credit risk and 1 percent for market risk.[38]

E. Interest Rate Risk in the Banking Book

Earnings Approach

123. Swiss banks' net interest income has been compressed by the low interest rate environment (Figure 11). The average net interest margin (nim) on outstanding loans hovered about 150 bps in 2017. It reached 121 bps for outstanding claims, including financial claims, due to the exceptionally low interest rate environment with 3-month libor rates at -75 basis points and 5-year sovereign benchmark rates at -52 basis points. Banks have, however, managed to keep the nim broadly stable since the introduction of negative rates in Dec 2014 partly by widening asset margins on new mortgages. Going forward, the concern is that average lending rates will continue to fall as loans taken out in the past are renewed at lower rates. Also, there is recent evidence that asset margins on newly extended mortgage loans have decreased adding pressures to profitability. In addition, liability margins have been negative since 2015 given the zero lower bound threshold applied by bank on most retail deposits.

124. Interest rate risk is a major risk for domestic banks. DFBs rely mainly on interest income to boost profitability. NII represents about 70 percent of total earnings. Banks are exposed to maturity transformation risk as they lock in rates on assets for longer periods that rates on liabilities which are mainly sourced from retail deposits. This risk has increased with the replacement of

[38] Bottom-up results for operational risk calculated by banks were benchmarked against realized operational losses during the global financial crisis and banks' reported risk weighted assets for operational risk.

variable rate mortgages, which were repriced at the discretion of the bank, by long term fixed-rate mortgages as borrowers are increasingly inclined to secure fixed-rate mortgages in the current low interest rate environment. Also, the government benchmark curve has flattened since 2008 from 150 bps in the 5-year to 3-month Treasury spread to the current 50 bps, constraining long-term rates further.

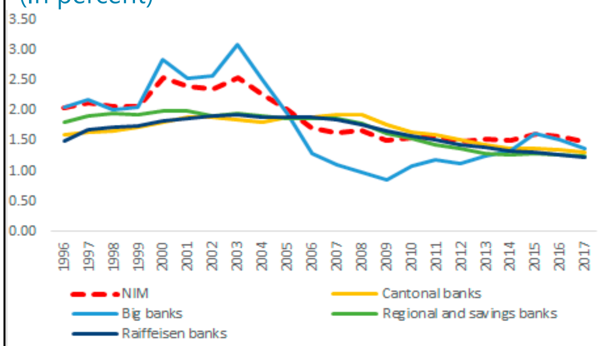
125. The focus of the IMF test on IRRBB is on the EA rather than on the value of securities held at amortized cost. The key risk from sudden moves of interest rates is their potential adverse effect on the bank' capital and earnings prospects. While the 2016 Basel standards on IRRBB include the monitoring of the impact of adverse shocks to interest rates on both the economic value of the bank's banking book positions weakening the value of equity (EVE) as well as on the bank's EA, the IMF IRRBB module investigated EA sensitivity as the economic impact of interest rate moves on banking book securities (AFS) was examined in the market risk module.

Figure 11. Switzerland: Interest Rate Environment

After declining in 2006, net interest margins have remained stable on aggregate with some variation across banking groups…

Net Interest Margin

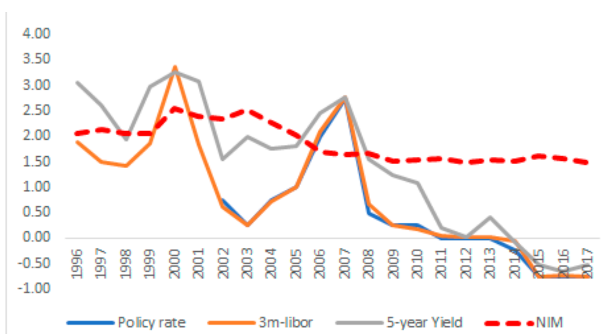
(In percent)



…despite the sharp drop in benchmark rates.

Benchmark Rates

(In percent)



Source: SNB, Bloomberg, and IMF calculations.

126. Results from the SNB's IRRBB analysis suggest that banks would benefit from a moderate increase in interest rates but would be strongly negative affected by large upward shocks.[39] Banks' net interest income would increase, on average, in the event of a small to moderate upward interest rate shock, despite their exposure to maturity transformation risk, as they would be able to restore the liability margin that has remained negative since the introduction of negative rates. The SNB estimates that following a 200-bps interest rate shift, banks' net interest margin would increase by about 20 bps. By contrast, a large upwards shock in the interest rate curve would negatively affect earnings as the decrease in structural margin and the behavioral decrease in asset margin would offset the beneficial impact of the restoration of the liability margin. In the event of a 400-bps shock, banks' interest rate margin would fall by about 20 bps from the current low levels.

[39] SNB (2018, 2017, and 2016), "Financial Stability Report".

127. The FSAP assessment of IRRBB followed a four-pronged approach which shares some similarities with the SNB approach:

- The '*economic value approach*', which measures the valuation effect of an interest rate shock on the fair value of assets, and impacts EVE due to long duration (e.g., long-dated fixed rate bonds), was evaluated using a market risk approach (see section on market risk). By contrast to the Basel EVE measure, only marked-to-market assets in the banking book (through other comprehensive income) were re-valued rather than all balance sheet positions;

- The '*earnings approach*', which measures the impact of an interest rate scenario on banks' future net interest income over a 5-year horizon was assessed against a range of interest rate shocks calibrated at the *bank/product* level. While the SNB approach has developed a granular approach in terms of products and time bands, and has incorporated dynamic elements from bank and borrowers' behavior, rates are projected at the banking system level;

- The *scenario* includes a commercial margin and an intermediation margin. In particular, two components are included in the calibration of the interest rate shocks: a systematic risk factor (broadly aligned with the scenario) and an idiosyncratic component (linked to banks rates' historical behavior); and

- As in the SNB test, shocks were applied to the *repricing structure* of assets and liabilities using the Interest Rate Risk report as of June 2018. Impact is measured separately for the stock of loans/liabilities and for the flow of new lending/funding instruments.

Structure of Assets and Liabilities

128. The exposure of banks' earnings to interest rate risk depends on changes in market rates as well as on banks' structure of assets and liabilities. The impact of a change in market rates on funding costs depends on the liability margin which varies across funding instruments (e.g., sight deposits vs debt securities). The impact of a rate shock on interest income depends on the commercial margin which differs across loan products (e.g., mortgage vs consumer loans). Margins are a function of banks' business model as well as the level of market competition in product markets.

129. For the sample of banks included in the stress test, mortgage loans represent about 40 percent of total loans.[40] About 18 percent are amounts due from banks, whereas Lombard loans represent 16 percent of outstanding claims. The share of 'other customer loans' and securities financing transactions is similar at 13 percent of total loans. This hides, however, important differences in the composition of the loan portfolio across banks, in line with banks' business models. Whereas G-SIBs have relatively larger exposures to other banks (24 percent of loans), DFBs are heavily exposed to mortgage loans (82 percent of loans), and private banks have larger shares of Lombard loans (62 percent).

[40] This loan definition includes amounts due to banks, SFTs, and customer loans including Lombard loans, mortgage loans, and other loans.

130. Swiss banks fund their balance sheet mainly with retail deposits. In line with banks domiciled in other advanced economies, large Swiss banks have re-oriented their business away from trading and more complex activities, towards less capital-intensive activities, including a retrenchment from foreign wholesale funding, supported by the low interest rate environment, and FINMA implementation of Basel LCR regulation. This pattern is reflected in banks' increased reliance on customer deposit funding.

131. In the stress testing sample, retail funding represents over 70 percent of interest-bearing liabilities. By contrast, reliance on less stable sources of funding ('wholesale funding') is low. Amounts due to banks and repos contribute to about 10 percent while debt securities issued account for 20 percent. All banks rely heavily on customer deposits regardless of their business model, with private banks showing greater reliance on retail deposits at about 85 percent of interest-bearing liabilities.

132. While market sensitivity of liquidity reserves at the SNB (asset side) and of retail funding (liability side) to money market stress is low, positions are subject to considerable behavioral uncertainty. This is because cash balances at the SNB are motivated by the ultra-low interest rate environment, and therefore, are subject to behavioral shocks if rates start to raise.[41] Moreover, the decoupling of rates paid to depositors from market rates has increased the uncertainty of the pricing of these deposits if rates were to rise. Another element of uncertainty relates to the shift in retail deposits from sight deposits to term deposits should interest rates start to rise.

133. Some relevant dynamic elements were captured by the FSAP's IRRB assessment. Given that banks' capacity to generate substantial interest income depends significantly on dynamic effects, the FSAP team attempted to model explicitly changes in commercial margins, liability margins, and pass-through effects. Non-maturing deposits (e.g., current accounts) where modeled as overnight deposits. On the other hand, the team did not change the maturity profile of maturity positions at renewal, or customer behavior related to shifts between different types of deposits, in line with the constant portfolio nature of banks' balance sheets. This contrast with SNB approach that incorporates dynamic elements in customer shifting patterns across deposits, and banks' implied duration targets.

Modelling Strategy

134. The FSAP team calculated interest income and expense at the portfolio level using a twofold approach:

- For competitive loan products and funding instruments, rates were projected at the aggregate level using shocks to benchmark rates and assuming no changes in margins.

[41] On the back of the extraordinary low interest rate environment, the volume of cash balances at the SNB has grown strongly at 11 percent of total assets for the sample of banks, reaching about 50 percent for some private banks.

- For non-competitive loan products and credit sensitive liabilities, rates were projected at the bank level using shocks to systematic and idiosyncratic risk factors, with bank margins determined endogenously.

135. This approach addresses two major developments since the global financial crisis. First, funding market conditions have become heterogeneous across banks reversing a pre-crisis trend of lower and more similar rates. Second, there have been concerns over the policy rate pass-through to lending rates. Possible sources in the inefficient transmission of monetary policy have been attributed to the misalignment of policy rates and funding costs and to banks' internal transfer policies to set lending rates. Both aspects are examined in this section.

136. The modeling strategy was enabled by the granular data shared by the Swiss authorities collected in FINMA's interest rate risk (IRR) report. This report includes all banking book positions according to their repricing maturities. Time bands are highly granular with eighteen time-buckets, ranging from up to 1 day to over 15 years. Positions are classified by reporting category including: Category I: positions with determined repricing maturities (e.g., fixed-rate loans, or medium-term notes); and, Category II: positions with undetermined repricing maturities (i.e., sight claims, claims against customers, variable mortgage loans, sight liabilities, and customer deposits callable).[42]

137. The IRR report was mapped to SNB's maturity structure survey to deepen the portfolio composition and enable margin projection. The IRR does not report separately positions with remaining contractual maturity for instruments at fixed rate and instruments at floating rate.[43] This distinction is, however, required to project margins when fixed rate instruments are re-issued over the stress test horizon. Another limitation of the IRR report is that is based on cash-flows which include the nominal value (principal) and interest payments, whereas the IMF analysis is based on carrying amounts. The FSAP team mapped the IRR report to the SNB's maturity structure survey which also has a finer breakdown of portfolios (e.g., Lombard loans, amounts due to banks, SFTs, 'other customer loans'…) and splits carrying amounts by time to maturity including on sight, cancellable, and remaining maturity buckets (<1m, 1-3m, 3m-1y, 1-5y, and >5y).

138. To project individual bank specific margins, position data was combined with income statement information from banks' annual reports and Dealogic. To estimate empirically banks' pricing behavior, interest income on loans was split into main product categories. To project funding cost, information from banks' annual reports on cost on deposits and other liabilities was mapped to interest spread over benchmark at issuance for debt instruments drawing on Dealogic data.

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[42] Other categories include: Category III: positions with no repricing maturity (e.g., trading portfolio assets and liabilities); Category IV: own funds; and, Category V: non-linear derivatives.

[43] This contrast with the SSM report on IRRBB used for the 2017 ECB Sensitivity Analysis of the IRRBB.

Funding Costs Modeling

139. A key contribution of this approach is to carefully construct an effective measure of funding costs. Interest rates paid on liabilities vary across banks depending on their funding patterns and liquidity management practices.[44] Given that core funding markets vary across the sample of banks, we expect different rates paid on deposits across banks. Another important determinant of interest expense is banks' liability margin which depends, among other factors, on the proximity to the zero lower bound.

140. The effective funding cost measure is built by matching bank' liability structure with the interest rate path by funding instrument conditional on the scenario:

- Amounts due to banks and funding from repo transactions are linked to 3-month libor rates by currency. The breakdown of liabilities by instrument and currency (CHF, USD, EUR, other) is available in SNB balance sheet surveys;
- The rate on customer deposits is a function of the type of deposit (sight deposits, saving deposits, time deposits) and evolves with benchmark rates (libor rates, government yields);
- Debt securities are repriced according to the swap rate (at time to repricing bands) and the spread over benchmark at issuance (at re-issuance intervals) which is bank and instrument specific. Debt securities include cash bonds, bond issues, and central mortgage institution loans;

141. Interest rates on customer deposits are projected using a cointegration approach. The FSAP team examined the composition of retail funding by type of deposit and bank-by-bank pricing policy. The findings suggest that most retail funding is in the form of savings deposits and that bank savings rates comove with benchmark rates. Projections over the stress test horizon were estimated using a cointegration equation of savings rates (by currency), 3-month libor (by currency) and sovereign yields (by currency) using a FMOLS approach.

142. The approach to model funding rates on debt instruments enabled capturing banks' ALM response to stress and introduce credit sensitivity elements on maturing debt. The empirical strategy using spreads at issuance represents more closely the actual cost that banks face when they raise wholesale funding than other proxies used by the empirical literature. Common proxies include the 5-year Credit Default Swap (CDS) spreads and the secondary market spread for 5-year senior unsecured bonds. However, these rates are not representative of actual funding costs under stress, as banks tend to refrain from unsecured issuances when market spreads widen significantly. Spreads over issuance control for the instrument issued by banks under adverse market conditions (e.g., commercial paper vs. long-term bonds), yielding more realistic cost estimates. At the same time, they incorporate bank solvency risk which tend to increase when bank capital position weakens under stress.

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[44] It has been argued that to the extent that wholesale funding is used to finance the acquisition of assets outside of their home markets, the post-crisis' greater reliance on retail funding has led to more decentralization of funding as banks seek to increase local funding in the countries they operate (see BIS, 2010).

143. The modeling strategy is based on estimating debt spreads over benchmark using two econometric approaches:

- A panel-based regression using fixed effects. To make sure that the estimation is robust we also run regressions by type of bank (i.e., Big and private banks vs. DFBs) using fixed effects.
- A quantile regression approach to assess the impact of underlying drivers at different percentiles of the funding cost distribution.

Table 5. Switzerland: Determinants of Debt Spreads at Issuance, Panel Regression

Debt spreads are highly sensitive to economic conditions with evidence of non-linear effects during recessions, money market spreads, and equity prices.

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	c1_s1	c1_s2	c2_s1	c2_s2	all_s1	all_s2
L.g	-10.080***	-4.795	-10.080***	-6.973	-10.080***	-6.446
	(3.503)	(5.166)	(3.503)	(5.641)	(2.466)	(4.138)
L.pol	-4.867	-20.621***	-4.867	-4.625	-4.867**	-5.992
	(3.375)	(7.003)	(3.375)	(5.967)	(2.375)	(4.496)
L.vix	-0.842*	-0.254	-0.842*	-2.529***	-0.842***	-2.755***
	(0.432)	(0.941)	(0.432)	(0.776)	(0.304)	(0.560)
L.libor_usd_tbill	39.148***	54.040***	39.148***	32.473**	39.148***	29.171***
	(7.401)	(15.047)	(7.401)	(12.612)	(5.208)	(8.942)
L.g_ea	-9.594***	-3.397	-9.594***	-8.309**	-9.594***	-7.926***
	(2.189)	(3.323)	(2.189)	(3.441)	(1.540)	(2.546)
1.stress_g#cL.g	23.409***	477.334***	23.409***	23.412***	23.409***	18.511***
	(4.171)	(164.304)	(4.171)	(6.989)	(2.935)	(5.829)
L.equity		0.243		-1.207***		-0.884**
		(0.487)		(0.460)		(0.342)
L.equity_sq		0.035*		0.049***		0.036***
		(0.018)		(0.014)		(0.011)
L.tier1		1.243		0.798		-0.274
		(10.174)		(6.773)		(4.981)
L.tier1_sq		0.020		0.035		0.044
		(0.363)		(0.183)		(0.144)
Constant	90.913***	21.897	90.913***	87.451	90.913***	107.662**
	(9.478)	(79.110)	(9.478)	(62.555)	(6.671)	(43.990)
Observations	330	89	330	143	660	232
R-squared	0.436	0.359	0.436	0.422	0.436	0.328
Number of cnid	6	5	6	6	12	11

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Source: IMF staff calculations. *The estimation period is 2002: Q2 through 2018: Q4. The dependent variable is Debt spreads over benchmark rates from Dealogic. Regressors include: g (growth rate), pol (policy rate – 3-m target libor), VIX (CBOE index), libor_usd_tbill (spread of the 3-month libor USD over the U.S. T-bill rate), g_ea (growth rate in the euro area), stress_g#cL.g (a dummy variable taking the lagged GDP rate when it's negative), equity (equity price growth), equity_sq (equity squared), tier 1 (tier 1 capital), and tier1_sq (tier 1 squared). Columns 1-2 show results for DFBs, columns 3-4 shows results for Big and private banks, and columns 5-6 for all banks. L. denotes the lag operator.*

144. The basic form of the relationship between funding cost and the explanatory variables is as follows:

$$i_t^{i,j} = \alpha + \delta_1^j \cdot i_{t-1}^{i,j} + \delta_2^j \cdot macro_{t-1}^{c,j} + \delta_3^j \cdot fin_{t-1}^{c,j} + \delta_4^j \cdot global_{t-1}^j + \varepsilon_t^{i,j}$$

where $i_t^{i,j}$ denotes the funding cost of instrument *j* for bank *i*.[45] To capture broad changes in the state of the economy and shifts to benchmark rates, the set of regressors includes macro variables (growth, inflation, unemployment, recession indicator), financial variables (libor, swap rates, spreads over swap), and regional/global factors (growth in the EA, ted spread, VIX).

145. Results suggest a negative comovement between policy rates and debt spreads (Table 5). The coefficient of SNB's policy rate on debt spreads is negative particularly for Big and private banks. Debt spreads are highly sensitive to economic conditions with evidence of non-linear effects during recessions, to money market spreads, and to equity prices suggesting contagion across financial markets.

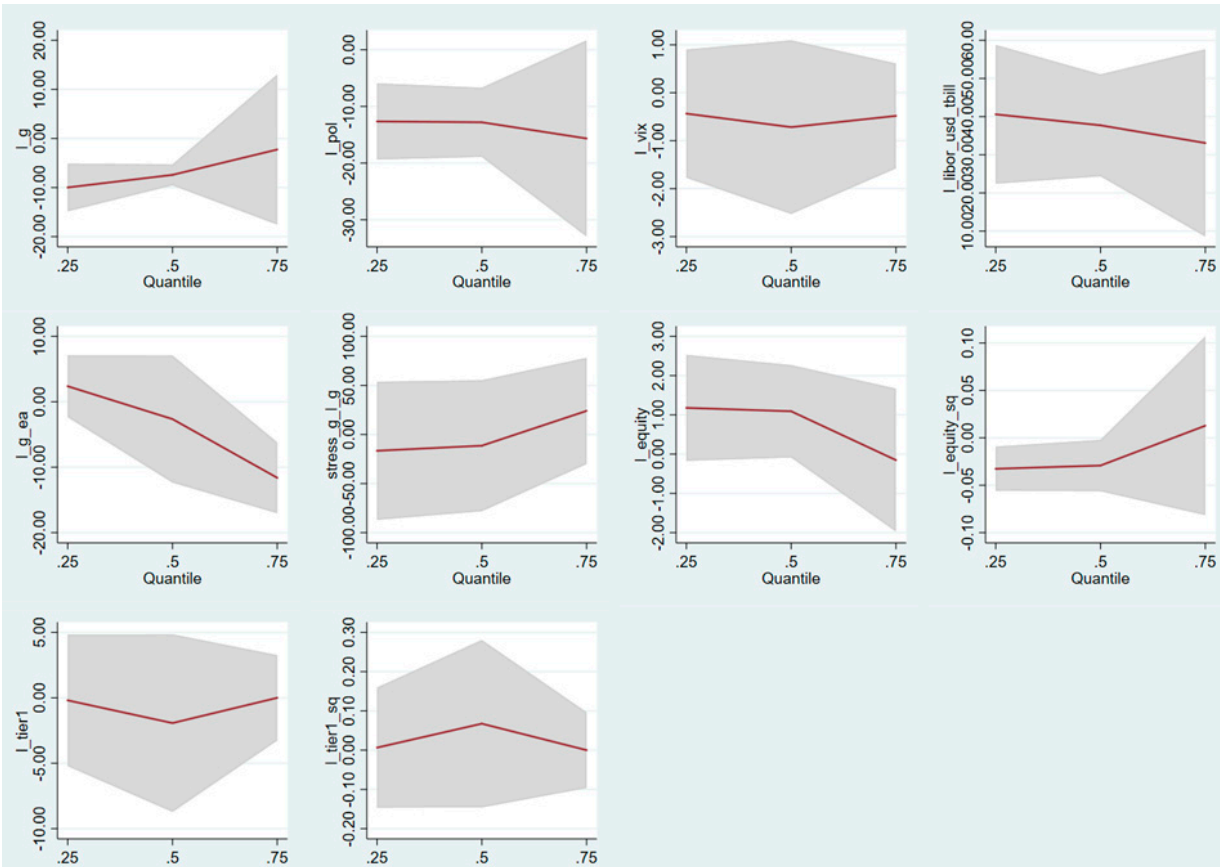
146. Debt spreads on bank issuance are less sensitive to idiosyncratic risk. Although the coefficient is negative for the pooled regression, it's not statistically significant. This might be explained by Swiss banks' limited issuance of debt (particularly among private banks and some DFBs), and by the issuance of Swiss covered bonds which are more sensitive to the underlying credit rating of the client pool than to the credit rating of the issuer.

147. Quantile results show that the negative contribution of money market stress and a sell-off in equity markets is more severe at higher percentiles. Figure 12 shows the coefficients of the main drivers of debt costs by quartile. At higher quartiles, the coefficient of money market spreads and a decline in equity prices is economically and statistically more significant than at lower quartiles pointing at amplification mechanisms from contagion across financial markets.

[45] Dynamic panel data estimators are not warranted as the length of the time series (48 observations) is large and the number of individuals (29 firms) is small. In this particular application, we are more concerned with the quality of the forecast than the quality of the coefficient estimates; simpler estimation techniques like fixed effects are expected to forecast better than Arellano-Bond. Dynamic panel bias can be a concern for small T and Arellano and Bond estimator is suitable for small T and large N.

Figure 12. Switzerland: Determinants of Debt Spreads at Issuance, Quantile Regression

At higher quartiles, the adverse effect of money market stress, and equity prices correction on debt spreads at issuance becomes more significant.



Source: IMF staff calculations. The panel shows the estimated coefficients across quantiles for lagged values of *g (growth rate), pol (policy rate – 3-m target libor), VIX (CBOE index), libor_usd_tbill (spread of the 3-month libor USD over the U.S. T-bill rate), g_ea (growth rate in the euro area), stress_g#cL.g (a dummy variable taking the lagged GDP rate when it's negative), equity (equity price growth), equity_sq (equity squared), tier 1 (tier 1 capital), and tier1_sq (tier 1 squared).*

Lending Rates Modeling

148. The projection of lending rates was mapped to banks' structure of the loan portfolio. Five portfolio segments were constructed: Amounts due from banks, securities financing transactions, Lombard loans, mortgage loans, and 'other customer' loans. These portfolios were mapped to the following lending rates:

- Amounts due from banks and securities financing transactions were linked to libor developments by currency;
- Rates on Lombard loans were linked to 3- through 12-month libor in USD;
- Mortgage loans were projected using the 5-year fixed rate mortgage rate as a benchmark; and

- Lending rates on 'other customer loans' (including consumer loans, leasing, corporate loans, loans to SMEs) were projected using an econometric approach allowing estimating time-varying bank-level asset margins. The assumption is that customer loans are less price sensitive than mortgage loans and the market is less competitive.[46]

149. Mortgage rates were projected using a cointegration approach. The FSAP team analyzed the correlation of mortgage rates across banks. Results show a high degree of comovement in rates conditional on the tenor of the loan. Mortgage lending rates were projected using a cointegration equation of 5-year fixed rate mortgages, 3-month libor, and sovereign yields, using a FMOLS.

150. The FSAP team used the estimated vintage composition of banks' outstanding mortgages (see mortgage risk section) to assess NII impact. The mortgage portfolio was broken down by vintage (i.e., prior to 2014, 2015, 2016, 2017, and 2018). These data were mapped against the maturity breakdown of the mortgage portfolio and linked to IMF balance sheet assumptions to identify the vintage of mortgages maturing over the stress test horizon. The analysis was used to quantify the NII impact on the portfolio from renewing older vintages issued at higher rates in the past at the lower rates projected in the scenario.

151. Rates on 'Other customer loans' were projected conditional on the scenario and bank specific drivers. This contrasts with the approach of estimating loan pricing relationships are often estimated at the system level. Often the relationship between bank lending rates and market variables is projected as a mark-up over benchmark rates rather than using banks' strategic targets and capital position.[47] A notable exception is BIS (2015) where the relationship between lending rate and market rates are based on banks' effective funding costs taking into account banks' liability structure.[48] Running bank specific regressions allows controlling for banks' behavior under stress.

152. The relationship between lending rates and bank drivers is specified as follows:

$$l_t^i = \alpha + \gamma_1 \cdot l_{t-1}^i + \gamma_2 \cdot state\ \mathrm{var}_{t-1}^c + \gamma_3 \cdot funding_{t-1}^i + \gamma_4 \cdot bank_t^i + \gamma_5 \cdot funding_{t-1}^i \cdot bank_t^i + \varepsilon_t^i$$

where l_t^i denotes the implicit lending rate for bank *I*. The equation includes an autoregressive coefficient and controls for the state of the economy reflected in the scenario. The coefficient γ_4 estimates banks' propensity to increase lending rates to restore capital ratios.

153. The empirical strategy includes panel-based regressions as well as quantile regressions. Analogous to the modeling approach used to project funding costs, a panel-based regression is performed using fixed effects. Table 6 shows results at the aggregate level for the

[46] This has been documented empirically. See Oliver Wyman (2012) "Pricing at European retail banks; EMEA Survey".

[47] See Harimohan, McLeay, and Young (2016), Schmitz, Sigmund, and Valderrama (2017), Arnould, Pancaro, and Zochowski (2018, forthcoming).

[48] A key difference is that the authors use the CDS rate over swap rate as a proxy of the cost of debt issuance, rather than using banks' actual spreads over swap rate which is the approach taken in this note.

entire pool of banks as well as broken down by type of bank. A quantile regression approach is used to assess the impact of underlying drivers at different percentiles of the lending rate distribution.

154. Lending rates on 'other customer loans' are driven by money market spreads, libor rates, and banks' capital position. Econometric results provide some evidence of pass-through effects from funding costs to lending rates in customer loans. Also, banks with a weaker capital position seem to price loans at higher rates suggesting managerial strategic targets to restore capital.

155. The impact of interest rate shocks on banks' net interest income is calculated as:

$$NII_{i,t} = \sum_b gap_{i,t}^b \cdot mid_{i,t}^b \cdot \Delta nim_{i,t}^b$$

where $gap_{i,t}^b$ is the gap of bank *i* in bucket b and time *t*, mid^b is the mid-point in bucket *b*, and $\Delta nim_{i,t}^b$ is the net interest margin shock for bank *i* at time *t*.

156. Crucially, shocks to interest rates differ across repricing gaps as different instruments reprice at different frequency. On the liability side, retail deposits reprice at high frequency whereas debt instruments reprice at longer frequency. Similarly, on the asset side, Lombard loans reprice at the 3–12-month frequency whereas mortgage loans repricing schedule tends to be longer depending on the type of mortgage and the tenor of the loan.

Table 6. Switzerland: Determinants of 'Other Customer Loans' Lending Rates

For higher quartiles, the coefficient of sovereign spreads on funding cost is more significant, pointing at the importance of the sovereign-bank nexus.

VARIABLES	(1) c1_s1	(2) c1_s2	(3) c2_s1	(4) c2_s2	(5) all_s1	(6) all_s2
L.g	0.204	-0.111**	-0.043	0.052	0.085	0.010
	(1.361)	(0.047)	(0.121)	(0.124)	(0.749)	(0.080)
L.lt	-3.477	0.229**	0.384*	0.193	-1.800	0.169
	(2.493)	(0.112)	(0.227)	(0.248)	(1.386)	(0.168)
L.spread_IT	0.411	0.077**	-0.005	0.019	0.271	0.045
	(1.106)	(0.036)	(0.107)	(0.109)	(0.631)	(0.066)
L.libor_usd_tbill	-0.353	0.256***	0.319*	0.237	-0.271	0.198*
	(1.775)	(0.090)	(0.168)	(0.179)	(1.004)	(0.105)
L.g_ea	-0.753	0.068**	0.007	-0.070	-0.410	-0.025
	(0.994)	(0.033)	(0.090)	(0.093)	(0.551)	(0.058)
libor_usd	2.390**	0.124***	0.455***	0.175*	1.585***	0.166**
	(0.983)	(0.039)	(0.090)	(0.098)	(0.549)	(0.064)
fx	0.113	0.008	-0.009	-0.015	0.077	-0.009
	(0.137)	(0.005)	(0.012)	(0.013)	(0.076)	(0.008)
int_mor	3.578	0.543***	0.192	0.266	2.345	0.373
	(3.199)	(0.159)	(0.303)	(0.337)	(1.811)	(0.231)
1.stress_g#cL.g	-0.536	2.554***	0.099	0.037	-0.237	0.033
	(1.625)	(0.823)	(0.149)	(0.159)	(0.907)	(0.114)
L.tier1		-0.038		-0.052		-0.048**
		(0.025)		(0.038)		(0.024)
Constant	-1.779	1.488***	1.448***	2.664***	-0.850	2.225***
	(4.829)	(0.480)	(0.450)	(0.943)	(2.716)	(0.567)
Observations	286	82	239	138	525	220
R-squared	0.116	0.940	0.605	0.584	0.094	0.652
Number of cnid	6	5	6	6	12	11

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Source: IMF staff calculations. *The estimation period is 2002: Q2 through 2018: Q4. The dependent variable is Implicit lending rates on customer loans using Fitch data. Regressors include: g (growth rate), lt (10-year sovereign rate), spread_IT (10-year Italian sovereign rate over swap rate), libor_usd_tbill (spread of the 3-month libor USD over the U.S. T-bill rate), g_ea (growth rate in the euro area), libor usd (libor rate on USD), fx (change in CHF over USD), int_mor (5-year fixed rate mortgage rate), stress_g#cL.g (a dummy variable taking the lagged GDP rate when it's negative), and tier 1 (tier 1 capital). Columns 1-2 show results for DFBs, columns 3-4 shows results for Big and private banks, and columns 5-6 for all banks. L. denotes the lag operator.*

F. Fees and Commissions

157. Over one third of Swiss banks' operating income is generated by fees and commissions (F&C) (Figure 13). F&C from securities trading and investment banking account for over three quarters of total commissions while commission income from lending activities contribute over 10 percent, and other services account for the remaining 10 percent. G-SIBs generate higher net income from F&C (33 percent) than from interest related activities, including loans and financial investments (30 percent). The share is even higher for Private banks due to private banking activities in asset and wealth management.

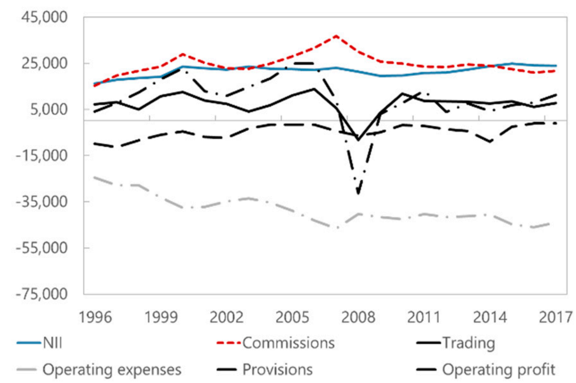
Figure 13. Switzerland: Overview of F&C Income

One third of operating income is generated by F&C primarily related to securities trading and investment banking.

Over one third of operating income is generated by fees and commissions…

Breakdown of Profits

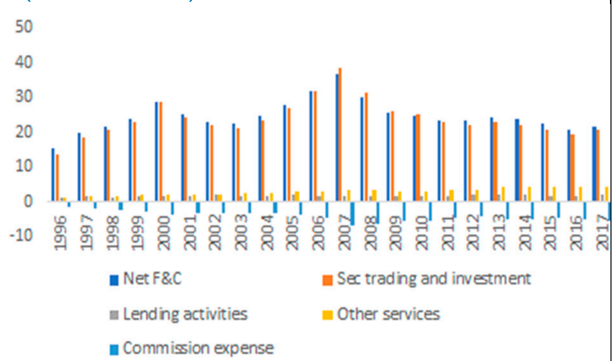
(In million CHF)



… mainly from securities trading and investment banking.

Breakdown of F&C

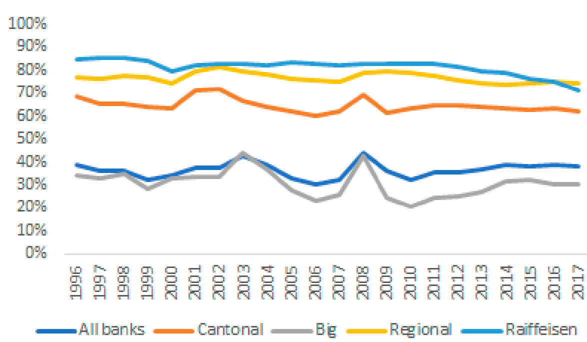
(In billion CHF)



The share of NII relative to results from ordinary activities stands at about 70 percent for cantonal, regional, and Raiffeisen banks…

Share of NII

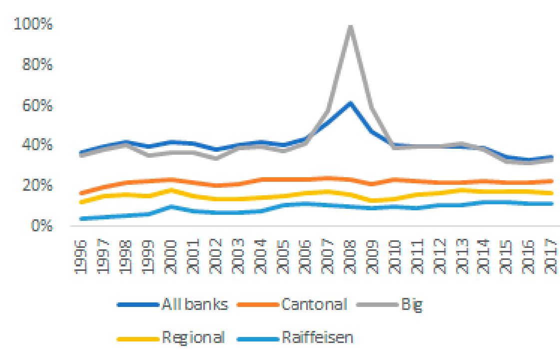
(In percent)



…while the share of F&C reaches 40 percent for G-SIBs in 2017 with the share rising during periods of financial distress.

Share of F&C

(In percent)



Source: SNB and IMF staff estimates.

158. At the same time, there are concerns over the stability of F&Cs going forward on the back of structural changes in the wealth management industry and a potential market correction [49] Some banks have expanded their asset management activities and sales of shares of collective investment funds. However, the competition on private banking activities, where nonbanks are active too, is strong and growing. In particular, the emergence of standalone asset managers and advisors (including the so-called multifamily office) is putting pressure on banks' capacity to sustain commission income. Also, income diversification might not necessarily improve the stability and resilience of banks' net income, given the sensitivity of performance fees to financial asset returns. The stability of F&C hinges on how resilient F&C income is to adverse developments in financial markets.

159. Other F&C pressures stem from developments related to the implementation of the Markets and Financial Instruments Directive (MiFID II)/ Markets and Financial Instruments Regulation (MiFIR) in the EU and future Swiss implementation of tighter conduct requirements for financial service firms. In December 2017, the European Commission made equivalence determinations of trading venues in Switzerland to permit EU-domiciled institutions and clients to continue to execute transactions on non-EU-domiciled trading venues. The introduction of MiFID II is expected to result in a reduction in commission rates and trading margins and might affect the timing of recognition of certain fee income.[50]

160. The FSAP team examined banks' composition of F&Cs to identify key drivers linked to the macrofinancial scenario. The composition of F&Cs is mainly associated to underwriting fees and mergers and acquisitions (in IB), and brokerage fees, investment fund fees, and portfolio management and advisory fees (in wealth management). The latter can be split into volume and transactions-based fees, advisory fees, and discretionary investment fees. Some of these components are linked to macrofinancial developments. For instance, a decrease in business and client activity and market volume, as a result of significant market volatility, is expected to adversely affect transaction fees, commissions and margin, particularly in wealth management business and IB operations.[51]

161. The empirical strategy relied on the estimation of a dynamic panel data model over the pool of banks:

$$fc_t^i = \alpha + \mu_1 \cdot fc_{t-1}^i + \mu_2 \cdot macro_t^c + \mu_3 \cdot fin_t^c + \varepsilon_t^i$$

where fc_t^i is the share of fees and commissions to total assets for bank *i* at time *t* and the vector of explanatory variables. The model is estimated using the system Generalized Method of Moments (GMM) estimator developed by Arellano and Bond to address endogeneity and dynamic panel bias.

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[49] ECB (2016), "Adapting bank business models: financial stability implications on greater reliance on fee and commission income", Financial Stability Review.

[50] See UBS annual report (2017).

[51] See UBS annual report (2016).

162. On the back of the linkages between F&C income and financial markets, the set of predictors include a wide range of financial conditions.[52] The set of variables comprises the lagged F&C over assets, contemporaneous and lagged GDP growth, the inflation rate, house price growth, stock market returns, the first difference of the short- and the long-term rate, equity volatility, government spread over swap, and TED spread.[53]

163. Results show that the F&C decrease with money market stress, low long-term rates, equity correction, and rising volatility (Table 7). This is reflected in the positive coefficient of the short-term rate difference, the positive estimate of changes to the U.S. equity price, the positive coefficient of the long-term rate difference, and the negative coefficient of the VIX. This implies that under the adverse conditions assumed in the scenario, F&C income decreases for most banks.

Table 7. Switzerland: Determinants of Fee and Commission Income

F&C decrease with money market stress, low long-term rates, equity correction, and rising volatility

VARIABLES	c1_s1	c1_s2	c2_s1	c2_s2	c1_s3	c2_s3	c1_s4	c2_s4	all_s1	all_s2
L.fc_assets					0.814***	0.767***	0.622***	0.691***		
					(0.074)	(0.068)	(0.104)	(0.084)		
equity	0.001	0.004**	-0.003	-0.006	-0.001	0.001	0.000	-0.001	-0.001	-0.001
	(0.002)	(0.002)	(0.004)	(0.004)	(0.001)	(0.003)	(0.001)	(0.004)	(0.002)	(0.003)
L.equity	-0.002	-0.002	0.007	0.006	0.001	0.001	0.001	0.002	0.002	0.002
	(0.002)	(0.002)	(0.004)	(0.004)	(0.001)	(0.003)	(0.001)	(0.003)	(0.002)	(0.002)
ch_mm	-0.048	0.000	-0.036	-0.048	-0.048	0.057	-0.022	0.058	-0.047	-0.031
	(0.031)	(0.035)	(0.086)	(0.102)	(0.032)	(0.068)	(0.039)	(0.082)	(0.044)	(0.056)
L.ch_mm	0.000	0.101	-0.050	-0.232**	0.018	0.050	0.032	-0.013	-0.019	-0.046
	(0.036)	(0.037)	(0.095)	(0.105)	(0.014)	(0.067)	(0.024)	(0.084)	(0.050)	(0.059)
ch_lt	0.026	-0.037	0.117	0.148	0.016	0.206***	-0.005	0.229***	0.077	0.067
	(0.047)	(0.043)	(0.104)	(0.102)	(0.021)	(0.072)	(0.022)	(0.077)	(0.059)	(0.062)
L.ch_lt	-0.057	-0.007	0.097	0.050	0.012	-0.079	0.026	-0.083	0.008	-0.002
	(0.039)	(0.036)	(0.103)	(0.102)	(0.019)	(0.076)	(0.022)	(0.080)	(0.054)	(0.057)
g	0.026	0.029	-0.003	0.005	0.013	-0.046	0.016*	-0.040	0.013	0.013
	(0.020)	(0.018)	(0.051)	(0.049)	(0.009)	(0.038)	(0.009)	(0.040)	(0.027)	(0.028)
L.g	-0.004	0.005	-0.012	-0.081	-0.019**	0.021	-0.009	0.002	-0.009	-0.037
	(0.019)	(0.019)	(0.046)	(0.050)	(0.008)	(0.033)	(0.010)	(0.040)	(0.025)	(0.029)
inf										
L.inf										
L.vix		0.007***		-0.018***			0.003*	-0.007		-0.004
		(0.002)		(0.006)			(0.002)	(0.005)		(0.004)
L.libor_usd_tbill		0.107***		-0.028			0.005	0.005		0.036
		(0.026)		(0.075)			(0.029)	(0.058)		(0.041)
L.spread_swap		0.074		-0.251			0.050	0.010		-0.094
		(0.109)		(0.295)			(0.071)	(0.215)		(0.170)
L.g_ea		-0.004		0.037			-0.006	0.003		0.017
		(0.009)		(0.025)			(0.005)	(0.020)		(0.014)
Constant	0.364***	0.185***	1.684***	2.041***	0.099**	0.351***	0.133***	0.612***	1.002***	1.067***
	(0.017)	(0.047)	(0.050)	(0.132)	(0.039)	(0.095)	(0.043)	(0.197)	(0.025)	(0.074)
Observations	170	170	159	159	64	106	64	106	329	329
R-squared	0.084	0.345	0.059	0.183	0.839	0.618	0.860	0.628	0.024	0.039
Number of cnid	6	6	6	6	2	2	2	2	12	12

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Source: IMF staff calculations. *The estimation period is 2002: Q2 through 2018: Q4. The dependent variable is implied net fee and commission income to total assets using Fitch data. Regressors include: g (growth rate), lt (10-year sovereign rate), spread_IT (10-year Italian sovereign rate over swap rate), libor_usd_tbill (spread of the 3-month libor USD over the U.S. T-bill rate), g_ea (growth rate in the euro area), libor_usd (libor rate on USD), fx (change in CHF over USD), int_mor (5-year fixed rate mortgage rate), stress_g#cL.g (a dummy variable taking the lagged GDP rate when it's negative), and tier 1 (tier 1 capital). Columns show results by type of bank (c1 for DFBs; c2 for Big and private banks), and by specification (s1-s4); with 'all' representing a pooled regression across all banks. L. denotes the lag operator.*

[52] See Kok, C., Mirza, H., and Pancaro, C. (2017), "Macro stress testing euro area banks' fees and commissions," European Central Bank, Working Paper No. 2029, February for a scenario-based analysis of fees and commissions using the 2016 EU-wide stress test scenarios.

[53] The set of predictors is similar to those in ECB (2017), "STAMP€" with greater focus on financial variables.

G. Other P&L Items

164. Other P&L items were projected drawing on a panel-based estimation using fixed effects. The time series data was sourced from Fitch and applied to bank supervisory returns drawing on SNB and FINMA data. The main variables included:

- Interest income from trading assets and financial investments;
- Other operating income;
- Non-interest expenses including administrative expenses, depreciation, negative goodwill and other operating expenses;
- Tax expenses over net profits.

165. The stress test analysis does not take into account one-off adjustments. One-off adjustments reported in banks' income statement are considered to be non-recurrent events. Therefore, their P&L impact is zero under both baseline or adverse conditions. The list of one-off events includes profit and loss from non-current assets, discontinued operations, and disposal groups, as well as extraordinary profit.

166. Dividend payout behavior, which is crucial to a bank's ability to recover from shocks, was linked to its profits and bank capital ratio. The dividend payout ratio was subject to the following constraints: (i) A floor set at 30 percent (positive profits); (ii) the capital conservation buffer (CCB) schedule for CET1; and (iii) statistical analysis on historical dividend payments. If profits exceeded 50 percent of income at the cut-off date, the dividend payout ratio was set at 50 percent.[54] If banks were making losses, a zero-dividend payout was assumed.

H. SNB Top-Down Stress Test

167. The SNB conducted a Top-Down stress test of the two G-SIBs and the DFBs using their stress testing framework. The exercise was run at the June 2018 reference date on IMF scenarios. Results were benchmarked against IMF results on the IMF sample (except for Private banks which are not included in SNB's exercise) and against SNB's stress testing results on SNB's calibrated scenarios (run on the IMF sample as well as on the SNB sample which includes the G-SIBs and all DFBs).[55] The SNB's stress testing framework uses a separate stress testing approach for DFBs and G-SIBs banks.

[54] This implies that banks can build capital buffers under the baseline. This is not material under stressed conditions as most banks make losses in the adverse scenario.

[55] To assess the resilience of the Swiss banking sector, the SNB considers a baseline scenario and four adverse scenarios. All four adverse scenarios concentrate on macroeconomic and financial risks, and include: a protracted euro area recession; an emerging market crisis; a U.S. recession; and, a sharp snap back in interest rates.

168. The stress test on DFBs was run using SNB survey data and FINMA's Interest Rate Risk report with a 5-year horizon. By contrast with the regulatory stress scenario analysis of G-SIBs, the data basis of the DFBs analysis is extracted mainly from existing SNB banking statistics. The scenario horizon of 5-years is longer than the 2-year horizon for G-SIBs' stress testing.

169. The SNB uses a structural modeling approach to assess mortgage lending risk in Switzerland. Default occurs when the borrower cannot longer service the loan due to shocks to income, interest rate payments, or tightened amortization rules from a housing price correction. The model is calibrated to match the empirically observed loss rate observed in the 1991-1995period. Projected loss rates are scaled according to regions, collateral types and ranks. Model validation ensures that the model performs as intended by comparing loan loss rates projections with actual outcomes.

170. Credit risk assessment for non-mortgage portfolios follows a hybrid approach combining structural and regression-based models. Total non-mortgage domestic exposures for DFBs account for about CHF 100 billion, with foreign exposures adding CHF 30 billion. This contrasts with the size of DBFs' mortgage exposures which reached about CHF 650 billion in 2017. Most exposures are to corporates and public entities. The model simulates the impact of stress scenarios on the default rate of loans using a Merton-based modeling approach. The model is calibrated based on bankruptcy rates for corporates. Loss rates are determined for unsecured loans and scaled for other positions.

171. The SNB has developed a rich dynamic approach to stress IRRBB. The analysis separates the modeling of assets and liabilities to account for impact of interest rate shocks through the repricing maturity ladder in the IRR report. The model accounts explicitly for banks' behavior on the choice of asset margins over benchmark rates for loans, and for changes in customers' behavior from monetary policy shocks leading to position migration in deposits. Maturing positions are renewed so as to reproduce historically observed renewal behavior (as regards product mix, client rates and contractual durations) in comparable interest rate environments. Margins are split into asset and liability margins and a structural margin to capture maturity transformation risk. The model considers the impact of different hedging strategies and tracks the evolution of sigh deposit accounts at the SNB conditional on the scenario.

172. For DFBs, business and market risk are assessed using a combination of regression analysis and expert judgment. Separate regression analyses are run for simulating the scenario impact on F&C income as well as on the income form trading assets and financial investments. Given the limited materiality of fair valued trading assets and financial investments for DFBs, a regression approach is taken, rather than collecting additional data for evaluating the fair value impact in a more granular manner. The results from regression analyses are checked against expert judgement and, if necessary, corrected by applying a prudent bias. Business expenses are kept constant, therefore not reflecting banks' potential reactions to reduce expenses in response to stressed earnings. Also, risk-weighted assets are kept constant, on the grounds that most DFBs use the standardized approach to determine risk-based regulatory capital requirements.

173. For G-SIBs, SNB's credit risk assessment approach uses a regression-based model which incorporates credit rating migration. Credit risk is modelled separately for domestic exposures (in line with the credit risk analysis for DFBs), and foreign exposures (mainly in the United States and the United Kingdom). Loss rates in foreign exposures are projected using an econometric approach linked to the macrofinancial scenario. To account for the credit quality of banks' portfolio, the model includes a scenario stress factor (SSF) which translates the projected loss rates into relative changes from a long-term average loss rate linked to the average credit rating of the portfolio. The approach includes a credit transition model to account for the deterioration of performing exposures under stressed conditions.

174. For market risk, calculations are based on standardized risk and exposures modules in bank's BBA reporting templates. The scope of the analysis includes a comprehensive range of risk factors related to interest rate risk, equity risk, FX risk, commodity risk, credit spread risk, and CVA risk. Banks compute for each risk the impact of immediate standardized shocks under full revaluation. For FSAP purposes, capital impact was calculated using IMF scenarios to interpolate, extrapolate standard shock results. In addition, several types of equity and credit basis risks were considered.

175. The assessment of other risk factors is based on a combination of BBA data and SNB econometric modeling. Business risks are estimated by using a structural approach differentiating major income and expense components according to BBA data. F&C income is projected by applying a granular model taking into account the composition of AuM and how their values change under the specific scenario. The projection of net earnings is controlled by ensuring consistency conditions between the development of individual income and expense components. The risk assessment also includes operational risk, and time-varying RWAs, drawing on banks' reported impact and historical behavior.

I. G-SIBs Bottom–Up Stress Test

176. The two G-SIBs run bottom-up tests on IMF scenario over a 5-year and 2-year stress testing horizon. For the bottom-up analysis, the IMF scenario was extended to include a traded risk component calibrated using historical data on granular market risk factors. The macroeconomic scenario was implicitly incorporated in the traded risk scenario through the percentiles choice to capture deep in the tail risk. Banks expanded the IMF scenario to generate additional risk factors, including among others, volatility shocks on interest rates, FX, equity prices, and commodities, commodity shocks by product, price shocks for credit structured products (by product category, instrument type, and original rating), and stressed collateral values for Lombard loans.

177. Banks performed their calculations based on their internal approaches for stress testing. The assessment included a highly granular approach at the loan/security level and covered a comprehensive range of risk factors. In addition to business risk, market risk, credit risk, and operational risk, the assessment included projections of share-based personnel expenses, pension impact, and regulatory impact from the implementation of the fundamental review of the trading book and the completion of Basel IV regulatory framework (including output floors, and revisions to the IRB and STA approach to credit risk).

J. Solvency Results

178. Under the baseline scenario, there is a slight decrease in capitalization ratios, in part reflecting the low interest rate environment. Baseline projections imply a weighted-average 70 basis point decrease in banks' CET1 ratio by 2020 with some differences across banks.[56] The results also differ across business models, with domestically-oriented banks facing greater profitability challenges. These banks are more affected by the negative liability margin under current baseline conditions.

179. Under the IMF adverse scenario, minimum capital requirements are met in aggregate, a few banks breach their capital buffers. Macroeconomic shocks and market risks deplete capital ratios by 440 basis points at the low point of stress, with a wide degree of variation across banks (Figure 14). [57]

[56] The assumed dividend payout rule is on average 50 percent of net profits.

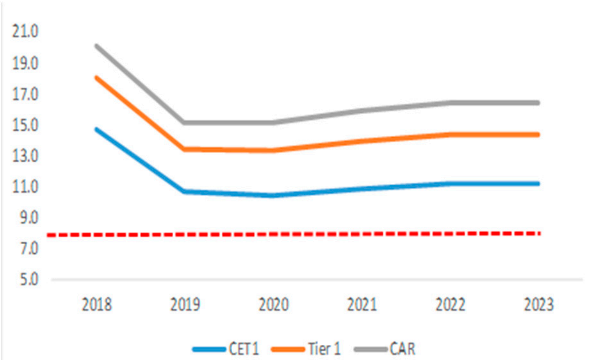
[57] Capital depletion for the sample of banks represents about 3 percent of projected nominal GDP in 2022.

Figure 14. Switzerland: Results of the FSAP Solvency Stress Test—Adverse Scenario—Aggregate

Under the severe scenario, all banks would meet minimum capital requirements with one bank breaching its CCB and posting partial recovery by the end of the 5-year horizon.

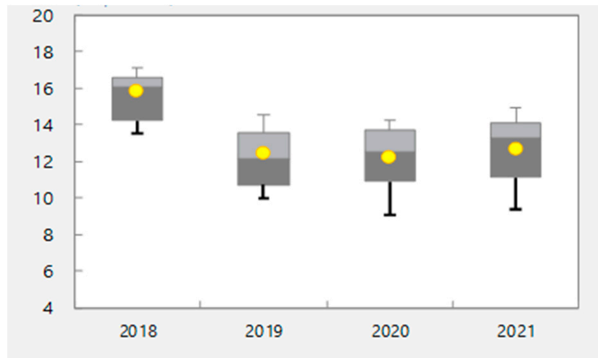
Risk-based bank CET1 ratios decline by 440bps at the low point of stress to 10.4 percent...

Capital Ratio
(In percent)



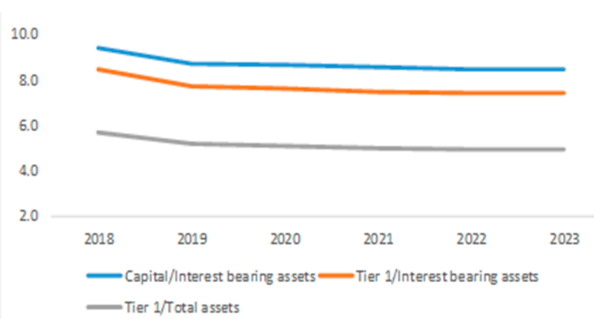
...with some variation of impact across banks.

CET1, All Banks
(In percent)



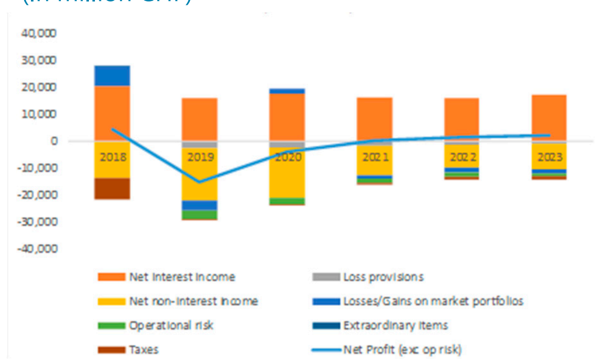
Tier1 leverage ratios soften by about 70 basis points by the end of the horizon.

Leverage Ratio
(In percent)



Profit and loss impact is driven by the impact of market price shocks on fair value portfolios, and significant stress in commission income and net interest income.

Net Profit Components
(In million CHF)



Source: IMF Staff Estimates. The sample of banks included the twelve major Swiss banks. The dashed line indicates the minimum capital regulatory ratio. Boxplots include the mean (yellow dot), the 25th and 75th percentiles (boxes) and the 15th and 85th percentiles (whiskers).

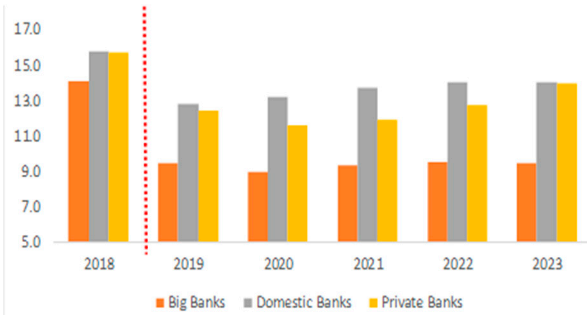
180. **Results differ across groups of banks due to differences in business models, risk exposures, and geographic segmentation.** Under the IMF scenario, the comparatively greater impact on G-SIBs stems from their larger trading books, risk weight expansion on IRB exposures, business risk from commission income, and higher operational risk from clients, products, and business practices. Private banks are comparatively more affected than DFBs from stressed earnings related to asset and wealth management activities, market risk on fair value portfolios, and operational risk, given the close link between the banks' reputation and their earnings capacity. Comparable results are obtained by SNB TD results and G-SIBs BU results (Figure 15).

Figure 15. Switzerland: Results of the Solvency Stress Test by Type of Bank

Domestic banks are relatively more resilient than G-SIBs to the adverse scenario. This result is confirmed by SNB TD results and G-SIBs BU results.

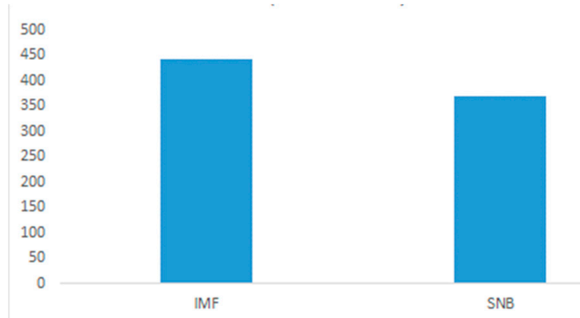
By 2020, the capital depletion reaches 510bps for G-SIBs, 410bps for Private banks, and 260bps for Domestic banks according to IMF calculations.

CET1 by Group
(In percent)



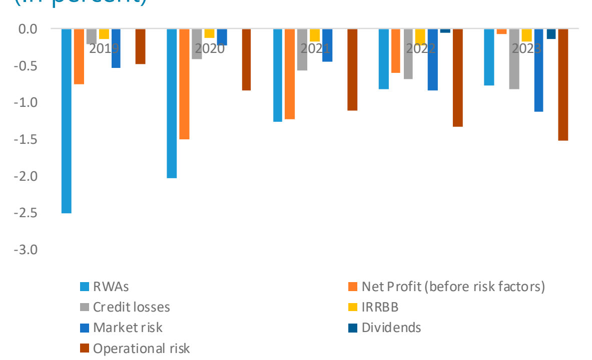
IMF TD results are broadly in line with SNB TD results calculated over the common stress test sample, including 2 G-SIBs and 6 Domestic banks. [1]

CET1 Depletion in 2020, G-SIBs and 6 DFBs Ratio (Basis Points)



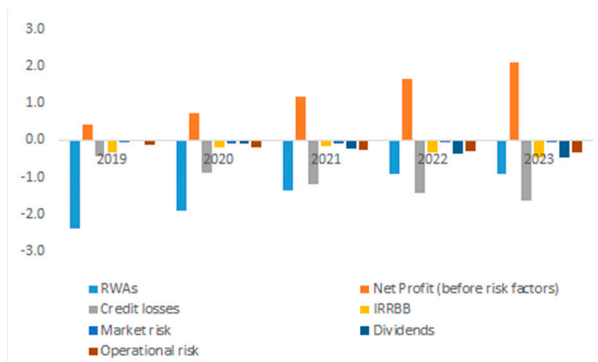
IMF results suggest that G-SIBs are impacted by shifts to RWAs, market risk, business risk, and operational risk. [2]

Cumulative Impact on CET1, Large Banks
(In percent)



While DFBs are comparatively more impacted by credit risk losses.

Cumulative Impact on CET1, Domestic Banks
(In percent)



Source: IMF Staff Estimates and SNB. The sample of banks includes the 2 G-SIBs, the 6 domestic banks, and the 4 private banks for the top LHS chart; the 2 G-SIBs and the 6 domestic banks for the top RHS chart, the 2 G-SIBs for the bottom LHS chart, and the 6 domestic banks for the bottom RHS chart. 1/ Differences in results are mainly attributable to the higher contribution of RWAs to capital depletion in the IMF test. 2/ Bottom-up results for operational risk calculated by banks were benchmarked against realized operational losses during the global financial crisis and banks' reported risk weighted assets for operational risk. The main drivers of operational risk losses include clients, products and business practices; and internal fraud.

181. **Sensitivity tests on mortgage default risk point at a large capital impact from the combination of a large real estate price correction and rising lending rates.** The IMF adverse scenario includes a 25 percent correction in real estate prices over two years, and a rise in 10-year mortgage lending rates from 1.5 to 3.0 percent. Additional sensitivity tests suggest that default rates increase exponentially with the size of the shock (Figure 16). Under the scenario-based real estate path, an increase in lending rates to 6.0 percent raises mortgage default rates to 3.5 percent, leading

to an aggregate 275 basis points CET1 capital depletion for the IMF G-SIBs and DFBs (excluding private banks).[58]

Figure 16. Switzerland: IMF Sensitivity Test: Mortgage Risk

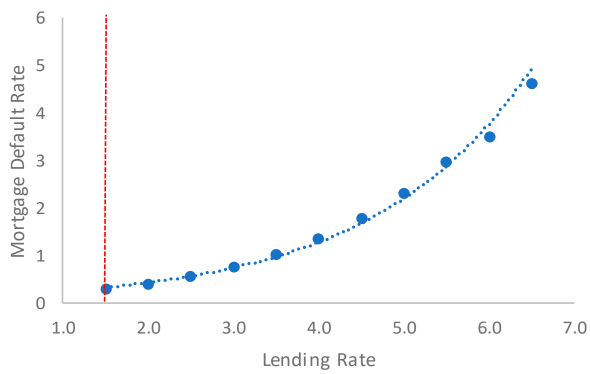
Mortgage default risk rises exponentially with shocks to lending rates.

Default risk sensitivity to interest rate shocks.

A parallel move in lending rates to 6 percent, combined with a a 25 percent housing price correction, would lead to a 3.5 percent default rate.

Lending Rate Sensitivity

(In percent)

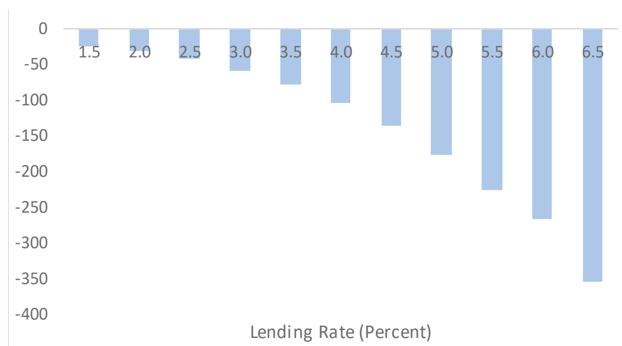


Contribution of default risk to CET1 depletion.

A 3.5 percent mortgage default rate would lead to a 275 bps capital depletion in the average CET1 ratio of the G-SIBs and the DFBs.

ΔCET1 Ratio

(Basis Points)



Source: IMF staff estimates. Note: The red line in the LHS chart shows the current rate for a 10-year mortgage. The test is based on an unemployment shock of 110 basis points, a house price correction of 25 percent, and a wide range of interest rate shocks. These projections are built on conservative assumptions related to: the distribution of historical vintages by LTV and LTI similar to the matrix observed in June 2018; the repricing tenor of outstanding mortgages; and, banks' activation of margin calls from the widening in Point-in-time LTV ratios due to a real estate price correction required to satisfy the amortization of the second mortgage over the remaining maturity of the mortgage.

182. In an extreme scenario, FINMA real estate stress tests indicate that total capital ratios could fall on average by about 400 bps (Figure 17).[59] In 2018: Q4, FINMA undertook a mortgage stress test covering 18 banks, including SIBs and other DFBs.[60] To capture mortgage risk profiles properly, banks were required to provide their portfolio distribution by region, LTV, and LTI. The potential mortgage stress loss over seven years was determined based on a predefined stress scenario calibrated by FINMA on the Swiss mortgage crisis of the late nineties. The 2018 stress test revealed the following key insights:

[58] The vulnerability of DFBs to sharp rises in interest rates is also explored by the Swiss authorities. Their results indicate that DFBs are more vulnerable to harsher interest rate shocks than G-SIBs, due to net interest income compression due to maturity mismatches, in combination with a surge in write-downs on domestic mortgages.

[59] Since 2012, FINMA has conducted regular real estate stress tests as a microprudential supervisory tool. Key scenario assumptions include: (i) a 30-40 percent real estate price correction for the owner-occupied segment (44-54 percent for owner-occupied luxury segment), and 35-45 percent for both the investment-led segment and commercial real estate; and, (ii) a hike in lending rates to 7.0 percent.

[60] The sample covered approximately 70 percent of the total Swiss mortgage lending currently standing at over CHF 1,000bn.

- On average, the banks' risk profile has deteriorated compared to the previous tests carried out between 2012 and 2017, which means that the loss ratios for the same negative scenarios are higher than in previous years.

- The risks have generally shifted from owner-occupied residential properties to investment properties. Over 70 percent of the stress losses would incur in the investment property portfolio, although this only accounts for 29 percent of total mortgage lending in the sample.

- About half of the banks would fall below their capital thresholds,[61] in some cases by a wide margin, and would therefore have to raise additional capital.

183. The impact of the adverse scenario on banks' capital positions reflects stressed earnings and risk-weighted assets expansion, with the contribution from other risk factors evenly distributed (Figure 18):

- Heightened credit risk, the projected paths for aggregate lending in foreign jurisdictions, and higher market volatility contribute to the expansion of RWAs, lowering CET1 ratios by about 190 basis points across banks.[62]

- Stressed earnings from a decline in commission income from portfolio management and advisory services, and underwriting activities, partly offset by higher brokerage fees from market volatility, contribute to a CET1 shortfall of 80 basis points.

- Operational risk mainly linked to clients, products, and business practices (including losses from fiduciary requirements and from the design of a product), execution, delivery and process management, and market regulatory reforms, contributes to a capital erosion of 60 basis points.

- Weaker GDP growth, falling real estate prices, and tightened amortization schedules increase credit risk, reducing the aggregate CET1 ratio by 50 basis points relative to June-2018. The decline in policy rates assumed in the scenario, despite the widening of spreads mitigates somewhat the impact of the recession.

- While most impact of sharp movements in market prices on fair value positions is offset by trading derivatives, basis risk in corporate debt markets, FX markets, and equity markets, along with the ineffectiveness of hedges in sovereign securities, lead to a CET1 capital depletion of 40 basis points.

[61] The capital threshold is defined as the total capital ratio, which is the total required regulatory capital incl. anticyclical buffer divided by RWA.

[62] Credit demand follows nominal GDP which contracts in Switzerland but increases in the U.S. and major emerging markets for most quarters, contributing to the expansion of RWAs, together with the initial depreciation of the Swiss franc relative to the USD.

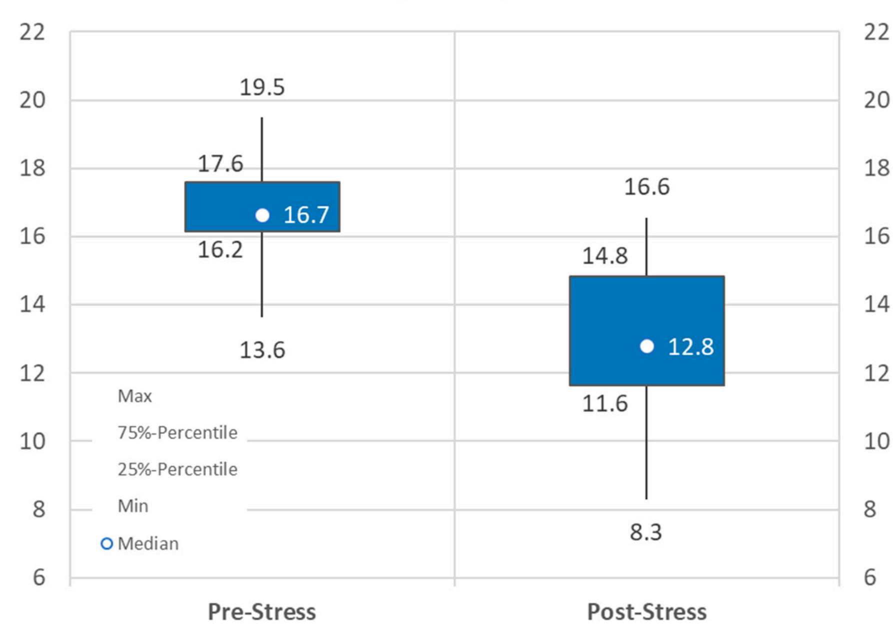
- The aggregate effect of interest rate risk on net income is moderate for most banks, resulting in CET1 ratio which declines by 10 basis points. This effect reflects the large stock of customer deposits, which are less sensitive to money market stress; hedging; the repricing structure of debt instruments with longer tenors; and banks' ability to partly pass-on funding cost to loans.

Figure 17. Switzerland: FINMA Real Estate Stress Test

Bank capital ratios could fall on average by about 400bps as a result of an extreme scenario.

Total Capital Ratio: Pre-Stress v. Post-Stress

(In Percent)



Source: FINMA. Note: The chart compares the post-stress total capital ratio to the pre-stress capital ratio as of 2017 year-end. The median post-stress total capital ratio would fall by about 400bps.

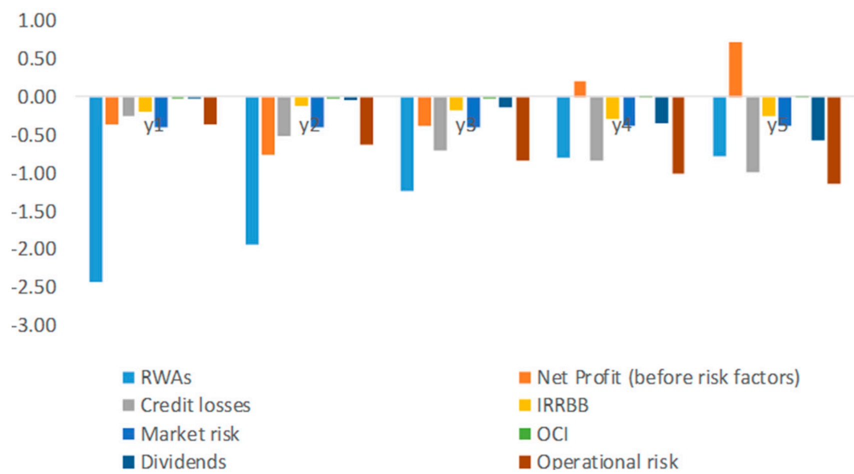
Figure 18. Switzerland: Cumulative Impact on Capital Depletion

(In percent)

The shortfall of 430 basis points in aggregate capital ratios at the low point of stress in 2020 is driven by RWA expansion, stressed earnings, operational risk, credit risk losses, and market risk.

Cumulative Impact on CET1, All Banks

(In percentage points)



Source: IMF staff estimates.

184. Scenario-based analysis is accompanied by a range of sensitivity tests to address the diverse risk factors identified in the RAM. These tests explore the additional CET1 impact relative to the starting point from replacing baseline inputs with hypothetical shocks capturing extreme shocks:

- *Further decompression of risk premia*: A 200 basis points widening of credit spreads over the swap curve lowers the post-stress aggregate CET1 ratio by 70 basis points (excluding hedges); with G-SIBs and Private banks relatively more affected;

- *Credit rating downgrade*: A one notch-credit downgrade on standardized exposures erodes bank capital ratios by 90 basis points. Domestically-oriented banks are impacted more severely on the back of their higher reliance on external ratings;

185. The SNB's stress testing framework—already advanced—could be enhanced along several dimensions. Increasing data granularity in supervisory returns would allow the SNB to leverage, to a greater extent, banks' regular supervisory reporting into their stress testing framework. This would also support the consistency of data sources when aggregating data within supervisory stress tests, or across multiple stress tests. The analysis of risk interactions could also be deepened, particularly regarding the interaction between solvency and liquidity risks and the modeling of feedback loops between banks.

186. The Swiss authorities should consider including major private banks in the stress testing frameworks. The possible failure of a major private bank would expose the Swiss banking system to significant reputational risk. A failure event of a private bank could also spread to other Swiss banks through their wealth management activities and potential contagion in funding markets.

LIQUIDITY STRESS TEST

A. Scope of the Stress Test

187. The analysis of Basel III liquidity metrics for Swiss banks was complemented by a variety of liquidity stress tests. The analysis included the assessment of LCR by currency, contractual maturity mismatch by time band, availability of unencumbered assets by currency, including a broader definition than HQLA, and banks' potential liquidity generation capacity through the monetization of securities over different horizons using market haircuts. LCR-based tests and cash flow-based liquidity tests were conducted using LCR banks' submissions and FINMA liquidity monitoring template on contractual flows across eighteen maturity buckets. For the LCR-based tests, the sample of banks is the one used for the solvency test. For the cash-flow based test, the sample covered twenty-two firms including Swiss entities included in the solvency sample at various levels of consolidation. On the other hand, the FSAP did not conduct a NSFR-based test as Switzerland—like the most important international financial centers—has not introduced a NSFR requirement and this ratio is currently not binding for most banks.[63]

188. The IMF LCR tests included the 2013 Basel LCR scenario and two additional scenarios that are more severe than those prescribed by Basel (Appendix V). The IMF adverse scenarios were tailored to local assumptions and Swiss banks' liquidity risk profiles. The LCR-based test included the following scenarios:

- An *LCR scenario,* with standard parameters set out by Basel III LCR 2013.
- A *Swiss. retail stress scenario*. Key assumptions include: (1) run-off rates of up to 20 percent for retail deposits; (2) inflow rates of 25 percent for maturing retail inflows; and (3) stressed contingent liability risk at 20 percent of undrawn but committed credit and liquidity facilities.
- A *Swiss wholesale stress scenario.* This scenario captures the liquidity stress observed during the global financial crisis related to stressed haircuts, a freeze of wholesale markets, and sizable contingent liquidity flows. Key assumptions include: (1) a 25 percent haircut on Level 2a assets and up to 60 percent of Level 2b assets; (2) a stressed inflow rate of 25 percent for maturing corporate inflows and 40 percent for financial institution flows; and (3) a 50 percent run-off rate for operational deposits, 100 percent for corporate deposits, 50 percent for secured funding backed by non-Level 1–2a assets; and a100 percent drawdown of liquidity facilities.

[63] Switzerland is ready and prepared to introduce the NSFR in line with the introduction of the NSFR in the jurisdictions of the most important international financial centers.

189. The IMF cash-flow based tests simulated a gradual outflow of funding over five consecutive days and over a 30-day time horizon[64] (Appendix VI). The assumptions were calibrated under the severe money market disruptions observed during the global financial crisis. Key assumptions on the 30-day test include:

- Haircuts of up to 60 percent for securities and bank loans that can be mobilized in repo transactions backed by other than general government collateral.
- No issuance of new unsecured funding and freeze of securitization markets.
- Callback rates of 100 percent on expected cash inflows related to credit extension without liquid financial assets as collateral, and no offsetting cash inflows from renewed wholesale lending.
- Cash outflows of up to 75 percent of maturing and non-maturity funding without liquid financial assets as collateral, and no renewal of term retail and wholesale deposits.

B. Liquidity Results

190. All large banks in the sample meet the 100 percent minimum LCR requirement however, foreign currency liquidity risks remain (Figure 19). The average LCR across all banks stood at 165 percent in 2018: Q2 owing to an ample stock of high-quality liquid assets, with G-SIBs and Private banks posting comparatively higher ratios. While the LCR in USD for G-SIBs and Private banks tends to be more volatile and falls below 100 percent for some banks, the overall shortage for Private banks in nominal terms is very small.

191. Under the IMF stressed scenarios, USD liquidity falls further, particularly for private banks. Private banks have a global franchise balanced across geographies to benefit from wealth creation across regions. Net new money in asset management flows, new or repaid loans and liabilities are to a large extent denominated in USD. Private banks extend Lombard loans benchmarked against the USD libor curve which are secured loans using the securities in the portfolio as collateral. Private banks fund their liabilities mainly by client sight deposits funded partly in USDs. At the same time, they hold a currency-balanced counterbalancing capacity, including non-USD securities. Given their exposure to maturity transformation risk, they show potential vulnerabilities in USD under a 30-day period of stress related to USD unsecured retail funding from high value deposits which are subject to a higher run-off rate than other liabilities in the LCR framework.

192. Potential liquidity shortage in USD is also driven by the G-SIBs' US-centric activities and FX activity in USD. Swiss G-SIBs' intragroup funding pattern is driven by a centrally controlled funding model where funding is distributed from the parent to its subsidiaries. At the same time,

[64] The analysis is based on Basel Liquidity Monitoring Tools template which includes contractual maturity flows. To extend the cash-flow analysis over a 30-day horizon meaningfully, the analysis would need to include behavioral flows because the behavior of Swiss Banks is more complex than can be proxied with contractual cash-flow data alone. This data was not available to the FSAP.

U.S. entities of Swiss G-SIBs need to have adequate liquidity risk tools to manage currency risk and adhere to local liquidity risk management rules and regulations at the entity level.

193. While Dollar liquidity poses a potential challenge for some Swiss banks, these banks have excess EUR and CHF liquidity. In the event of severe distress in USD, Swiss banks could use both the CHF/USD and EUR/USD swap markets to tap USD funding. Also, to the extent that shortages in USD liquidity come from USD-denominated liabilities with domestic counterparties (related to private banking activities), maturing outflows can potentially be settled in domestic currency. The Fed is also expected to provide USD liquidity assistance to the U.S. entities of Swiss G-SIBs. However, Swiss banks remain vulnerable to turmoil in global money markets that can spill over into FX and currency swap markets. Banks should ensure that currency-specific mismatches continue to be managed effectively to reduce the risk of funding strains and FINMA should ensure that major currency-specific liquidity requirements are closely monitored.

194. The LCR-based results suggest that the largest Swiss banks are resilient to a retail event but are more vulnerable to a wholesale event. Under more stressed conditions than prescribed by Basel captured by the 'Retail' scenario and the 'Wholesale' scenario, the average LCR ratio declines to about 140, and 95 percent, respectively. The LCR ratio's sensitivity to a wholesale event is higher than to a retail event reflecting potential liquidity risk from high value deposits and contingent liabilities.

195. Cash flow-based liquidity stress tests suggest that most banks are resilient to stressed liquidity conditions (Figure 20). This resilience is underpinned by large liquidity buffers, despite the relatively high share of encumbered assets shown by a few banks from covered bonds, derivatives, and securities financing transactions.

- Under 5 days of cumulative stress, no banks turn illiquid. This is supported by the availability of unencumbered collateral to fact immediate liquidity pressures.

- In the 30-day test, 4 banks face marginal liquidity shortages. These individual shortfalls are small, below 1.5 percent of system's total assets.

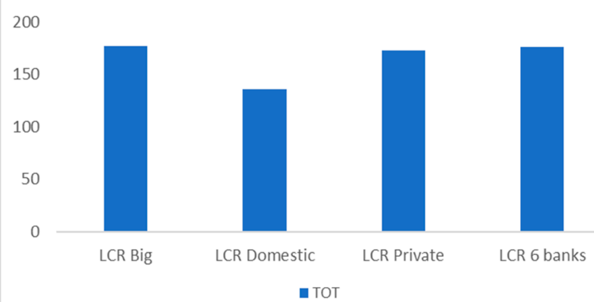
196. The general resilience of the system to liquidity shocks has substantially increased amid excess liquidity at the SNB. Swiss banks hold a significant amount of liquid assets in the form of sight deposits at the SNB partly due to the SNB's foreign exchange transactions against Swiss francs. Swiss banks have also changed the composition of banks liabilities and the structure of their counterbalancing capacity (CBC). At the same time, banks differ notably in terms of funding structures, asset encumbrance, and the amount and composition of CBC.

Figure 19. Switzerland: Banks' Liquidity Position

Swiss banks post high LCR ratios in total currency, Swiss francs, and Euros, but their ratios in USD fall significantly below 100 percent. Some banks are vulnerable to a stressed wholesale scenario characterized by high run-off rates in unsecured corporate funding, operational deposits, repo operations, and liquidity risk from contingent liabilities.

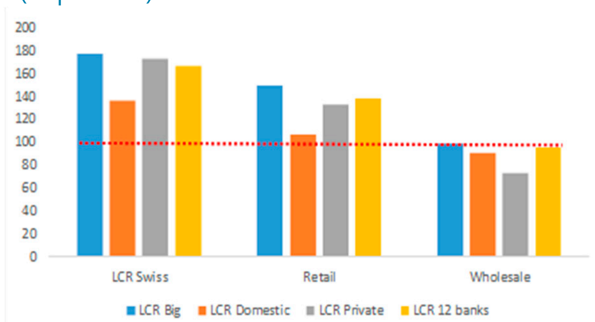
The average total currency LCR stood at 165 percent in 2018: Q2 with G-SIBs and Private banks posting comparatively higher ratios than domestic banks.

LCR Swiss Total Currency
(In percent)



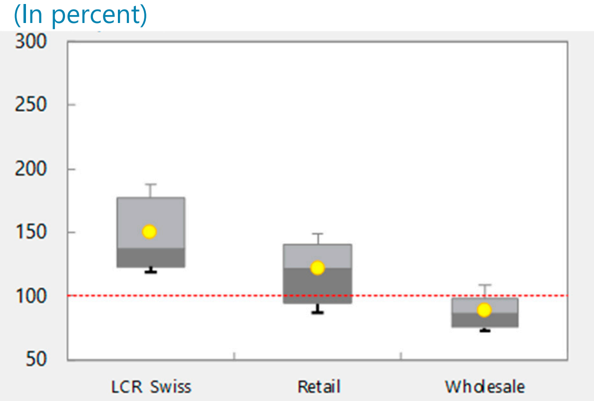
A Retail-based scenario would erode the LCR ratio to 140 percent, while a Wholesale-based scenario would have a greater impact leading to a post-stress 95 percent LCR ratio.

LCR Total Currency
(In percent)



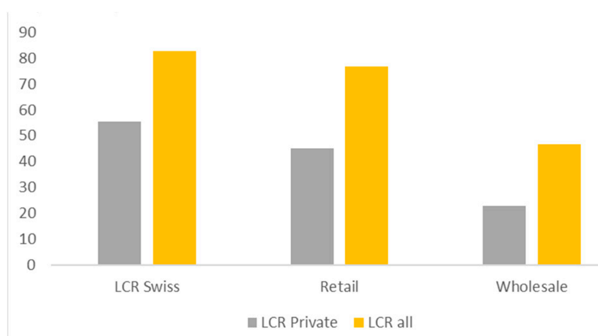
The impact of a Retail-based scenario on their liquidity position varies across banks, but most banks are impacted by the Wholesale-based scenario.

LCR, 12 Banks
(In percent)



A wholesale event would have a major effect on the LCR USD position of Private banks. Yet this is somewhat alleviated by their strong counterbalancing capacity in CHF and EUR, and caused by the fact that deposits booked via trusts and PICs count as wholesale deposits

LCR USD
(In percent)



Source: IMF Staff Estimates and FINMA.

197. **The continued monitoring of FINMA Liquidity Monitoring Metrics by currency helps monitoring FX-related funding and liquidity risks.** The data collection introduced by FINMA enhances the monitoring and supervision of contingent liquidity risks including those associated with sudden changes to market haircuts on unencumbered assets, non-maturing liabilities, the cross-border flow of collateral, securities funding transactions, currency swaps and other derivative flows, and contingent liabilities from credit and liquidity facilities. Potential risks from liquidity trapping in foreign jurisdictions, and ring-fencing of intragroup liquidity also need continued vigilance.

Figure 20. Switzerland: Cash-Flow Based Stress Test Results

While a few banks become illiquid under the 30-day Cash-Flow test, they are small relative to system-wide liquid assets and aggregate total assets.

5-day Cash-Flow Test

	Cumulative loss of all unsecured funding (In percent)	Cumulative loss of all secured funding (In percent)	Minimum number of days of survival	No. of banks illiquid	Percent of banks illiquid (In percent)	Net cash shortfall relative to total liquid assets (In percent)	Net cash shortfall relative to total assets (In percent)
t_0	0.0	0.0	0	0	0.0	0.0	0.0
Day 1	4.0	17.1	1	0	0.0	0.0	0.0
Day 2	7.8	30.8	2	0	0.0	0.0	0.0
Day 3	11.4	41.8	3	0	0.0	0.0	0.0
Day 4	14.8	50.5	4	0	0.0	0.0	0.0
Day 5	18.1	57.5	5	0	0.0	0.0	0.0

	Total Sample	Group 1	Group 2
Number of Banks failing the test	0	0	0
Liquidity Shortfall	0	0	0
Liquidity Shortfall (In % of total	0.0	0.0	0.0
Liquidity Shortfall (In % of liquid	0.0	0.0	0.0

30-day Cash-Flow Test[1]

Cumulative loss of all unsecured funding (In percent)	Cumulative loss of all secured funding (In percent)	Survival	No. of banks illiquid	Percent of banks illiquid (In percent)	Net cash shortfall relative to total liquid assets (In percent)	Net cash shortfall relative to total assets (In percent)	Weighted avg. capital adequacy ratio of failing banks (In percent)
23.4	100.0	No	4	19.0	-1.5	-0.3	1.2
		Yes	17	81.0	0.0	0.0	0.0

	Total Sample	Group 1	Group 2
Number of Banks failing the test	4	4	0
Liquidity Shortfall	-15,009,752	-15,009,752	0
Liquidity Shortfall (In % of total	-0.3	-0.4	0.0
Liquidity Shortfall (In % of liquid	-1.5	-1.6	0.0

	Liquidity shortfall by percentile (acccording to assets)						Individual	
	Top 10% (i.e., largest banks)	10%-25%	25%-50%	50%-75%	75%-90%	90%-100%	max	min
Shortfall (abs)	0	-13,403,082	-15,009,752	-15,009,752	-15,009,752	0	-13,403,082	-13,396
Percent of Liquid Assets	0.0	8.5	61.5					
Number	0	1	4	4	4	0	13	

Source: IMF Staff Estimates and FINMA. Figures are expressed in thousands of CHF.

[1] The output table of the 30-day Cash-Flow test shows the number of banks that become illiquid after 30 days of cumulative stress (column "Survival", row "No"), and their size relative to system assets (column "Net cash short shortfall") using FINMA contractual maturity mismatch data. Stressed assumptions on contractual inflows, contractual outflows, and available unencumbered assets are shown in Jobst, Lian Ong, and Schmieder (2017), "Macroprudential Liquidity Stress Testing in FSAPs for Systemically Important Financial Assets," IMF Working Paper 17/102.

SOLVENCY AND LIQUIDITY INTERACTION

198. **From a regulatory perspective, solvency and liquidity risks are treated as if they were unrelated sources of risk.** The risks are measured separately, and regulatory requirements against each risk type are assessed separately. However, as the global financial crisis confirmed, the failure to adequately model the nexus between solvency risk and liquidity risk can lead to a dramatic underestimation of risks. Examples of key interactions from the 2008-09 crisis include asset fire sales, credit rating downgrades pressuring banks' funding costs, loss of market funding, and liquidity risk from securitization pipeline back-ups.

199. **Supervisors are increasingly developing new stress testing models to assess financial stability taking into account the interplay between solvency and liquidity risk at a system-**

wide level. BIS Working Paper 29 (2016) provides an overview of supervisory stress testing models with liquidity and solvency interactions and systemic risk feedback effects. The impact of stressed capital ratios can feed into liquidity stress via reduced inflows from maturing credit claims and maturing securities; larger haircuts on banks' counterbalancing capacity following a deterioration in the credit rating of the underlying issuer; or higher run-off rates of outflows of credit sensitivity funding following a downgrade in the bank's credit rating.[65]

200. Still, further progress needs to be made to improve the calibration of the impact of solvency and liquidity risk on banks' risk profiles. Empirical calibration is hindered by banks' behavioral response under stress (e.g., banks can choose to deleverage to meet liquidity needs), the activation of unconventional monetary policy (e.g., central banks' asset purchase programs to increase market liquidity), and the broadening of central banks' collateral framework to provide liquidity assistance under exceptional financial stress situations (to prevent solvent but illiquid banks from defaulting).

201. This section attempts to quantify the interaction between solvency, liquidity, and contagion risk based on a three-pronged approach:

- Feedback loops between solvency risk and funding costs;
- Impact of financial institutions' distress on solvency risk; and
- Exploratory analysis of liquidity-at-risk.

A. Feedback Loops Between Solvency Risk and Funding Costs

202. The projection of bank funding costs followed an iterative process at each time step between 2019: Q1 and 2023: Q4 (Figure 21):[66]

- ***Initial Projection of Funding Costs (Stage 1)*****:** An effective cost measure is projected at the bank level by mapping the structure of bank liabilities with the interest rate path for each funding instrument. By contrast to the modeling strategy explained in the IRRBB section, the interest paid on debt instruments at issuance is conditional on bank's initial capital ratio.
- ***Initial Projection of Interest Income (Stage 2)*****:** Net interest income is projected using an econometric-based approach at the bank level. Asset margins over reference rates are allowed to vary by bank for 'other customer loans'. On the other hand, loan rates on claims against financial institutions, Lombard loans, and mortgage loans follow benchmark rates at current spreads.

[65] For instance, the OeNB's solvency stress test model incorporates interdependencies between solvency and liquidity stress test through these channels.

[66] Modeling of simplified and less granular feedback cost loops were included in the 2018 Euro Area FSAP, the 2017 Japan FSAP and the 2017 New Zealand FSAP.

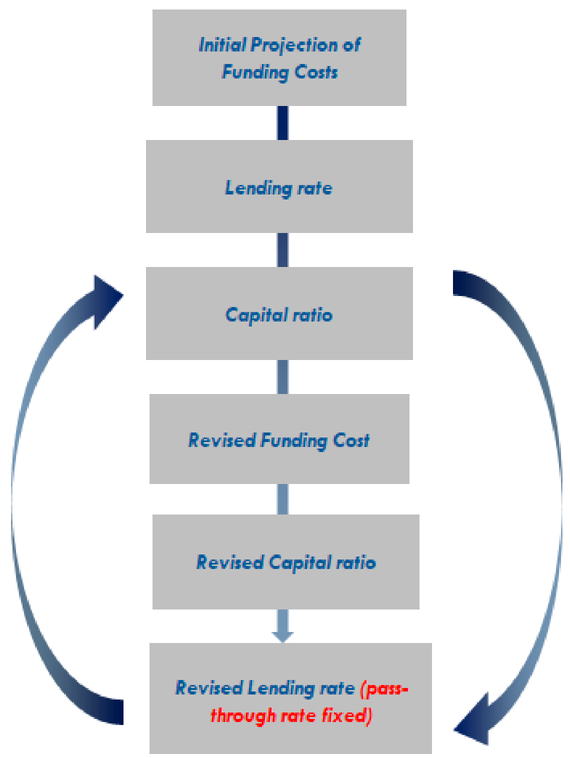
- ***Initial Projection of Capital (Stage 3)*:** The projected path for net interest income (together with other risk projections) translates into bank revenues, costs, and balance sheet

  Positions which pin down bank CET1 capital at t+1.

- ***Iterative Process (Stage 4):*** At each time step, defined quarterly over 2019Q1 through 2023Q4, the projection of bank CET1 capital acts as a driver to inform next period's funding cost and interest income projections. The process is repeated until convergence in funding costs is achieved.

203. Accounting for feedback loops in funding costs adds an average 15 bps to capital depletion. The impact is moderate for the average bank due to the low credit risk sensitivity of debt instruments at issuance (partly driven by the share of central mortgage institution loans in debt securities), the limited reliance on wholesale funding by Swiss banks, and the relative resilience of Swiss capital ratios to stress.

Figure 21. Switzerland: Solvency and Funding Cost Interactions



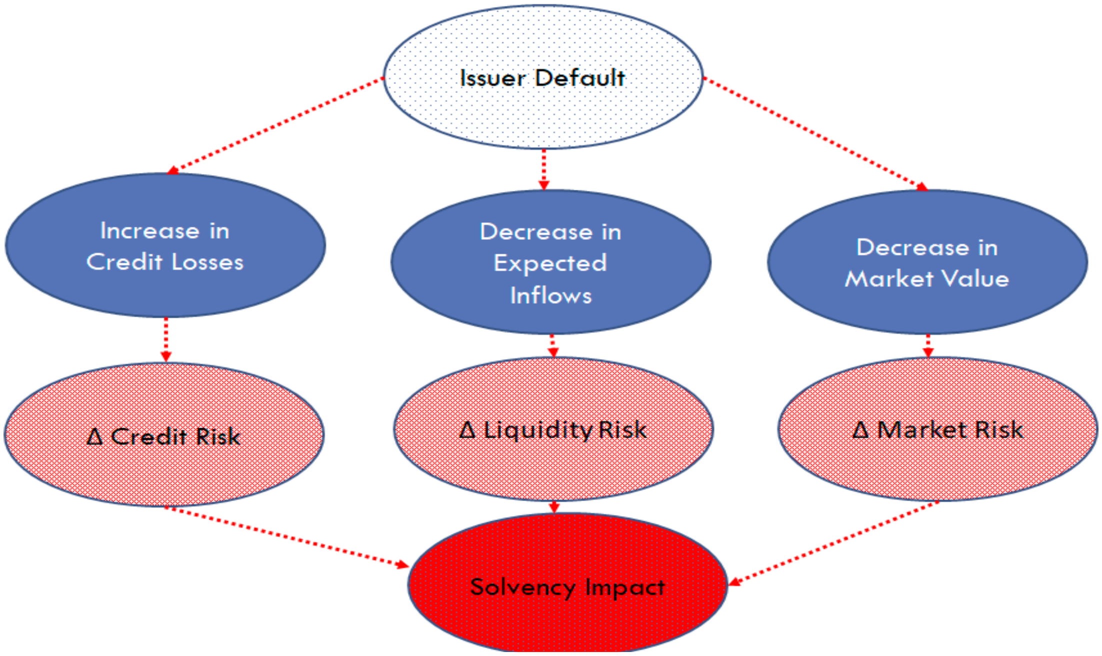
Source: IMF staff.

B. Impact of Financial Institutions' Distress on Solvency Risk

204. The model explores solvency and liquidity impact from issuer default risk (Figure 22). Issuer default risk is related to credit default events on underlying names to which banks' positions refer. The default of underlying issuers has a direct impact on solvency through an increase in credit risk losses. The issuers' long exposures to underlying names correspond to "jump to recovery" measures and are reported by banks in the BBA templates. It also has a liquidity impact from a lower inflow rate of maturing inflows.

205. The sensitivity test assumed that issuer default risk generates lower inflows from currency swaps and other derivative inflows. Large Swiss banks have large expected derivatives inflows in the overnight-to-two-week maturity window from their active role in derivative markets. While under LCR rules, the sum of net derivatives cash-inflows receives a 100 percent inflow factor, and cash flows are calculated on a net basis (i.e., inflows can offset outflows) by counterparty, the test assumes 10 percent of lost inflows from counterparty default.

Figure 22. Switzerland: Credit Risk, Market Risk, and Liquidity Risk Interactions



Source: IMF staff.

206. To meet liquidity pressures, banks replace lost inflows by interbank borrowing. On the back of financial institutions' distress, liquidity dries up on money markets, credit spreads widen, and libor rates increase to 100 bps adding funding cost pressures to the borrowing counterparty.

207. At the same time, default risk impacts P&L through stressed CVA. P&L impact from changes in the fair value of credit spread shocks on the CVAs of OTC derivatives are reported by G-SIBs in BBA templates. Calculations are made net of CVA hedges but without dynamic hedging consideration. CVA impact from a 200-bps widening of credit spreads for investment grade financial institutions is considered for the analysis.

208. Results suggest significant impact from risk interaction. Risk interaction in derivative markets: Issuer default risk from long exposures to financial institutions on a jump to recovery measure, compounded with CVA losses on OTC derivative from a 200bps widening of credit spreads on financial firms, and the replacement cost of 10 percent of lost contractual cash-inflows from derivative transactions (overnight through 2 week) at a 100bps libor rate, would lead to a CET1 capital depletion of 75 bps for the G-SIBs.

C. Exploratory Analysis of Liquidity-at-Risk

209. While the LCR has made the measurement of liquidity across banks more consistent, it does not capture well contingent liquidity risks.[67] For large Swiss banks, contingent liquidity risks arise mainly from changes on the value of posted collateral securing derivative and SFTs and from

[67] See Pohl (2017) for a comprehensive assessment of Basel liquidity monitoring tools.

valuation changes on derivatives and other transactions. On the former, the LCR assumes a prescribed 20 percent of the value of non-Level 1 posted collateral to account for valuation changes on pledged collateral. On the latter, the LCR uses a look-back approach to calibrate any outflow generated by increased needs related to market valuation changes in derivatives. Outflow needs are calculated by identifying the largest absolute net 30-day collateral flow realized during the preceding 24 months. Under the current period of compressed volatility, realized outflows are very low.

210. The exploratory analysis identifies the solvency impact from contingent liquidity needs linked to the solvency scenario.[68] Bank assets are split into four separate categories, namely: (i) Category I: marketable assets subject to variation margin (VM); (ii) Category II: marketable assets not subject to VM; (iii) Category III: illiquid assets subject to VM; and (iv) Category IV: illiquid assets not subject to VM. Liquidity risks arise from market valuation changes on Category I and III. Solvency shocks can impact the four balance sheet categories through credit risk losses (on credit claims in Category IV), and market risk losses (on fair value securities in Categories I–III). These changes are generated by the same scenario used to assess solvency risk.

211. A bank facing liquidity pressures follows a pecking order approach to meet liquidity needs:

- The bank repoes available unencumbered marketable assets at repo rate R_t. Marketable assets are constrained by the initial counterbalancing capacity;

- The bank borrows in the interbank market at interbank rate L_t. Access to interbank market is linked to the bank's credit rating. If the solvency shock triggers a rating downgrade (from a sudden reduction in the leverage ratio), the bank cannot longer access the interbank market to borrow funds;

- If liquidity pressures persist, the bank resorts to the liquidation of non-marketable assets at a discount rate Dt. The discount rate is linked to the credit quality of the underlying portfolio (e.g., credit claims);

- If the bank's liquidity is insufficient to cover immediate liquidity needs the bank turns illiquid.

212. Results show that the impact of solvency and liquidity interactions on G-SIBs is contained. The test allows identifying the size of the solvency shock to marketable assets subject to VM (x axis) and to illiquid assets not subject to VM (y axis) that will render the bank solvent and/or illiquid. The grey area identifies regions where the bank is solvent and liquid (under different management actions); the yellow area pinpoints regions where the bank is insolvent but liquid, and the purple area locates regions where the bank is insolvent and illiquid (high-risk region). Results suggest that only very large shocks would put banks under severe solvency and liquidity stress. This is due to banks' large counterbalancing capacity and strong solvency position (Figure 23).

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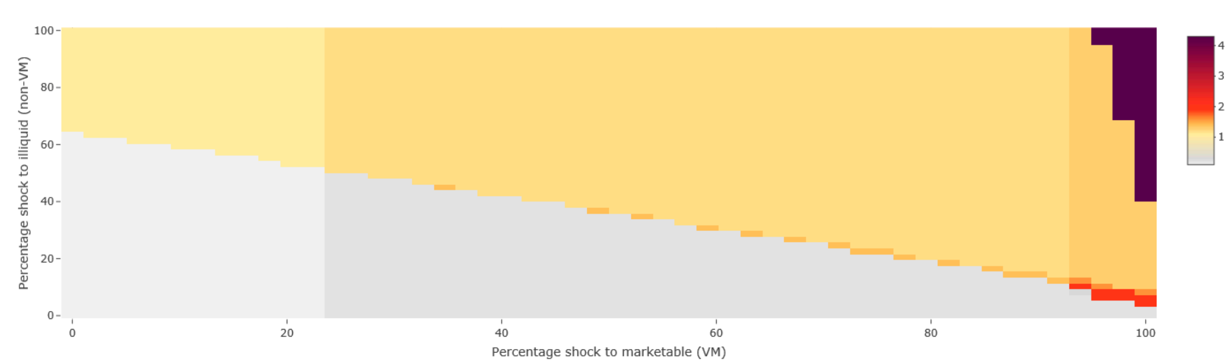
[68] Cont, R., Kotlicki, A., and Valderrama, L. (2019), "Liquidity-at-risk", IMF Working Paper (forthcoming)".

Figure 23. Switzerland: Stressed Solvency and Liquidity Regions



Source: IMF staff based on publicly available data sourced from Pillar 3 and annual reports.

SYSTEMIC RISK ANALYSIS

A. Scope of the Stress Test

213. Additional tests were conducted to determine whether the financial system is likely to absorb or amplify severe macrofinancial shocks. The analysis was confined to the banking system and focused on the risk of contagion through the Swiss interbank market including intragroup domestic exposures. Contagion through equity markets was assessed using the market-based CoVaR methodology. Other advanced stress testing approaches to capture feedback between the financial sector and the macroeconomy, and contagion effects from banks to non-banks rely on the evolution of banks' balance sheets under stress (i.e., dynamic balance sheets) and therefore are not assumption free. These areas remain in need of additional research to strengthen macroprudential stress tests.

214. The transmission of shocks from an individual bank to the rest of the system is assessed through the following channels:[69]

- **Bilateral Exposures:** Counterparties with large exposures to a distressed firm may suffer material losses resulting in their inability to satisfy their obligations hence transmitting distress to other parts of the interbank market in the form of cascading defaults.

- **Market Contagion:** Banks may suffer equity losses from market participants' revised expectations on the solvency of banks following similar business models to a bank in distress, conditional on the broader economic environment.

[69] These channels have been highlighted by Daniel K. Tarullo, "Regulating Systemic Risk," Speech, 2011 Credit Markets Symposium, North Carolina, Charlotte, March 31, 2011, Board of Governors of the Federal Reserve System, available at http://www.federalreserve.gov/newsevents/speech/tarullo20110331a.htm.

215. The potential for cascading defaults through the interbank market was assessed in a sample comprising the twelve major Swiss banks using ARIS large exposures data.[70] The analysis includes a credit shock simulation whereby one credit counterparty defaults at a time. It also includes a funding shock simulation whereby the default of a funding counterparty might induce a liquidity shortfall. [71]

B. Network Analysis

216. Network analysis allows understanding risk propagation through the interbank market given the current network of exposures. The failure of one or more banks in a stress test might have implications for other banks through credit or funding channels if they are exposed to banks that, in turn, are creditors of the failing institutions. Thus, network analysis moves the analysis towards a more systemic view – a deeper understanding of which institutions are central or peripheral in a crisis – and is a material improvement on bilateral exposure data in evaluating potential second-round effects on other institutions from credit or funding shocks.

217. The possibility of contagion depends strongly on the precise structure of interbank claims. Contagion is less likely to occur in a 'complete structure of claims', in which every bank has symmetric linkages with all other banks in the economy. However, 'incomplete structures', where banks have links only to a few neighboring institutions are expected to be much more fragile. In two-tiered structures, the failure of the money center bank is more likely to trigger the breakdown of other institutions that the failure of a bank on the periphery.

218. The appraisal of contagion risks is conducted using a model-based simulation on major Swiss banks. The analysis, following on Espinoza-Vega and Sole (2010) and using granular supervisory data on interbank exposures, includes a stylized credit shock simulation, whereby one credit counterparty defaults at a time. It includes also a funding shock simulation, where a counterparty default may induce a liquidity shortfall.

219. The results suggest that the risk of contagion through interbank exposures within the Swiss interbank market are currently low relative to their capital buffers. A network depiction of the large Swiss banks displays a modest degree of interbank connectedness relative to banks' capitalization levels (Figure 24). The banking network indicates that spillovers are greatest between the G-SIBs and some Private banks. The analysis indicates that spillovers have decreasing due to the implementation of the Large Exposures regulation, minimizing the treatment of exceptions.

[70] The data made available to the FSAP team included positions to the Swiss counterparties included in the stress test sample (i.e., twelve major banks). Lack of access to foreign exposure data precluded the assessment of cross-border contagion using banks' position data. However, the implementation of the Basel large exposures framework limits direct losses incurred from single counterparty default.

[71] Based on Espinosa, M., and Sole. J. (2010).

C. Systemic Risk Analysis

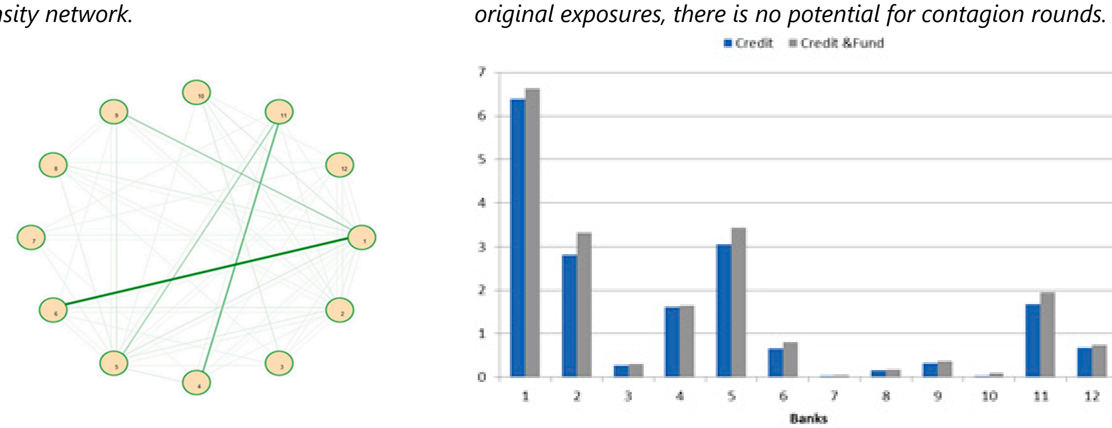
220. To capture risks to the stability of Swiss banks from market contagion, the CoVaR methodology is applied (Appendix IV). The CoVaR methodology evaluates the potential for individual bank stress to propagate through equity markets. Contagion can occur if the failure of one bank is a signal to investors that banks operating in the same region or with similar business models are likely to be in trouble. A correction in market value or the restriction of liquidity might follow as counterparties shy away. The quantification of contagion effects depends on: (i) the definition of the financial system; (ii) the characterization of financial stress; and (iii) the macro-financial environment in which firm stress arises. The analysis uses weekly data from October 2005 through November 2018.

Figure 24. Switzerland: Network Analysis

The potential for contagion through cascading networks in the Swiss banking sector is insignificant.

The Swiss banking system is characterized by a low-density network.

Even under extreme assumptions of LGD=100 percent of original exposures, there is no potential for contagion rounds.



Source: SNB ARIS data and IMF estimates. The nodes in the chart represent different banks. The lines between the nodes represent gross exposures between the banks. A thicker line between the nodes implies a larger bilateral exposure. Figure 1 Index of Contagion shows the average percentage of loss of other banks due to the failure of each bank in the X axis, in terms of excess CET1 capital over regulatory minimum.

221. Market perceptions of systemic risk through equity markets have eased following crisis episodes (Figure 25). The VaR of financial system returns controlling for macrofinancial drivers, edged down to about -15 percent of quarterly equity returns in October 2018 from a peak of -60 percent during the GFC.

222. The CoVaR measure of comovement in tail returns is affected by distress in individual banking institutions. The coefficient related to the dynamics of individual bank returns is always significant and enhances the ability of the model to forecast the tail performance of the financial system portfolio.

223. The risk of spillovers between listed Swiss banking institution appears moderate. The CoVaR analysis suggests that, on average, the risk that severe distress affecting one listed Swiss bank is transmitted through equity markets to other Swiss banks is moderate. The average delta CoVaR of the most systemic bank reached -15 percent of weekly equity returns during the GFC.

Figure 25. Switzerland: Market-based Contagion

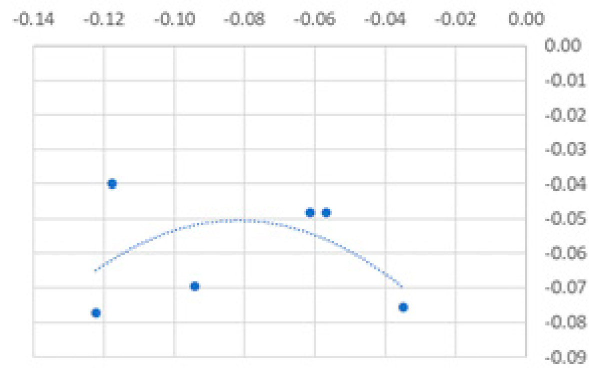
The risk of the Swiss financial system based on market-based CoVaR has come down from crisis levels. The contribution to systemic risk of the listed Swiss banks is contained.

VaR returns have edged down to about -15 percent of weekly equity returns from a peak of -60 percent during the global financial crisis.

VaR
(In percent)

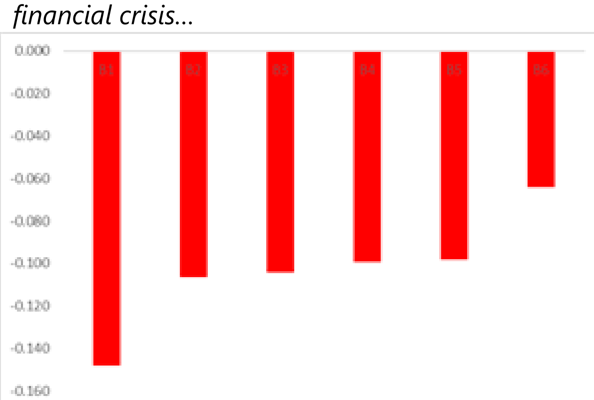
The scatter plot shows the weak correlation between banks' individual risk marginal contribution measured by VaR (x-axis), and its contribution to systemic risk measured by Delta CoVaR (y-axis).

Delta CoVaR vs. VaR, 2018
(In percent)



Delta CoVaR, 2007–09
(In percent)

While the average delta CoVaR of the most systemic—in the sense of this Delta CoVaR analysis by the IMF—bank reached -15 percent of weekly banking system returns during the global financial crisis…



Delta CoVaR, 2007–09
(In percent)

…it has edged down to -8 percent during 2018.

Source: Fund Staff estimates. The sample of banks included the 6 listed Swiss banks in the 12-bank solvency sample. The analysis is based on weekly data from October 2005 through November 2018. The bottom charts show the average contribution to systemic risk during the global financial crisis (LHS) and during 2018 (RHS).

Appendix I. Risk Assessment Matrix (RAM)

Risk	Overall Level of Concern	
	Relative Likelihood	Expected Impact if Materialized
1. Tighter financial conditions and volatile trading business. Volatility rises, and term premia decompresses, triggering an abrupt tightening of financial conditions. This generates a generalized sell-off in stock markets, and the reemergence of sovereign stress in the Euro Area. Despite low policy rates, the sustained rise in risk premia leads to raising funding costs for banks bringing a sharp increase in lending rates. Higher debt service stresses leveraged firms, stretched households, and vulnerable sovereigns. Trading business suffers as volatile markets push clients to seek shelters in cash hurting transaction-driven capital market revenue and lowering performance fees.	**High**	**High**
2. Severe global recession and low net new money. A hard Brexit without a deal in place, a U.S. trade war against Europe or China, concerns over public debt sustainability in Europe, or a credit cycle downturn in emerging markets undermine global medium-term growth. Switzerland economy is severely impacted as it remains exposed to global fragile economic conditions and the potential misallocation of investments in an ultra-low-yield environment. Financial stress from confidence shocks trigger a sharp fall in asset prices, followed by a pronounced credit crunch. Swiss banks face additional external risks (particularly in emerging markets), such as sudden inability to exchange currency, risk of capital controls and restrictions to capital transfers, political risk, or inability to enforce the right to sell collateral due to legal prescriptions. Net new money outflows surge hurting the wealth and asset management industry.	**Medium**	**High**
3. Regional tensions and regulatory pressures. A significant deterioration of bilateral relations with the European Union (EU) impacts Switzerland's externally-oriented economy eroding competitiveness and weighing on economic growth in Switzerland. Marked changes in tax and regulatory requirements impact the wealth-management industry's putting pressure on Swiss banks' business models and feeding adverse feedback loops. Litigation reserves prove insufficient and operational risks inherent in private banking business models increases.	**Medium**	**High**
4. Large correction in real estate prices. A sharp reversal of historically high house prices in Switzerland poses material credit risks, due to domestic banks' high exposure to real estate markets. The correction in residential and Commercial Real Estate prices is concentrated in regions which have experienced more rapid price increases. Falls in asset prices widen LTV ratios, trigger margin calls, and increase borrowers' amortization schedules. Affordability risk surges and default events spread to the nonbank financial industry exposed to real estate.	**Medium**	**High**

Appendix II. EDF Projections for Non-Financial Corporates in the United Kingdom

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	1	2	3	1	2	3
L.inf	0.119**	0.084	-0.039	0.112**	0.133***	0.002
	(0.044)	(0.053)	(0.115)	(0.055)	(0.044)	(0.140)
L2.inf		0.009	-0.040		-0.038	-0.050
		(0.054)	(0.095)		(0.063)	(0.110)
L.gap	-0.104**	-0.650*	0.595	-0.107**	-1.267***	-0.971
	(0.044)	(0.359)	(0.984)	(0.046)	(0.361)	(2.429)
L.tb	0.091	-0.285	3.384**	0.102*	0.008	1.128
	(0.060)	(0.295)	(1.415)	(0.056)	(0.317)	(3.557)
L.ltr	0.041	-0.282	-1.868***	0.075	-1.015**	-1.769
	(0.058)	(0.243)	(0.422)	(0.103)	(0.435)	(1.417)
L2.ltr		0.227	2.770***		0.960**	2.814
		(0.240)	(0.916)		(0.362)	(3.091)
L.slope	0.052	-0.361	3.455**	0.053	-0.051	1.145
	(0.075)	(0.300)	(1.431)	(0.075)	(0.305)	(3.696)
L.credit	-0.003	-0.018	-0.037**	-0.007	-0.052***	-0.028
	(0.011)	(0.016)	(0.018)	(0.011)	(0.016)	(0.028)
L.equity	-0.007*	-0.004	-0.002	-0.008**	0.003	-0.001
	(0.004)	(0.002)	(0.004)	(0.004)	(0.004)	(0.005)
L.g_w	-0.069**	-0.046	0.002	-0.068***	-0.161***	0.039
	(0.027)	(0.078)	(0.109)	(0.024)	(0.058)	(0.137)
L.g_em	-0.042	0.039	-0.048	-0.027	0.113	0.001
	(0.038)	(0.073)	(0.074)	(0.044)	(0.067)	(0.124)
L2.g_em		-0.096*	-0.361***		-0.136**	-0.205
		(0.052)	(0.118)		(0.049)	(0.260)
L.libor_usd_tbill	0.298***	0.213**	0.158	0.310***	0.192**	0.147
	(0.062)	(0.078)	(0.098)	(0.067)	(0.078)	(0.124)
L2.libor_usd_tbill		0.177***	-0.123		0.111*	-0.032
		(0.061)	(0.073)		(0.064)	(0.141)
L.spread_IT	-0.097**	-0.084	-0.050	-0.068	0.048	-0.017
	(0.038)	(0.073)	(0.075)	(0.066)	(0.086)	(0.138)
1.stress_g#cL.g	0.032	-0.033	-0.019	0.045	-0.032	0.009
	(0.054)	(0.031)	(0.032)	(0.062)	(0.028)	(0.057)
Constant	-3.287***	-3.476***	-2.046***	-3.466***	-4.417***	-2.961*
	(0.177)	(0.341)	(0.379)	(0.330)	(0.322)	(1.594)
Observations	66	66	66	59	59	59

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Sources: Moody's KMV, WEO, Bloomberg, and IMF estimates. Note: The estimation period is 2002: Q2 through 2018: Q4. The dependent variable is Moody's 1-year average EDF for the corporate portfolio (i.e., "1-Yr EDF 9 Average") in the United Kingdom. Regressors include: inf (inflation rate), gap (output gap), tb (3-month T-bill), ltr (10-year real interest rate), slope (10-year over 3-month sovereign yield), credit (credit growth to the private sector), equity (equity price growth), g_w (global GDP growth), g_em (EMs GDP growth), spread_IT (10-year Italy sovereign minus 10-year Bund yield), libor_usd_tbill (spread of the 3-month libor USD over the U.S. T-bill rate), and stress_g#cL.g (a dummy variable taking the lagged GDP rate when it's negative).
Three specifications are shown for each corporate portfolio for the full sample period (66 observations) and a truncated sample (59 observations) to conduct out-of-sample forecasting. L denotes 1 lag, L2 denotes 2 lags and L3 denotes 3 lags. The model is used for forecasting purposes rather than for the structural identification of shocks. Therefore, the forecasting ability of the specification is the relevant metric for model performance rather than the economic interpretation and magnitude of the drivers.

Appendix III. EDF Projections for Non-Financial Corporates in the United States

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	1	2	3	1	2	3
L.inf	0.068**	0.034	0.015	0.096**	0.030	-0.003
	(0.030)	(0.025)	(0.014)	(0.036)	(0.024)	(0.024)
L.gap	-0.085*	-0.054	-0.826*	-0.098**	-0.152	-1.040
	(0.045)	(0.278)	(0.465)	(0.043)	(0.361)	(1.073)
L2.gap		0.011	1.171		0.105	1.054
		(0.263)	(0.892)		(0.324)	(1.606)
L.tb	0.086	-0.915***	-0.450	0.120	-1.078***	-1.034
	(0.075)	(0.185)	(0.541)	(0.084)	(0.229)	(1.578)
L.ltr	0.074*	0.255***	0.435	0.085**	0.271***	0.904**
	(0.038)	(0.086)	(0.292)	(0.040)	(0.095)	(0.357)
L.slope	0.089	-0.819***	-0.419	0.132*	-0.960***	-1.041
	(0.058)	(0.174)	(0.516)	(0.066)	(0.192)	(1.594)
L.equity	-0.007*	-0.001	-0.001	-0.006*	-0.001	-0.004*
	(0.004)	(0.002)	(0.002)	(0.004)	(0.003)	(0.002)
L.g_em	-0.086	0.021	0.031	-0.079	0.052	-0.019
	(0.056)	(0.073)	(0.075)	(0.065)	(0.087)	(0.075)
L2.g_em		-0.093*	-0.006		-0.100**	0.021
		(0.046)	(0.065)		(0.044)	(0.072)
L.g_oil	-0.002	-0.000	0.001	-0.003*	0.000	0.004
	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)	(0.002)
L.libor_usd_tbill	0.185***	0.106	0.101	0.154***	0.084	0.068
	(0.050)	(0.065)	(0.082)	(0.056)	(0.071)	(0.089)
L.spread_IT	-0.087*	-0.075	0.011	-0.069	-0.087	0.093
	(0.044)	(0.052)	(0.055)	(0.049)	(0.058)	(0.065)
1.stress_g#cL.g	-0.015	-0.027	0.017	-0.008	-0.024	-0.016
	(0.024)	(0.019)	(0.041)	(0.023)	(0.020)	(0.031)
Constant	-2.545***	-2.521***	-2.790***	-2.769***	-2.590***	-3.062***
	(0.208)	(0.306)	(0.575)	(0.296)	(0.339)	(0.932)
Observations	63	62	61	56	55	54

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Sources: Moody's KMV, WEO, Bloomberg, and IMF estimates. Note: The estimation period is 2002: Q2 through 2018: Q4. The dependent variable is Moody's 1-year average EDF for the corporate portfolio (i.e., "1-Yr EDF 9 Average") in the United States. Regressors include: inf (inflation rate), gap (output gap), tb (3-month T-bill), ltr (10-year real interest rate), slope (10-year over 3-month sovereign yield), equity (equity price growth), g_m (EMS GDP growth), g_oil (spot fuel price growth), spread_IT (10-year Italy sovereign minus 10-year Bund yield), libor_usd_tbill (spread of the 3-month libor USD over the U.S. T-bill rate), and stress_g#cL.g (a dummy variable taking the lagged GDP rate when it's negative).

Three specifications are shown for each corporate portfolio for the full sample period (66 observations) and a truncated sample (59 observations) to conduct out-of-sample forecasting. L denotes 1 lag, L2 denotes 2 lags and L3 denotes 3 lags. The model is used for forecasting purposes rather than for the structural identification of shocks. Therefore, the forecasting ability of the specification is the relevant metric for model performance rather than the economic interpretation and magnitude of the drivers.

Appendix IV. Overview of the CoVaR Methodology

The CoVaR is defined as the maximum expected loss in the banking system for a given confidence level and time horizon, conditional on the maximum expected loss of an individual bank at a specific confidence level and time horizon.[72] More formally, the $(1-\lambda)\%$ CoVaR of system j given the $(1-\lambda)\%$ VaR of bank *i*, denoted $CoVaR^{j|i}_{\lambda,t}$, is defined as the λ quantile of the conditional loss function:

$$\Pr\left(X_t^j \leq CoVaR^{j|\Phi\left(X_t^i\right)} \middle| \Phi\left(X_t^i\right)\right) \tag{1}$$

where X_t^j and X_t^i denote system and individual bank returns.

A bank's individual contribution to systemic risk can be approximated by its Δ CoVaR:

$$\Delta CoVaR^i_{\lambda,t} = CoVaR^{j|i}_{\lambda,t} - VaR^j_{\lambda,t} \tag{2}$$

which captures how much risk bank i adds to overall systemic risk when it reaches its VaR.

For each conditioning event, we construct a different banking system to avoid spurious correlation. The banking system is defined as the weighted average returns of the remaining banks in the sample, once we exclude the bank in distress. In particular, the returns of the banking system given bank *i*'s distress are constructed as:

$$X_t^{S,i} = \sum_{j=1, j\neq i}^{n} \omega_{t,j} X_t^j, \quad \omega_{t,j} = W_t^j \left(\sum_{j=1, j\neq i}^{n} W_t^j \right)^{-1} \tag{3}$$

where X_t^j refers to the returns of the *j*th bank and W_t^j is the book value of total assets.

The existence of risk spillovers is captured through the estimates of the $\delta_{\lambda,i}$ parameter. The left tail of the banking system can be predicted by observing the distribution of bank i's returns. The symmetric specification can be approximated by:

$$X_t^{S,i} = Z'_{t-1}\beta_\lambda + \delta_{\lambda,i} X_t^i + u_{\lambda,t} \tag{4}$$

We check for possible asymmetries in the specification. Since the interest of our analysis is clearly on the behaviour of the left tail, for which 5 percent VaR is expected to be a negative value,

[72] Based on Adrian and Brunnermeier (2016), and Valderrama et al (2012, 2017).

the basic specification (4) neglects an important feature of the conditioning: the final prediction is constructed on a negative value. If we factor in the reinforcing effects from credit constraints in a downward market, the model is likely to yield parameter estimates of $\delta_{\lambda,i}$ which can significantly underestimate the impact on the system of a negative shock in the balance sheet of a bank. We estimate the asymmetric specification:

$$X_t^{S,i} = Z'_{t-1}\beta_\lambda + \delta^-_{\lambda,i} X_t^i I_{\left(X_t^i<0\right)} + \delta^+_{\lambda,i} X_t^i I_{\left(X_t^i\geq 0\right)} + u_{\lambda,t} \quad (5)$$

The econometric specification of the contribution of bank *i*'s distress to the distress of the banking system is approached by:

$$\Delta CoVaR^i_{\lambda,t} = \hat{\delta}_{\lambda,i}\left(VaR_i^t(\lambda) - VaR_i^t(50\%)\right) \quad (6)$$

Appendix V. Calibration of IMF LCR-based Liquidity Test

A. Eligibility of liquid assets

Potential liquidity generation capacity through the monetization after haircut	LCR	Liquid assets scenario 2	Liquid assets scenario 3
Level 1 Assets	100%	100%	100%
Coins and bank notes			
Qualifying marketable securities form sovereigns, central banks, PSEs, and			
Qualifying central bank reserves			
Domestic sovereign or central bank debt for nonzero risk-weighted entities			
Level 2a Assets	85%	85%	75%
Qualifying marketable securities form sovereigns, central banks, PSEs, and			
Qualifying corporate debt securities rated AA- or higher			
Qualifying covered bonds rated AA- or better			
Level 2b Assets			
Qualifying Mortgage Backed Securities	75%	75%	65%
Qualifying corporate debt securities rated between A+ and BBB-	50%	50%	40%
Qualifying common equity shares	50%	50%	40%

B. Inflow rate (over 30 days)

Maturing secured lending transactions backed by the following assets:	LCR	Inflows scenario 2	Inflows scenario 3
Level 1 assets	0%	0%	0%
Level 2a assets	15%	15%	15%
Level 2b assets			
Eligible RMBS	25%	25%	25%
Other	50%	50%	50%
Margin lending backed by all other collateral	50%	50%	50%
All other assets	100%	100%	100%
Credit or liquidity facilities	0%	0%	0%
Operational deposits held at other financial institutions	0%	0%	0%
Other inflows, by counterparty			
Retail counterparties	50%	25%	50%
Nonfinancial wholesale counterparties, transactions not listed above	50%	50%	25%
Financial institutios and central banks, transactions not listed above	100%	100%	40%
Net derivative cash inflows	100%	100%	100%
Other (contractual) cash inflows	100%	100%	100%

C. Run-off rate (over 30 days)

	LCR	Outflow scenario 2	Outflow scenario 3
Retail Deposits			
Demand deposits			
Stable deposits	5%	10%	5%
Less stable retail deposits	10%	20%	10%
Term deposits, residual maturity > 30d	0%	0%	0%
Unsecured Wholesale Funding			
Demand and term deposits, residual maturity < 30d, small business			
Stable deposits	5%	5%	10%
Less stable deposits	10%	10%	15%
Operational deposits generated by clearing, custody, and cash management activities	25%	25%	50%
Portion covered by deposit insurance	5%	5%	10%
Cooperative banks in an institutional network	25%	25%	100%
Nonfinancial corporates, sovereigns, central banks, multilat development banks, PSEs			
Fully covered by deposit insurance	20%	20%	50%
Not fully covered by deposit insurance	40%	40%	100%
Other legal entity customers	100%	100%	100%
Secured Funding			
Secured funding with a central bank, or backed by Level 1 assets	0%	0%	0%
Secured funding backed by Level 2A assets	15%	15%	15%
Secured funding backed by non-Level 1 or non-Level 2A asset, with domestic sovereigr	25%	25%	50%
Funding backed by RMBS eligible for Level 2B	25%	25%	50%
Funding backed by other Level 2B assets	50%	50%	100%
Other secured funding transactions	100%	100%	100%
Additional Requirements			
Valuation changes on non-Level 1 posted collateral securing derivatives	20%	20%	20%
Excess collateral held by bank related to derivate transactions that could be called anyt	100%	100%	100%
Liquidity needs related to collateral contractually due on derivatives transactions	100%	100%	100%
Increased liquidity needs related to derivative transactions allowing collateral substitu	100%	100%	100%
ABCP, SIVs, conduits, SPVs, or similar			
Liabilities from maturing	100%	100%	100%
Asset backed securities	100%	100%	100%
Undrawn but committed credit and liquidity facilities			
Retail and small business	5%	20%	5%
Nonfinancial corporates, sovereigns, central banks, multilat dev. banks, PSEs			
Credit facilities	10%	10%	20%
Liquidity facilities	30%	30%	50%
Supervised banks	40%	40%	100%
Other financial institutions			
Credit facilities	40%	40%	100%
Liquidity facilities	100%	100%	100%
Other legal entity customers, credit and liquidity facilities	100%	100%	100%
Other contingent funding liabilities			
Trade finance	5%	5%	15%
Customer short positions covered by customers' collateral	50%	50%	75%
Additional contractual outflows	100%	100%	100%
Net derivative cash outflows	100%	100%	100%
Any other contractual cash outflows (not listed above)	100%	100%	100%

Source: Basel (2013) and IMF staff.

Appendix VI. Calibration of IMF Cash-Flow-based Liquidity Test

Test	Definition	Basic Assumptions: Assets (cash inflows)	Basic Assumptions: Liabilities (cash outflows)	Other Assumptions
5-day implied cash flow (ICF) test	cumulative inflow and outflow over 5 consecutive days	Liquid financial assets: (i) cash and cash balances with central banks [**haircut**: 0 percent], (ii) securities and bank loans eligible at major central banks [0-15], (iii) securities and bank loans which can be mobilized in repo transactions (or another type of lending against financial collateral) [5-30], and (iv) marketable securities [10-35]; Cumulative cash inflows: (i) expected cash inflows related to credit extension without liquid financial assets as collateral [**call-back rate**: 20 percent per day], (ii) expected inflows of cash and liquid assets related to maturing transactions with liquid securities and bank loans (e.g., reverse repo and securities borrowing transactions) [20], (iii) expected and potential net cash flows related to derivatives (excl. credit derivatives) – net contractual cash flows [20], and (iv) potential inflows from committed/uncommitted credit lines to related and third parties [5/3].	Cumulative cash outflows: (i) maturing and non-maturity funding without liquid financial assets as collateral [**discount factor**: 5 percent per day] (i.e., all deposits and funding from financial and non-financial corporates as well as private households and SME clients) with the exception of sovereign and other public sector and central bank clients [0], (ii) expected outflows of cash and liquid assets related to transactions with liquid securities and bank loans (e.g., repo and securities lending transactions) [20], (iii) maturing outflows to related parties [20], and (iv) committed/uncommitted contingent claims to related and third parties [5].	A ratio lower than 100 percent implies a liquidity shortage if the stress scenario would materialize at the reporting date (i.e., potentially required liquidity > potentially available liquidity); only unencumbered liquid assets (generating cash inflows), i.e., assets used as a collateral to receive funding (with the exception of cash/cash-equivalents) are included in the test ("liquidity scope"); new unsecured financing and securitization impossible within the time horizon; no offsetting cash inflows from new or renewed (secured/unsecured) wholesale lending (at contractual maturities) but full renewal of secured retail lending (e.g., secured lending with illiquid collateral (residential mortgages); central bank eligible collateral can be monetized at appropriate haircuts; repo markets are open at appropriate haircuts; fire-sale of assets possible at appropriate haircuts; no consideration of funding via potentially re-usable securities received as collateral ("rehypothecation"); limited potential unsecured support in convertible currencies from related and third parties (e.g., in the form of committed lines); no renewal of term retail and wholesale deposits; and full convertibility between currencies (within one week).
30-day implied cash flow (ICF) test	non-cumulative	Liquid financial assets: (i) cash and cash balances with central banks [0], (ii) securities and bank loans eligible at major central banks [0-20], (iii) securities and bank loans which can be mobilized in repo transactions (or another type of lending against financial collateral) [10-60], and (iv) marketable securities [20-70]; Non-cumulative cash inflows: (i) expected cash inflows related to credit extension without liquid financial assets as collateral [**call-back rate**: 100 percent], (ii) expected inflows of cash and liquid assets related to maturing transactions with liquid securities and bank loans (e.g., reverse repo and securities borrowing transactions) [100], (iii) expected and potential net cash flows related to derivatives (excl. credit derivatives) – net contractual cash flows [100], and (iv) potential inflows from committed/uncommitted credit lines to related and third parties [23/12].	Non-cumulative cash outflows: (i) maturing and non-maturity funding without liquid financial assets as collateral [10-75] (i.e., all deposits and funding from financial and non-financial corporates as well as private households and SME clients) with the exception of sovereign and other public sector and central bank clients [0], (ii) expected outflows of cash and liquid assets related to transactions with liquid securities and bank loans (e.g., repo and securities lending transactions) [100], (iii) maturing outflows to related parties [100], and (iv) committed/uncommitted contingent claims to related and third parties [23].	

Appendix VII. Banking Sector Stress Testing Matrix (STeM)

A Banking Sector: Solvency Test				
Domain		**Framework**		
		Top-Down by SNB	**Top-Down by FSAP Team**	**Bottom-Up by Banks**
1. Institutional perimeter	Institutions included	The two G-SIBs, and all domestically focused banks (DFB). DBFs include banks whose domestic credit exposure amounts to at least 50 percent of their total balance sheet.	Twelve major banks, including the two G-SIBs, six domestically focused banks, and four private banks. The criteria used to determine the institutional perimeter include: firms' balance sheet; firms' share in the domestic market; and firms' reputational risk.	The two G-SIBs.
	Market share	About 90 percent of the domestic credit positions.	About 80 percent of banking system total assets.	Over 50 percent of banking system total assets.
	Data	Effective date: June 2018. Data: SNB survey data; FINMA regulatory data (including interest-rate risk report templates), and Building Block Analysis data. Scope of consolidation: Consolidated group basis.	Effective date: June 2018. Data: SNB survey data; FINMA regulatory data (including interest rate risk report templates); and Building Block Analysis data. Supervisory data are complemented by public sources including: bank Pillar 3 disclosures; Bloomberg; Dealogic; Haver Analytics; Moody's KMV; and Fitch. Scope of consolidation: Consolidated group basis.	Effective date: June 2018. Data: Banks' managerial and proprietary data at the portfolio level.
	Stress testing process	SNB conducted the stress test for G-SIBs using its own internal models and the Building Block Analysis (BBA) module based on standardized risk and exposures modules ("building blocks") provided by the G-SIBs. SNB carried out	The FSAP team conducted its own TD macroprudential stress test using in house models. For internal ratings-based (IRB) exposures, a separate credit risk model was calibrated for 5 Basel asset	Banks performed their bottom-up calculations based on the FSAP scenarios.

A Banking Sector: Solvency Test				
Domain		Framework		
		Top-Down by SNB	Top-Down by FSAP Team	Bottom-Up by Banks
		stress tests for DFB using data primarily based on SNB banking statistics using a structural model for mortgage loans, a hybrid of structural, regression approaches, and historical benchmarking for other retail and corporate loans, a simulation of interest rate bearing cash-flows taking into account bank and client behavior for interest rate risk, regression analysis and expert judgment for market and business risk, and constant RWA.	classes in Switzerland and 10 foreign geographies including: Australia, China, Germany, Ireland, Italy, Korea, Netherlands, Turkey, United Kingdom, and United States. For STA exposures, stressed NPL ratios, stressed coverage ratios, and a stressed transition matrix for performing exposures was projected. Fair valuation impact on fair value debt instruments was projected for 40 country issuers.	Results were benchmarked against top-down projections (on the same scenario but different methodology).
2. Channels of risk propagation	Methodology	All major risk categories, depending on the risk profile of the corresponding banking category, are covered, including credit risk, market risk, IRR, funding risk, F&C risk and operational risk. Structural credit risk models explicitly account for non-linear responses to shocks, benchmarked against banks' practices. Mortgage risk models incorporate affordability risk linked to the interest rate path and projected income among clients. The average loss rates of the model match the empirical loss rate over the 1991–1995 period, and it's scaled according to regions, collateral types, and ranks. The modelling approach for non-mortgage domestic credit simulates the impact of stress on unsecured loans using bankruptcy rates for corporate since the 1980s. Loss rates are scaled depending on the loan type (bank, covered loan, off balance sheet). Interest rate risk is based on a granular and dynamic top-down simulation with	A comprehensive battery of econometric and structural models were specifically developed and calibrated for the 2019 Switzerland FSAP. The Top-Down stress test included a detailed stress test of the Swiss mortgage book by LTV/LTI density (measures by the distribution of LTV and LTI ratios by bucket) and estimated vintage, using a structural approach building on the Merton-based TUI model. TUI is a structural model of the residential housing loan default process. It is designed to calculate economic capital for housing loan portfolios in jurisdictions where empirical evidence of tail-event losses is slight or non-existent Over 50 credit risk models and 150 econometric specifications were estimated for PDs based on multivariate vector autoregressive models (VAR), principal component analysis (PCA),	Combination of banks' own models and pre-defined benchmarks set in the Building Block Analysis (BBA). Constrained assumptions based on FSAP stress testing methodology (e.g., balance sheet dynamics, pass-through of funding costs to margins, dividend payout ratios).

A Banking Sector: Solvency Test				
Domain		Framework		
		Top-Down by SNB	Top-Down by FSAP Team	Bottom-Up by Banks
		explicit modeling of dynamic elements including banks' margins and client's behavior as regards migration of product categories and durations at renewal. For G-SIBs, idiosyncratic funding risks are evaluated based on sensitivities included in the BBA reporting. Market risk is based on granular market risk sensitivities on cash and derivative positions for G-SIBs, and on regression approaches for DFBs.. For the G-SIBs, business risks are estimated by using a structural approach differentiating major income and expense components according to BBA data, while, for DFBs, a regression approach complemented by expert judgment is applied. The scenario impact from operational risks is determined based on banks' risk-based capital requirements for operational risks.	quantile-based regressions, panel regressions, and a structural Merton-based approach for LGDs on mortgage loans. For business risk, shocks to net interest income, trading income, fees & commissions will be modeled separately using projections of client flows linked to projected trading volume and assets under management. The methodology included solvency and funding cost interactions. Bank funding costs were linked to system-wide stress in money markets, bank-specific capital positions, and contagion pressures from peer banks. Lending rates were linked to shocks to government yields and bank funding costs. Interest rates risk were applied on granular repricing and maturing banking book positions simulated to target banks' initial duration gap over the stress testing horizon. For market risk, stress from interest rate risk and credit spread on cash instruments and derivative underlying were assessed including fair valuation impact on fair value debt instruments in 40 countries. Equity risk and foreign exchange risk were modeled separately linked to major indexes and currency pairs, and allowing for basis risk.	
3. Tail shocks	Scenario analysis	The baseline scenario is based on the October WEO forecast. The adverse scenario is calibrated using the IMF's Global Macrofinancial Model and auxiliary models to estimate stressed paths for investment-led residential and commercial real estate prices. The calibration of the scenario follows a layer-of-shocks approach featuring exogeneous shocks and the economy's endogenous structural response. A global financial cycle downturn impacts Switzerland, triggering a slowdown in real GDP, financial market volatility, and a housing market correction. Global equity risk premium decompression reduces real equity prices by 40.0 percent in advanced		

A Banking Sector: Solvency Test				
Domain		**Framework**		
		Top-Down by SNB	**Top-Down by FSAP Team**	**Bottom-Up by Banks**
		economies and by 30.0 percent in emerging economies. Global term premium decompression interacts with the reemergence of sovereign stress in the Euro Area periphery to raise long term government bond yields by 300 basis points in the Euro Area periphery, by 150 basis points in the Euro Area core, by 200 basis points in other advanced economies, and by 120 basis points in emerging economies. Interbank market stress raises interbank spreads by 100 basis points in advanced economies and by 50 basis points in emerging economies. Global housing risk premium decompression reduces real house prices by 10.0 percent in advanced economies and by 5.0 percent in emerging economies. In Switzerland, peak-to-trough declines in real estate reach 40 percent in commercial real estate, 45 percent in investment-led residential real estate, and under 30 percent in owner-occupied real estate. Output in Switzerland falls 7.7 percent below baseline by 2020, reflecting a 8.7 percent fall in consumption and a 20.1 percent fall in investment, with consumption price inflation falling 2.5 percentage points below baseline by 2020, and the unemployment rate rising by 2 percentage points. The nominal policy interest rate is cut 2.3 percentage points below baseline by 2020. The scenario includes an additional idiosyncratic and system-wide funding risk shock triggered by dislocation of money markets and linked to banks' capital ratios under stress. This scenario constitutes a 3.3 standard deviation move in two-year cumulative real GDP growth rate by 2020, calculated over 1990–2018.		
	Sensitivity analysis		Additional shocks to credit spreads in fixed income instruments. Impact of a risk-based risk-weight add-on on STA exposures. Shocks to the interest rate swap curve, bond yields, and LIBOR rates, impacting affordability risk in mortgages. Counterparty risk in derivative markets.	
4. Risks and buffers	Positions/risk factors assessed	<u>Credit risk</u> Estimated according to the Swiss implementation of the Basel III framework. Credit risk includes: (i) lending risk from exposures to sovereign, public entities, financial institutions, corporates, and other; (ii) mortgage-related lending; (iii) Lombard lending; and, (iv) leveraged loans including syndicated loans, bridge loans, and equity bridges. Positions include term loans, revolving credit facilities, and loan commitments. Counterparty credit risk from combined credit and market risk stress on OTC products and securities financing transactions (SFTs) is included. Issuer default risk related to credit default events on underlying issuers and structured credit risk on of financial assets securitization (e.g., ABS, MBS, or ABCP), and structured credit derivatives is covered. <u>Sovereign risk</u> Mark-to-market valuation of securities (from shocks to interest rates and credit spreads) in trading book and AFS/FVO linked to macro scenario.		

A Banking Sector: Solvency Test				
Domain		Framework		
		Top-Down by SNB	Top-Down by FSAP Team	Bottom-Up by Banks
		<u>Market risk other than sovereign risk</u> Market stress from shocks to changes in interest rates, credit spreads, exchange rates, commodities, and equity prices. <u>Profits</u> Income from loans and non-loan activities. Interest income declines for the amount of lost income from defaulted loans. Interest income from non-defaulting loans is estimated according to satellite models. Interest expenses increase due to rising funding costs linked to the macroeconomic scenario with empirically estimated pass-through, and add-on funding stress from a market event with no pass-through to lending rates. Trading income evolves with projected client flows and market prices. Net fee and commission income evolves with projected off-balance sheet customer assets, including: (i) deposits and holdings of securities and precious metals from customers without securities dealers; (ii) assets under discretionary asset management agreement; and (iii) fiduciary investments.		
	Behavioral adjustments	<u>Dynamic balance sheets</u> Credit supply effects are disallowed to calibrate credit risk projections. Balance sheets evolve with key macroeconomic aggregates adjusting for credit demand effects. Exposure at default under stress from off-balance sheet exposures increases about 5–10 percent on average, reflecting higher use of undrawn credit and liquidity facilities. As a conservative assumption, all facilities are assumed to be contractually irrevocable ("committed") to extend funds in the future. Maturing assets are replaced by exposures of the same type and risk. Dividends are linked to banks' net profits. Under positive profits, the dividend payout floor is set at 30 percent. Otherwise, no dividend payout is assumed. The effective tax rate evolves with the macro scenario. Losses are recognized in the same year that a shock hits. If banks' capital ratio falls below regulatory minimum during the stress test horizon, no prompt corrective action is assumed.		
5. Regulatory and market-based standards and parameters	Calibration of risk parameters	Mortgage risk: default risk parameters are matched to the empirical loss rate over the 1991–1995 period, and it's scaled according to regions, collateral types, and ranks. Non-mortgage risk: credit risk simulates the impact of stress on unsecured loans using bankruptcy rates for corporate since the 1980s. Loss rates are scaled depending on the loan type (bank, covered loan, off balance sheet).	<u>Parameter definition</u> PiT PDs and LGDs for expected losses (P&L impact) and stressed regulatory PDs and LGDs on non-defaulted exposures for regulatory capital requirements. Estimated non-defaulted PDs by Basel asset class and geography. Estimated non-defaulted LGDs calculated post-credit risk mitigation by Basel asset class and geography.	Banks' internal models to project PiT stressed losses on credit exposures (both investment banking and private banking) covering: lending risk mortgage related lending, Lombard lending, and, leveraged loans; interest rates risk in the banking book, equity risk, foreign exchange risk; commodity risk; credit spread risk; lending risk; counterparty credit risk; issuer default risk; structured credit risk; business risk;

A Banking Sector: Solvency Test				
Domain		**Framework**		
		Top-Down by SNB	**Top-Down by FSAP Team**	**Bottom-Up by Banks**
			Parameter calibration For IRB exposures, shifts to PDs are informed by shocks to credit risk losses, Moody's EDFs rates, and banks' estimated PDs calculated in historical stressed episodes. Shocks to LGDs are projected using a Merton-based approach for mortgage exposures, shocks to unemployment for retail unsecured exposures, and shocks to GDP for corporate exposures. For STA exposures, inflows into NPL categories are based on a panel regression estimated on supervisory data, including risk migration for performing exposures, and stressed coverage ratios.	funding risk; and, operational risk. Banks' regulatory models to project TTC capital requirements for credit risk, market risk, and operational risk.
	Regulatory standards	Capital definition according to the phased-in Swiss implementation of Basel III. Non-material impact from transitional arrangements for capital components that are no longer eligible for additional Tier 1 and Tier 2 capital components. Under the TBTF regime, the going concern requirements consist of a basic requirement for the five D-SIBs as well as a progressive component depending on the degree of systemic importance according to their market share and asset size. The basic requirement for risk-weighted assets is 12.9 percent and 4.5 percent for the leverage ratio. In addition, the Swiss sectoral counter cyclical buffer is set at 2 percent of risk-weighted positions secured by residential property situated in Switzerland.		
6. Reporting format for results	Output presentation	Evolution of CET1, Tier 1, CAR, and leverage ratio, for the aggregate banking system, and by type of bank (i.e., G-SIBs, Domestically-focused Banks, and Private Banks). Contribution of key drivers to aggregate net profits and aggregate CET1 capital ratios. Number of banks and share of total assets below hurdle rates. Capital shortfall in terms of nominal GDP.		

Liquidity Stress Testing Matrix

Domain		**IMF designed stress test conducted jointly with SNB and FINMA**
1. Institutional perimeter	Institutions	Twelve major banks including the 2 G-SIBs, 6 domestically focused banks, and 4 private banks.
	Market share	About 80 percent of banking system total assets.
	Data and base date	Regulatory data based on Basel III standardized liquidity monitoring tools as of June 30, 2018.
2. Channels of risk propagation	Methodology	Shocks to inputs feeding into four-metrics included in the Basel III monitoring tools: • Liquidity coverage ratio (LCR) in CHF (requirement), and in significant currencies (EUR, GBP, JPY, USD) (monitoring metric) • Contractual maturity mismatch analysis (monitoring metric) • Concentration of funding (monitoring metric) • Available unencumbered assets (monitoring metric)
3. Risks and buffers	Risks	Funding risk, rollover risk, market liquidity risk, and liquidity risk related to margin requirements mainly related to the overall level of collateral posted for derivative positions.
	Buffers	HQLA securities assessed at market values net of haircut on a security-by-security basis.
4. Tail shocks	Size of the shock	<u>A range of adverse scenarios</u> • LCR Scenario under standard assumptions calibrated by BCBS. • An LCR “Switzerland retail stress” scenario. The calibration of this deposit run-off scenario replicates the peak stress observed in relevant comparator jurisdictions during the global financial crisis. • An LCR “Switzerland wholesale stress” scenario. This scenario replicates the liquidity stress observed during the global financial crisis characterized by: a freeze of wholesale funding; liquidity risk from margin calls related to secured funding, derivatives and foreign currency funding; and disruptions in the FX swap market (with rollover of secured funding backed by other than Level 1 and Level 2A assets of up to 0 percent). Implied cash flow 5-day and 30-day tests using contractual cash-flow data on the maturity ladder and unencumbered assets in the counterbalancing capacity. Assumptions include haircuts of up to 60 percent for securities and bank loans that can be mobilized in repos, no issuance of new unsecured funding and freeze of securitization markets, call-back rates of up to 100 percent, and cash outflows of up to 75 percent.
5. Regulatory standards	Regulatory standards	Basel III full implementation for the LCR ratio for total currency and CHF at 100 percent. Counterbalancing capacity above net cash outflows under stress scenario.
6. Reporting format for results	Output presentation	Changes in average liquidity position and counterbalancing capacity for each scenario. Distribution of banks’ liquidity position for each scenario. Number of banks with counterbalancing capacity below net cash outflows. Banks’ post-shock net liquidity position. Liquidity shortfall in terms of banking system total liabilities.

Interconnectedness Matrix—Network Analysis

Domain		**TD by IMF**
1. Institutional perimeter	Institutions	Twelve major banks including the 2 G-SIBs, 6 domestically focused banks, and 4 private banks.
	Market share	About 80 percent of banking system total assets.
	Data and base date	Regulatory data based on large exposure template as of June 30, 2018.
2. Channels of risk propagation	Methodology	Network analysis using Furfine algorithm and Espinosa-Sole tool. Cascading effects from individual defaults through counterparty exposures. Liquidity shortages from individual defaults through concentration of funding.
3. Approach	Linkages with solvency and liquidity stress tests	• The transmission of credit shocks will be linked to solvency stress test results to project capital depletion endogenously. • The transmission of funding shocks will be linked to liquidity stress test results by allowing banks to draw down their liquid buffers to replace funding from defaulting funding counterparties.
	Buffers	Tier 1 capital. Counterbalancing capacity.
4. Tail shocks	Size of the shock	Individual bank defaults. Stressed capital position in line with solvency stress test results.
5. Sensitivity test	Factors	Performance of collateral (for secured exposures), loss given default (for unsecured exposures), substitutability of funding (for funding shock)
6. Reporting format for results	Output presentation	• Failed capital in percent of total capital. • Number of induced failures and contagion rounds. • Absolute hazard rate. • Vulnerability level to counterparty defaults.

Interconnectedness Matrix—CoVaR Analysis		
Domain		**TD by IMF**
1. Institutional perimeter	Institutions	The financial sector included all listed Swiss banks.
	Market share	About 70 percent of Swiss banking system assets.
2. Data	Data type and base date	Assessment of contagion at weekly frequency over October 2005 through November 2018. • Bank-level data includes equity prices. • Swiss financial state variables include: VSMI, liquidity spread (difference between the 3m SNB repo rate and the 3m CHF benchmark curve), change in CHF 3m rate, change in the slope of the Swiss government yield curve, change in corporate credit spread of 10y Swiss BBA bond; change in Swiss equity market index; a global/European crisis dummy.
3. Channels of risk propagation	Methodology	CoVaR methodology based on Adrian and Brunnermeier (2016), and Valderrama et al (2012, 2015). • Characterization of co-dependence using a quantile approach. • Characterization of individual VaR dynamics using a GARCH (1,1) process on conditionally demeaned returns.
4. Tail shock	Size of the shock	5 percent quantile of the conditional loss distribution.
5. Robustness checks		Symmetric/asymmetric specification in the co-dependence structure of tail returns. CoVaR analysis applied to banks' equity returns and implied asset returns. Analysis of the 99^{th} percentile of the loss distribution.
6. Reporting format for results	Output presentation	• Evolution of systemic risk in Switzerland • Determinants of tail banking system returns. • Individual contribution to systemic risk in the Swiss financial system; the European financial system; and the Global financial system.

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