INTERNATIONAL MONETARY FUND

IMF Country Report No. 19/120

REPUBLIC OF POLAND

FINANCIAL SECTOR ASSESSMENT PROGRAM

May 2019

TECHNICAL NOTE—STRESS TESTING AND SYSTEMIC RISK ANALYSIS

This technical note on Stress Testing and Systemic Risk Analysis for the Republic of Poland was prepared by a staff team of the International Monetary Fund. It is based on the information available at the time it was completed in April 2019.

Copies of this report are available to the public from

International Monetary Fund • Publication Services
PO Box 92780 • Washington, D.C. 20090
Telephone: (202) 623-7430 • Fax: (202) 623-7201
E-mail: publications@imf.org Web: http://www.imf.org
Price: $18.00 per printed copy

International Monetary Fund
Washington, D.C.

INTERNATIONAL MONETARY FUND

REPUBLIC OF POLAND

FINANCIAL SECTOR ASSESSMENT PROGRAM

April 19, 2019

TECHNICAL NOTE

STRESS TESTING AND SYSTEMIC RISK ANALYSIS

Prepared By
Monetary and Capital Markets Department

This Technical Note was prepared in the context of a joint IMF-World Bank Financial Sector Assessment Program (FSAP) mission in Poland during May 2018 mission led by Michael Moore, IMF and Loic Chiquier, World Bank. The note contains the technical analysis and detailed information underpinning the FSAP assessment's findings and recommendations. Further information on the FSAP program can be found at http://www.imf.org/external/np/fsap/fssa.aspx.

CONTENTS

TABLES

ANNEXES

Glossary

AFS	Available-for-Sale
APT	Advanced Persistent Threat
BIS	Bank of International Settlements
BGF	Bank Guarantee Fund
BGK	Bank Gospodarstwa Krajowego
TCR	Total Capital Ratio
CCP	Central Counterparty
CET1	Common Equity Tier 1
CRD	Capital Requirements Directive
CRR	Capital Requirements Regulation
DDoS	Distributed Denial of Service
EBA	European Banking Authority
ECB	European Central Bank
EU	European Union
FIAT	Financial Institution Asset Tax
FAT	Financial Activities Tax
FSAP	Financial Sector Assessment Program
FX	Foreign Currency
GDP	Gross Domestic Product
GFM	Global Macrofinancial Model
GVD	Generalized Variance Decomposition
HFT	Held-for-Trading
HTM	Held-to-Maturity
IMF	International Monetary Fund
IPS	Institutional Protection Scheme
IRB	Internal Ratings-Based
ITS	Implementing Technical Standards
LCR	Liquidity Coverage Ratio
LGD	Loss Given Default
LTV	Loan-to-Value
MCM	Monetary and Capital Markets Department
MFIs	Monetary and Financial Institutions
MoF	Ministry of Finance
NBP	National Bank of Poland
NIMs	Net Interest Margins
NSFR	Net Stable Funding Ratio
NPL	Nonperforming Loan
OSIIs	Other Systemically Important Institutions
PD	Probability of Default
PFSA	Polish Financial Supervision Authority
PLN	Polish Zloty

RAM	Risk Assessment Matrix
ROAA	Return on Average Assets
ROAE	Return on Average Equity
RWA	Risk Weighted Asset
SME	Small Medium Enterprises
SNB	Swiss National Bank
STeM	Stress Testing Matrix
TD	Top-Down
VAR	Vector Autoregression
WEO	World Economic Outlook
WIBOR	Warsaw Interbank Offered Rate
YoY	Year-over-Year

EXECUTIVE SUMMARY

Poland's financial system is dominated by the banking sector, with significant state participation and foreign ownership. Commercial and cooperative banks play a leading role in financial intermediation, channeling deposits to credit to households and corporates. State-controlled and foreign-owned commercial banks account for about 60 percent of the financial sector (or 83 percent of the banking sector). While interbank and cross-sectoral exposures are relatively limited, the cooperative banks are highly interconnected with their affiliating commercial banks through the affiliating "Apex" network structure.

For the Poland FSAP, a comprehensive set of stress tests and contagion analysis were conducted to assess the resilience of the Poland's financial system. The FSAP risk analysis included solvency stress testing (scenario-based and sensitivity analysis) and liquidity stress testing of commercial and cooperative banks, as well as interbank, cross-sectoral and cross-border contagion analysis using both exposure and market data. The FSAP risk analysis also considered the second-round impact of interbank contagion on banks' solvency positions.

The banking system shows resiliency to adverse shocks in the aggregate, however, some *other systemically important institutions* (OSIIs) show weakness. In the adverse case, the solvency ratio for the system (i.e., common equity tier one (CET1)) declines from 16.2 percent to 12.9 percent of risk-weighted assets, driven by loan loss provisions, valuation losses on debt securities, and funding interest rate risks. Some of the medium-sized banks would come under pressure, with the necessary recapitalization need at around 0.5 percent of GDP. The cooperatives banking sector is exposed to credit and concentration risks, as evidenced by the simulated default of the five largest borrowers. The authorities should therefore sustain supervisory attention towards weaknesses in mediums-sized banks and OSIIs, including the affiliating banks of cooperatives networks, given their importance in the banking system.

The banks system appears resilient to short-term liquidity risks in local currency. While the adverse retail event had a limited impact, the wholesale event affected some large banks in the system. The combined extreme event compounded costs that nevertheless totaled still less than 3.6 percent of GDP. The Liquidity Coverage Ratio (LCR) by currency showed resiliency in local currency but not in foreign currency (FX). While there is uncertainty about the robustness of data provided to the FSAP team, the Net Stable Funding Ratio (NSFR) tests results appear to indicate vulnerability to more protracted events. The authorities should improve the monitoring of FX liquidity risks and ensure banks' readiness for the upcoming NSFR implementation timeframe.

Domestic and cross-border contagion risks are generally limited with some material exceptions. Interbank analyses showed that any destabilization to affiliating banks could cause severe distress to the affiliated cooperative banks. This finding strengthens the reasons for the authorities to address identified weaknesses in the affiliating banks. Moreover, banks' large holdings of sovereign bonds and the substantial presence of state-controlled banks cause a significant sovereign-bank nexus in Poland. To avoid incentives for banks to hold sovereign debt, the FSAP team recommends that the Financial Institution Asset Tax (FIAT) is redesigned on grounds of both financial stability and efficiency.

Table 1. Poland: Key Recommendations

Recommendations		Agency	Time
Risk Analysis			
1.	Address identified weakness in mediums-sized banks and OSIIs, including the affiliating banks for cooperative banks, given their systemic importance in the banking system.	PFSA	I/NT
2.	Replace the FIAT with a Financial Activities Tax (FAT), addressing both stability and efficiency concerns.[1]	MoF	I/NT
3.	Improve the enforcement of common parameters of the LCR and the monitoring of FX liquidity risk and ensure banks' readiness for the upcoming CRR II implementation timeframe.	PFSA	NT
4.	Improve data for credit risk analysis by collecting Probability of Default (PD), Loss-Given-Default (LGD) data and move towards PD, LGD-based models.	PFSA, NBP	NT
5.	Improve the collection of institution-by-institution counterparty-specific data for banks and non-banks on asset and liability-side exposures and loss-absorbing capacity to allow for improved analyses of intra-sector and cross-sectoral contagion.	PFSA, NBP	I/NT
6.	Improve the collection of Polish banks' asset- and liability-side cross-border exposures to foreign banks. Collect more granular data on banks' secured and unsecured interbank exposures.	PFSA, NBP	NT

Time Frame: C = continuous; I (immediate) = within one year; NT (near term) = 1–3 years; MT (medium term) = 3–5 years.

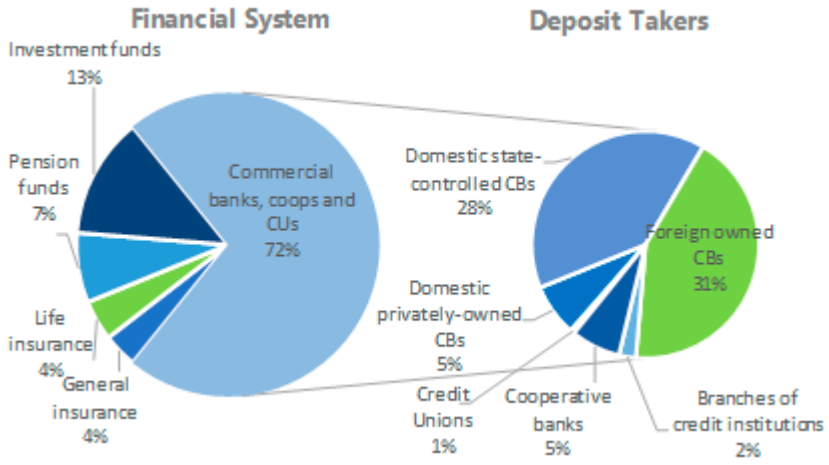
[1] The recommendation of replacing the FIAT with the FAT is consistent with the Poland Article IV Staff Reports (2016 and 2017). The rationale for introducing the FAT can be found in Box 4 of the 2016 Poland Article IV staff report and the 2010 IMF paper "A Fair and Substantial Contribution by The Financial Sector."

INTRODUCTION[1]

A. Financial System Structure and Financial Conditions

1. **Poland's financial system is largely bank-based** (Figure 1). The financial system is 125 percent of the GDP (end-2016) with the banking sector representing about three-quarters of system assets. The two largest commercial banks and the largest insurer are state-controlled through significant shareholdings, though remaining shareholdings are widely dispersed. Among the 12 domestic systemically important banks (or Other Systemically Important Institutions, OSIIs) designated by the Polish Financial Supervision Authority (PFSA) as of December 2017, seven are foreign-owned, with six of these headquartered in the European Union (EU).[2]

Figure 1. Poland: Structure of the Financial System, September 2017
(Percent of Financial System Assets)



Source: PFSA and IMF staff calculations. Note: CBs refer to commercial banks.

2. **Cooperative banks are interconnected with their affiliating commercial banks through the "Apex" network structure.** While servicing in total about one quarter of the population, with only five percent of financial system assets, cooperative banks are non-systemic. The 553 cooperatives focus on lending to agriculture (providing around half the total) and SMEs. The cooperative banks are mostly affiliated with two networks that each own an affiliating "Apex" commercial bank. The "Apex" commercial banks each account for less than 1.5 percent of banking assets but are also designated as OSIIs due to their role in providing solvency and liquidity support to network cooperative banks.

[1] The risk and vulnerability analysis was led by TengTeng Xu (IMF), who also conducted the solvency stress tests. Ivan Guerra (IMF) conducted the liquidity stress tests, and Johannes Forss Sandahl (Expert) the interconnectedness analysis. Ran Bi (IMF) conducted the background analysis on FX mortgages (Annex VI).

[2] Since August 2018, the number of OSIIs reduced from 12 to 11, with 6 foreign-owned OSIIs.

3. **Banks' financial soundness indicators are improving (Annex I), but some unresolved issues could make banks vulnerable to shocks.** Capital ratios have generally risen with the average Tier 1 ratio at 16.5 percent of risk weighted assets (RWA). Profitability has been declining (10.4 percent ROE) due to slower asset growth and the low interest rate environment but remains above EU average (6.1 percent ROE). The FIAT (0.44 percent on adjusted assets) introduced in February 2016 also impacted profitability. Nonperforming loans (6 percent of total loans) continue to decline. Nonperforming loan (NPL) risk is generally well managed, with overall coverage ratios of about 57 percent. However, the affiliating banks and some medium-sized domestic commercial banks appear to have relatively high NPL ratios and low provisioning coverage.[3] Banks are generally liquid and mostly funded by low-cost retail deposits.[4] Liquid assets, over 20 percent of the total, are mostly Polish government bonds. Some cooperative banks show liquidity shortfalls based on the reported Liquidity Coverage Ratio (LCR); however, most of those are exempted from fulfilling LCR minimum by the competent authority due to their participation in the Institutional Protection Scheme (IPS), on the basis of relevant provisions in the Capital Requirements Regulation (CRR).

4. **Triggers for increases in systemic risk in the financial sector could come from a retreat from cross-border integration and a faster than expected tightening in domestic and international financial conditions.** A retreat from cross-border integration could hurt risk sentiment and consequently investment in Poland. A resulting zloty depreciation and an increase in interest rates could impact both FX and domestic loan portfolios. Domestically, policy slippages and the weakening of key institutions combined with heightened tensions with the EU could further erode investor sentiment.

5. **Risks could be amplified through tighter sovereign- bank linkages.** The linkages between the sovereign and banks have tightened, spurred recently by the FIAT, which exempts holdings of government securities. Commercial banks' holdings of government securities have increased from around 20 percent of RWA at December 2015 to around 25 percent at December 2017. At about 50 percent of GDP, and capped at 60 percent by the constitution, the public debt to GDP ratio is moderate, implying limited sovereign risks in Poland at present. Nevertheless, sovereign exposures can mutually reinforce fiscal and financial vulnerabilities, and where the securities are of long duration, interest rate rises may further amplify the shocks.

B. Risk Analysis in the Poland FSAP

6. **The risk and vulnerability analysis under the Poland FSAP provides an in-depth assessment of the financial system's resilience to adverse shocks and contagion.** The FSAP risk analysis included Top-Down (TD) solvency and liquidity stress testing of the banking sector, as well as domestic and cross-border contagion analysis. The stress tests and single factor sensitivity

[3] NPLs refer to impaired loans according to MSR 39 for banks under the IAS/IFRS accounting standards or domestic accounting regulations for other banks (mostly cooperative banks). As in the NBP FSR and IMF Financial Soundness Indicators, impaired loans are gross of collateral (and reserves/impairment provisions).

[4] Only the largest banks have access to global capital markets, mostly through their mortgage bank subsidiaries, given regulatory requirements for collateralized bond issuance and foreign currency portfolio funding needs.

analysis covered commercial and cooperative banks, accounting for 92 percent of banking sector assets. The scenario-based solvency stress tests assessed the impact of a combination of severe but plausible external and domestic shocks on the banking system and considered credit, market (equity, exchange rate, and interest rate risks), sovereign (repricing and spread risks), and funding interest rate risks. The liquidity stress tests assessed the resilience of the banking system based on the LCR and the estimated net stable funding ratio (NSFR), both at the aggregate level and by currency. The contagion analysis examined interbank, cross-sectoral, and cross-border interconnectedness based on both exposure and market data and considered channels of bank-sovereign nexus. Finally, the risk analysis integrated the results from the solvency stress test and the contagion analysis, where failed banks from the solvency stress test were used as initial triggers of the interbank network analysis to capture the second-round impact of interbank contagion on bank capital.

7. **While stress tests and contagion analysis are powerful tools to analyze vulnerabilities in a financial system, results should be interpreted with care.** FSAP stress tests are macroprudential in nature and are intended to help identify key sources of systemic risk in the financial sector and policies that enhance the resilience to shocks and contagion. Adverse stress testing scenarios should not be interpreted as macroeconomic "forecasts," as they capture a combination of external and domestic shocks that are considered "tail" events based on historical distributions. More generally, it should be noted that the nature of crises may result in unanticipated shocks and relationships between key variables, departing from historical experience. Furthermore, the results of stress testing and contagion analysis are dependent on the availability and quality of data provided to the FSAP team, which could be hindered in some cases.

8. **This FSAP risk analysis benefited from close collaborations with the National Bank of Poland (NBP).** In addition to the provision of confidential supervisory data, the NBP carried out sensitivity analysis (solvency) and liquidity stress tests (LCR) for cooperative banks based on agreed scenarios, and interbank network simulations using confidential counter-party exposure data. The constructive discussions with NBP staff on scenarios, methodologies, and results were extremely beneficial for the FSAP risk analysis.

BANKING SECTOR SOLVENCY STRESS TESTS

A. Scope and Coverage

9. **The solvency stress test and sensitivity analysis cover commercial banks and cooperative banks, accounting for 92 percent of banking sector assets.** The scenario-based macro stress tests cover 34 commercial banks, accounting for about 85 percent of total banking

sector assets.[5] Among the 34 commercial banks, about 52.7 percent is foreign-owned, 38.3 percent is state-owned, with the remaining banks privately-owned (domestic). Sensitivity analysis was also conducted to assess the resilience of commercial banks to concentration risks, additional foreign exchange risks, and interest rate risks. Although cooperative banks are not systemic in terms of assets, their concentrated exposures to the local economy justifies the diagnostic exercise through a set of sensitivity analyses, covering concentration, credit and interest rate risks.[6]

B. Macroeconomic Risks and Scenarios

10. **The solvency stress test evaluates the stability of the Polish banking system against a baseline macroeconomic scenario and an extreme but plausible adverse scenario.** The baseline scenario is based on the December 2017 World Economic Outlook (WEO) projections by the Article IV team. The adverse scenario reflects external and domestic risk factors identified in the Risk Assessment Matrix (RAM) for Poland (Annex II). The adverse scenario is designed using the IMF's Global Macrofinancial Model (GFM) model.[7]

- **The baseline scenario** reflects a strong cyclical upswing in GDP growth, with inflation broadly at NBP's target. The baseline projection is supported by an expected acceleration in the EU funds' absorption and strong private consumption, with real GDP growth projected to be 3.9 percent in 2018 before moderating to 3 percent in 2020. Inflation is expected to remain at around the target of 2.5 percent throughout the stress testing horizon (2018–2020), assuming prompt monetary policy response to domestic inflationary pressures due to strong domestic demand.

- **The adverse scenario** for Poland features external financial market stress and growth slowdown and captures the macrofinancial impact of domestic policy uncertainty. The narrative assumes financial market stress and a tightening in financial conditions in systemic economies, heightened uncertainty and confidence losses in Europe and the United States, as well as protectionist measures in Europe and the United States that ultimately lead to growth slowdown, given constrained macroeconomic policy responses. It also assumes domestic policy slippages, weakening in key institutions and heightened uncertainty weighing on confidence and consequently consumption, investment, and output (Annex II. RAM).

11. **The adverse scenario leads to sizable cumulative GDP losses relative to the baseline.** The decline in real GDP level in the adverse scenario is comparable to the experience of the

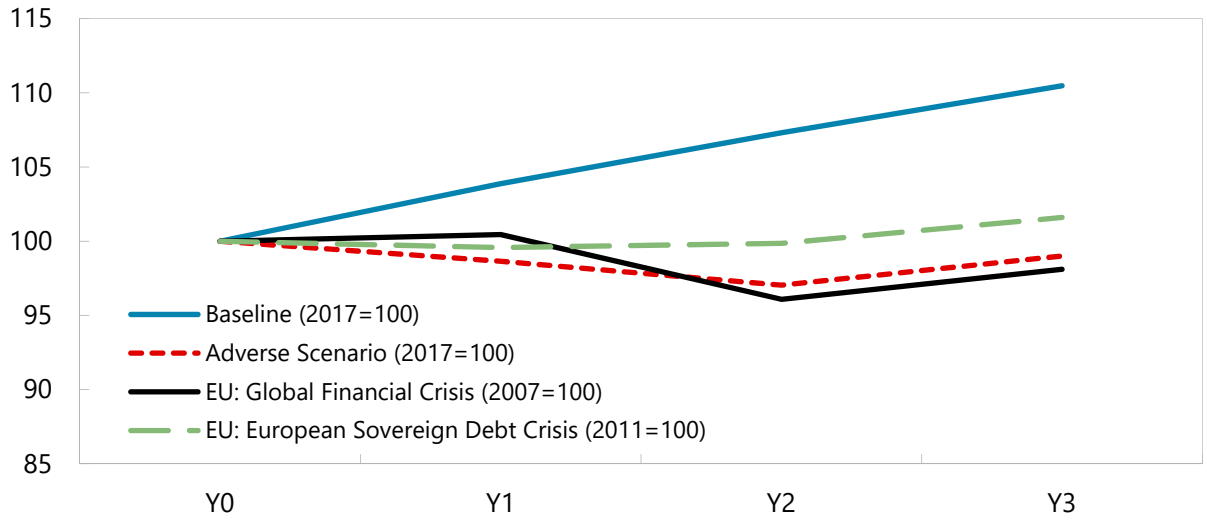
[5] The state-owned development bank BGK is explicitly exempted from CRD/CRR requirements and therefore not included in the stress testing sample.

[6] See Annex IX for detailed methodology on the solvency stress test.

[7] Vitek, F. (2015), Macrofinancial analysis in the world economy: A panel dynamic stochastic general equilibrium approach, *International Monetary Fund Working Paper*, 227. This estimated panel dynamic stochastic general equilibrium model features a range of nominal and real rigidities, extensive macrofinancial linkages with both bank and capital market based financial intermediation, and diverse spillover transmission channels.

European Union during the Global Financial Crisis (Figure 2), with output at about 11.5 percentage points lower than the baseline by 2020. Unemployment rises due to the worsening macroeconomic environment, whereas long term government bond yields rise by 280 basis points compared to the baseline at their peak due to a potential rating downgrade (Table 2). The projections of key macroeconomic variables, including real GDP growth, inflation, short-term money market rate, long-term government bond yield, unemployment rate, and the Zloty/Swiss Franc exchange rate are shown in Figure 3.

Figure 2. Poland: Scenario Severity from a Historical Perspective



Sources: IMF's WEO database; IMF staff calculations.
Note: The adverse scenario reflects external and domestic risk factors identified in the Risk Assessment Matrix (RAM) for Poland. The severity of the adverse scenario was benchmarked using neighboring countries' (European Union) crisis episodes, since Poland has not experienced a severe contraction since 1990. The baseline scenario is based on the December 2017 World Economic Outlook (WEO) projections.

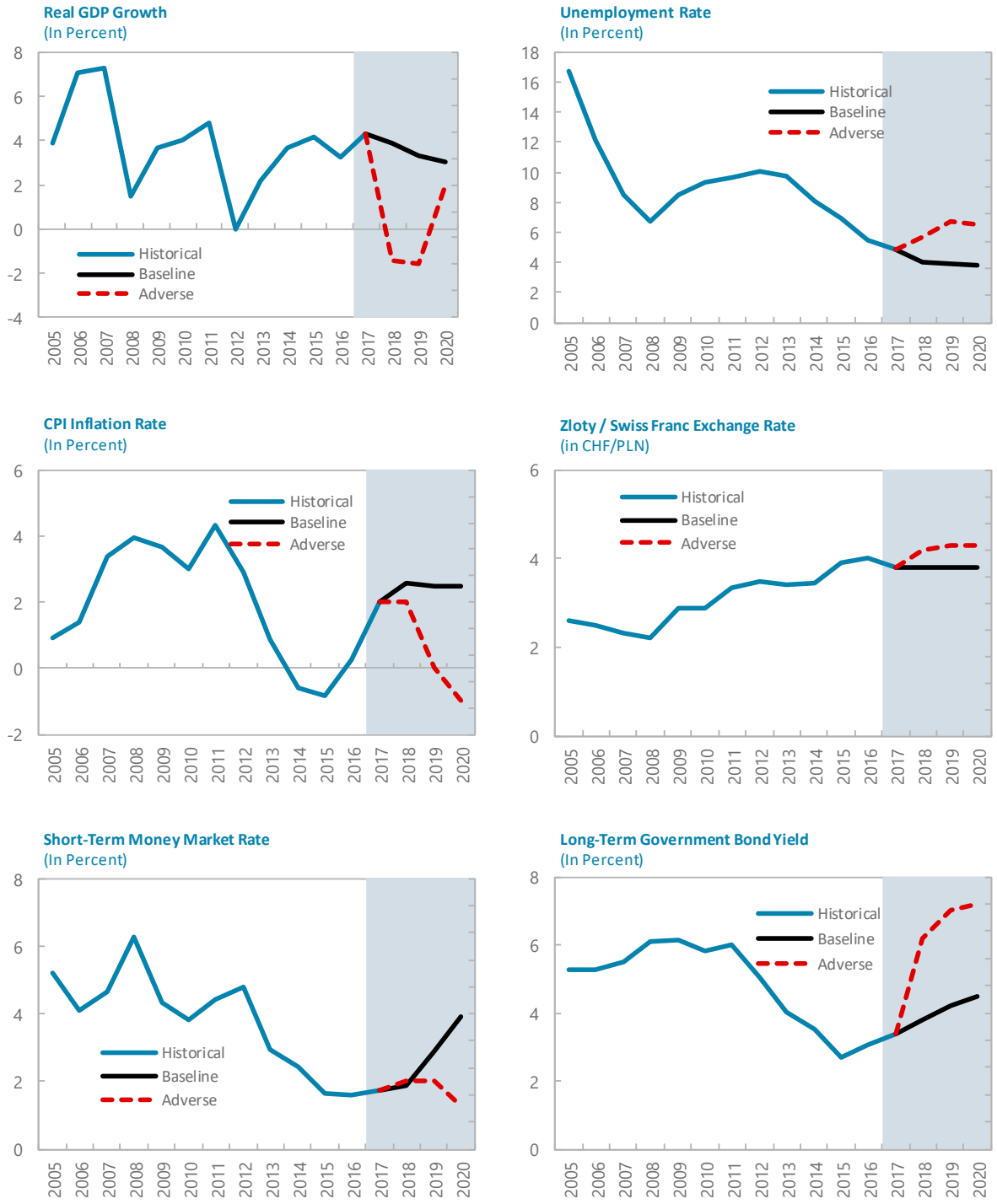
Table 2. Poland: Macroeconomic Scenarios for Stress Tests

In percent (unless otherwise specified)

	Adverse Scenario			Baseline Scenario		
	2018	2019	2020	2018	2019	2020
Real GDP (2017=100)	98.6	97.0	99.0	103.9	107.3	110.5
Real GDP growth	-1.4	-1.6	2.0	3.9	3.3	3.0
Inflation (CPI)	2.0	0.0	-1.0	2.6	2.5	2.5
Monetary Policy rate	1.0	0.8	0.1	1.9	2.9	3.9
Short-term money market rate	2.0	2.0	1.3	1.9	2.9	3.9
Long term government bond yield	6.2	7.0	7.2	3.8	4.2	4.5
Unemployment rate	5.7	6.7	6.5	4.0	3.9	3.8
Exchange rate (Zloty/SF)	4.2	4.3	4.3	3.8	3.8	3.8
Nominal GDP growth	0.6	-1.6	1.1	5.9	5.8	5.3

Source: IMF staff calculations.
Note: The adverse scenario reflects external and domestic risk factors identified in the Risk Assessment Matrix (RAM) for Poland. The severity of the adverse scenario was benchmarked using neighboring countries' (European Union) crisis episodes, since Poland has not experienced a severe contraction since 1990. The baseline scenario is based on the December 2017 World Economic Outlook (WEO) projections.

Figure 3. Poland: Macroeconomic Baseline and Adverse Scenarios



Source: Haver Analytics, IMF Staff Estimates.

C. Approach for Scenario-Based Solvency Stress Test

12. **The top-down solvency stress test accounted for a comprehensive set of risks.** The FSAP team used IMF's internally developed solvency stress testing framework, to capture credit risk, sovereign risk (repricing and spread risks), market risk (including interest rate, foreign exchange, and equity risks), funding and interest rate risk on the banking book.

Balance Sheet, Income Projections, and Hurdle Rates

13. **The balance sheet growth followed a quasi-static allocation assumption.** Asset allocation and the composition of funding sources remained the same. Banks' balance sheet size was projected to grow in line with the baseline and adverse macroeconomic scenarios (nominal GDP paths), with a cap on deleveraging in the adverse scenario. In addition, the balance sheet growth accounted for losses from the previous period and exchange rate adjustments.

14. **The projection of RWAs accounted for balance sheet growth, impairments and changes in the exchange rate.** RWAs changed due to balance sheet growth, additional risk weights from newly defaulted loans and exchange rate movements, accounting for new provisions due to losses, and differentiated risk weights for domestic and foreign currency mortgage portfolios.

15. **Income (profit or loss) was projected based on all risk factors considered in the stress test.** Specifically, total comprehensive income reflected net interest income decomposed into base and interest rate risk components, non-interest income and expense, trading income and losses, other comprehensive income, loss provisions, capturing credit, market, sovereign and funding risks, and interest risks on the banking book. The income tax and the FIAT were also reflected in the profit and loss calculations.[8] Liability interest rate (funding rate) shocks underlying the interest rate risk analysis were estimated based on satellite models. NPL ratios were projected using satellite models for credit exposures by sectors: household mortgages, consumer credit (loans to households other than mortgages), and corporate credit, based on various macro and financial factors.

16. **Banks were assumed to distribute their after-tax profits following the regulations on dividend policy.** Banks were not allowed to distribute dividends if the total comprehensive income (net profit and other comprehensive income) was below zero, or if they were not in compliance with the supervisory capital requirements, or in restructuring. In addition, banks could only distribute dividends if their leverage ratios were above 5 percent, and the Tier 1 and total capital ratios were 150 basis points above the regulatory requirements. Furthermore, a tiered dividend distribution policy was applied accounting for banks' FX exposures, following Polish Financial Supervisory Authority (PFSA) regulations.

[8] Starting in February 2016, the FIAT was levied on the total value of assets (less PLN 4 billion, own funds, and purchased sovereign debt) at a monthly rate of 0.0366 percent (or 0.44 percent per year). State-owned banks (relevant for BGK with legal status of state enterprise) and banks under recovery proceedings, in receivership, in liquidation, or those who filed for bankruptcy are excluded from the tax. In addition, affiliating banks pay practically no asset tax due to further exclusions of their exposure to cooperative banks.

17. **Hurdle rates were based on actual supervisory requirements during the ST horizon (2018–2020).** The stress testing results were benchmarked against two sets of hurdle rates: 1) capital ratio standards including both Pillar I and Pillar II requirements, similar to the one used in the Financial Stability Review of the NBP; and 2) Pillar I and Pillar II requirements and OSII buffer (Table 3), similar to that used in other European FSAPs, including Germany, Spain, and Romania. In addition to the capital ratios, the stress tests considered the leverage ratio as an additional metric.

Table 3. Poland: Hurdle Rates for Solvency Stress Tests

	Hurdle rate excluding OSII Buffers		Hurdle rate including OSII Buffers		
%	Pillar I	Pillar II	Pillar I	Pillar II	OSII
Total capital ratio	8	0 to 5.81	8	0 to 5.81	0 to 0.75
Tier 1 capital ratio	6	0 to 4.36	6	0 to 4.36	0 to 0.75
CET1 capital ratio	4.5	0 to 3.25	4.5	0 to 3.25	0 to 0.75

Note: Pillar II buffers are regulatory buffers designed to mitigate risks in the FX mortgage portfolios.

Credit Risk Analysis and Estimation

18. **Credit risk in the banking book represented the most important risk factor for the banking system (Figure 4).** Loans represented about three-quarters of total assets of commercial banks (74 percent),[9] followed by debt securities (21 percent). The credit gap remains negative, despite a recent pick-up in credit growth.[10] By sector, mortgage loans accounted for about 37 percent of the total loan portfolios, followed by corporate and consumer loans. By currency, more than three-quarters of the loans were in domestic currency (78 percent), with the remaining loans issued in foreign currency. Among the foreign-currency denominated loans (22 percent), the majority concentrated in the mortgage loan segment, dominated in Swiss Francs.[11] Finally, credit risk accounts for 89 percent of RWAs, followed by market risk (1 percent) and operational risk (8 percent).[12]

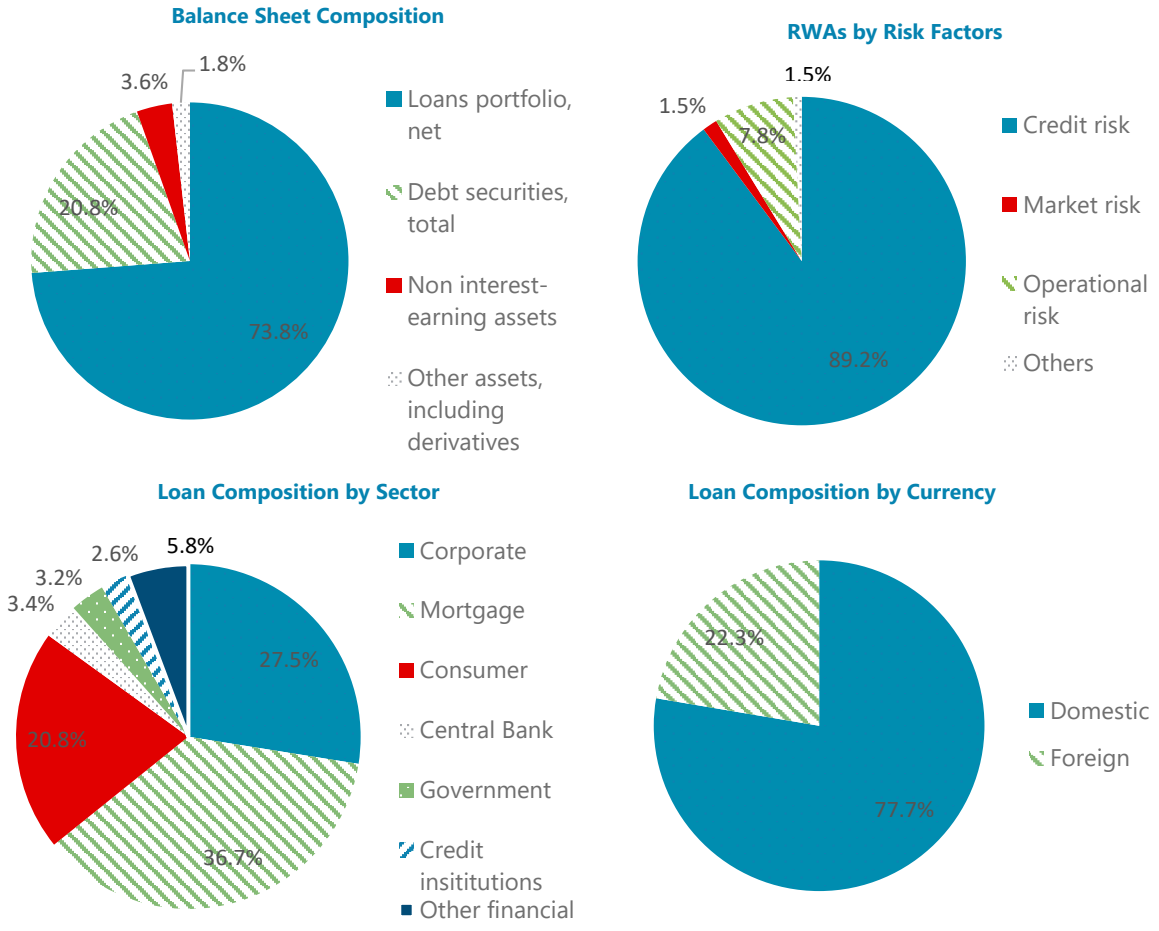
[9] The assets of the state-owned development bank BGK is excluded in the total assets of commercial banks.

[10] According to regression analysis conducted by the Article IV team, the credit-to-GDP gap in Poland remains negative.

[11] More recently, banks are required to provide mortgage loans only in the currency (or indexed to the currency), in which the borrowers receive the majority of income or hold the majority of financial means or other assets. The combination of a relatively stable zloty, higher household income, and amortization rates of around 8 percent per year has reduced the risks in FX portfolios.

[12] One of the components of operational risk is related to cyber risks. See Annex III for details on the monitoring of cyber risks in Poland.

Figure 4. Poland: Balance Sheet, RWAs, and Credit Compositions



Note: The information on balance sheet, RWAs and credit compositions is based on data for commercial banks (the state-owned development bank, BGK, is excluded). Date: 2017.
Source: NBP, PFSA and IMF Staff Calculations.

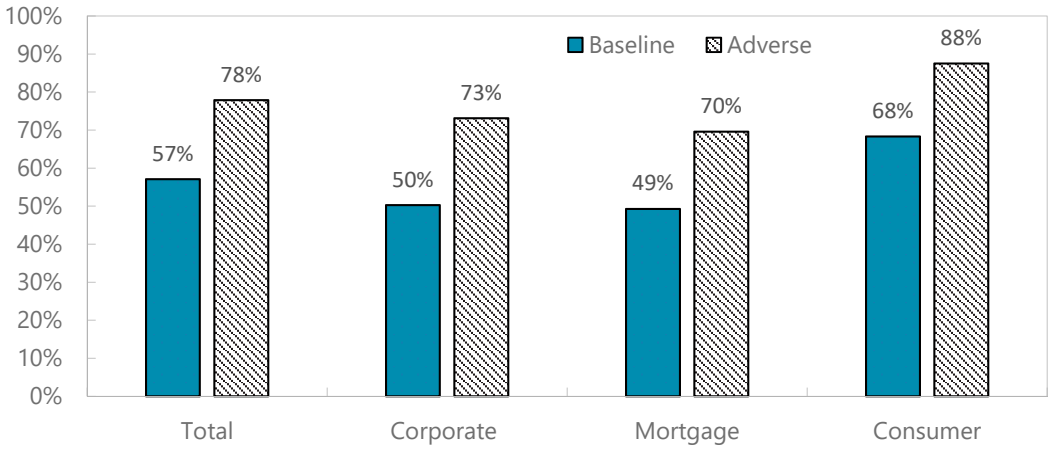
19. **The stress test made use of satellite models to project credit losses by sector.** Given that the majority of banks operate under Basel II standardized approach, NPL ratios were projected using panel regression techniques for three exposure classes: household mortgages, consumer credit (loans to households other than mortgages), and corporate credit. Supervisory data provided by the NBP were used to build credit risk satellite models.[13] Provisioning ratios were computed based on historical information on provisions by the three types of loans (Figure 5). To the extent possible, the treatment was similar to other European FSAPs.

[13] The majority of banks were regulated under the standardized approach (more than 90 percent of credit risk RWAs). Thirty-one out of the 34 banks in the stress testing sample applied exclusively the standardized approach, and 3 remaining banks applied the IRB approach only partially. Given that the data on the breakdown between

(continued)

Figure 5. Poland: Provisioning Ratio by Exposure

(Based on Historical Data)



Note: Baseline and adverse provisioning ratios were calcuated using the weighted average (by assets) of the average and maximum historical provisioning ratios from 2008 to 2017, respectively.
Source: IMF Staff Calculations.

20. **Macrofinancial conditions including GDP growth, the unemployment rate, interest rates, and exchange rates were important drivers of credit risks.** The satellite model for corporate exposure showed that a decline in real GDP growth and equity prices and a rise in the unemployment rate could lead to an increase in the corporate sector default rate. Mortgage default rates were sensitive to the unemployment rate, house price changes, and movements in the Swiss Franc/Zloty exchange rate. Exchange rate risks associated with Swiss Franc appreciation were in part captured by the satellite model for mortgage loans. Consumer loan default rates were associated with wage growth and interest rates. The detailed estimation results from the satellite models could be found in Annex IV.

Market Risk Analysis

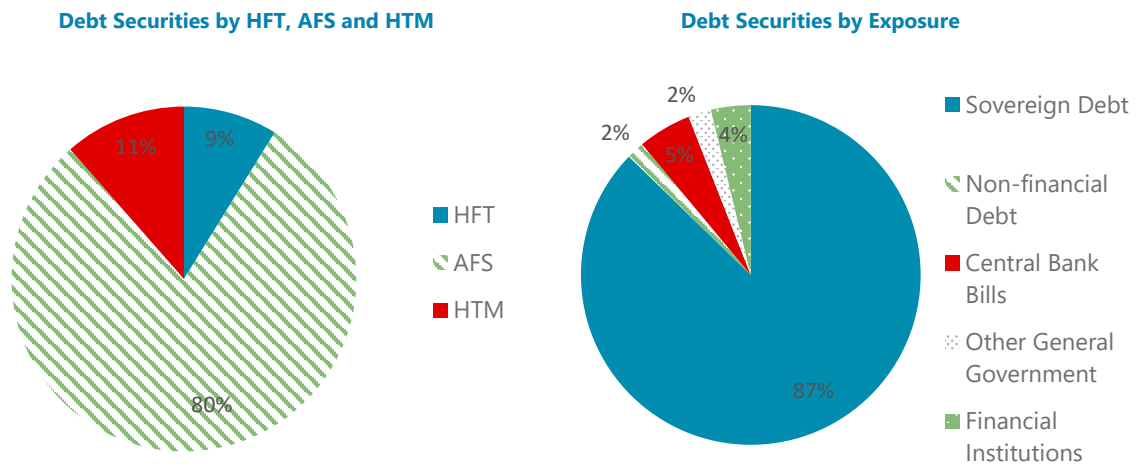
21. **Market risk analysis captured the valuation risks of bonds due to changes in risk-free interest rates and credit spreads, foreign exchange risks and equity risks from net open positions.** The analysis covered the impact of interest rate risks and spread risks on sovereign and corporate debt securities in the held-for-trading (HFT) book and the available for sale (AFS) book. Losses from HFT portfolios impacted the regulatory capital through net profits, while those for AFS portfolios affected capital through other comprehensive income. The impact arising from foreign exchange rate risks and equity risks from net open positions influenced net profits directly.

22. **Debt securities were mainly held in the available for sale (AFS) book, dominated by sovereign exposures (Figure 6).** In commercial banks, sovereign debt accounted for 87 percent of

standardized and IRB portfolios, and on PDs and LGDS were not available, the credit risk analysis focused on the use of NPL ratios, which were provided by the NBP.

the debt securities portfolio, with the majority in domestic government bonds.[14] Central Bank bills accounted for another 5 percent of the debt portfolios. About 80 percent of the debt securities were held in the AFS book, with the remaining in the hold-to-maturity (11 percent) and held-for-trading (9 percent) books. The average duration of the debt portfolio was relatively short at 1.2 years, with sizable variations across banks.

Figure 6. Poland: Debt Securities



Source: NBP and IMF Staff Calculations.
Note: The information on debt securities is based on data for commercial banks (the state-owned development bank, BGK, is excluded). Date: 2017.

23. **Market valuation losses from interest rate risks and spread risks in the debt portfolios were derived using a modified duration approach.** First, the analysis captured the re-pricing losses in the HFT and the AFS books due to shocks to the risk-free interest rates, which was measured by the policy rate in Poland. Second, it accounted for the valuation impact in the HFT and AFS books due to shocks to the spread of debt securities. For sovereign debt securities, the spread was constructed as the difference between the 10-year Polish government bond yield and the 10-year German government bond yield.[15] The corporate bond yield was computed based on the average bond yield for nonfinancial corporate debt available from Bloomberg.

24. **The direct impact of exchange rate risks and equity risks were analyzed through banks' net open positions in foreign currencies and equities.** For exchange rate, net open positions captured all foreign currency positions in the banking and trading book, mainly in Swiss Francs, the US dollar, and the Euro. The open position for equities reflected the equity holdings of

[14] The share of domestic bond holdings was estimated by the NBP to be 94 percent of total bond holdings. The state-owned development bank BGK is excluded from the sample.

[15] Sovereign risks were captured through two channels in the scenario-based solvency stress test: 1) repricing risks for AFS and HFT securities due to shocks to the risk-free interest rate; 2) spread risks for AFS and HFT securities. In addition, we consider a conservative assumption of applying haircuts to HTM securities as a robustness check.

banks. Changes in exchange rate and equity prices were then applied to these open positions to evaluate the gains or losses due to asset price movements.[16]

Interest Rate and Funding Risks in the Banking Book

25. **Interest rate risks in the banking book were assessed using maturity gap analysis, accounting for liability (funding) interest rate shocks.** The impact of funding interest rate shocks on net interest income was estimated by measuring the gap between interest sensitive assets and liabilities in several time-to-repricing buckets, from less than one months to the end of the three-year stress testing horizon.

26. **Liability interest rates were estimated using satellite models with dynamic panel regression techniques.** The effective interest rates on liabilities, which reflected the funding costs for banks, were sensitive to the level of the 3-month Warsaw Interbank Offered Rate (WIBOR) and the 10-year government bond yields. Under the adverse scenario, the relationship between the change in funding and lending rates were estimated using quantile regressions. The imperfect pass-through of changes in funding rates to lending rates implies a tightening in interest rate margins for banks in the adverse scenario. Detailed estimations on funding rates could be found in Annex V.

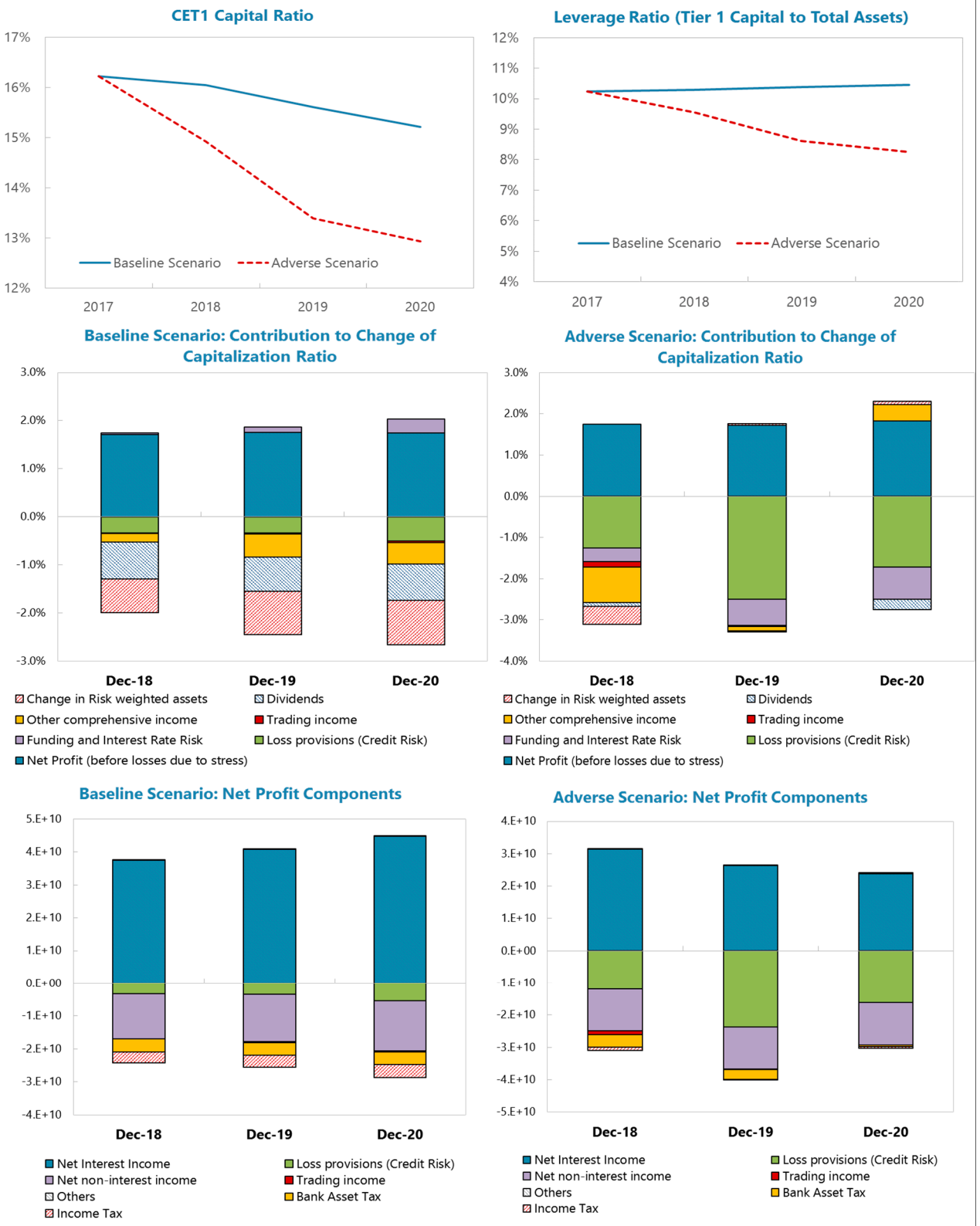
D. Results from Scenario-Based Solvency Stress Test

System-Wide Solvency Stress Test Results

27. **The scenario-based stress test suggests that the banking system is resilient under the baseline scenario (Figure 7).** The aggregate CET1 ratio stabilizes at around 15.2 percent, with the leverage ratio (Tier 1 to total assets ratio) remaining at around 10 percent for the group of 34 commercial banks. The slight decline in capital ratios under the baseline scenario was in part due to a rise in risk weighted assets and valuation losses in the AFS portfolio due to a rise in interest rate under the baseline scenario.

[16] Exchange rate risks were captured through two channels in the scenario-based solvency stress testing: 1) direct exchange rate impact on banks' net open positions in FX; 2) indirect exchange impact (Swiss Franc appreciation) on the credit risk for mortgage portfolios through satellite models.

Figure 7. Poland: Solvency Stress Testing Results



Source: IMF staff calculations.

28. **Under the adverse scenario, some commercial banks could not meet the regulatory minimum capital ratios, with the necessary recapitalization manageable (Figure 7).** The CET1 ratio declines from 16.2 percent to 12.9 percent, and 9 out of 34 banks could not meet the regulatory minimum for one of the three capital ratios (total capital, Tier 1 capital or CET1 capital ratios).[17] The leverage ratio declines from 10.2 percent to 8.3 percent for the group of 34 commercial banks, with 5 banks below the 3 percent level. The asset share of undercapitalized banks is 20 percent of the commercial banking system, with the necessary recapitalization at 0.5 percent of GDP.

29. **The main contributing factors to the decline in capital ratios under the adverse scenario are credit risk, funding interest rate risks and valuation risks on bond portfolios (Figure 7).[18]**

- *Credit risk* is the most significant driver for overall losses in the system, reflecting the dominance of the loan book on bank balance sheet (three-quarters of assets, see Figure 4), and accounting for 550 basis point decline in capital over the 3-year stress testing horizon. For corporate loans, credit losses were driven by a decline in GDP growth and equity prices, and a rise in unemployment. For mortgage loans, a rise in the unemployment rate, a decline in house prices and a depreciation of the Zloty/Swiss Franc exchange rate contributed to credit losses. Finally, a decline in wage growth and a rise in interest rates are important drivers for losses in consumer loans.

- *Funding and interest rate risks* contributed to the decline in capital by about 170 basis point in three years. Funding shocks triggered by a rise in the 3-month WIBOR rate and the long-term government bond yield led to a decline in the net interest rate margins. Margins were further compressed due to the formation of new NPLs that did not generate interest income in the adverse scenario.

- *Valuation losses* on debt portfolios led to a decline in capital by 90 basis point in the first year (through other comprehensive income). The large share of sovereign debt (most accounted for as AFS book, see Figure 6) was stressed in the adverse scenario due to a rise of sovereign bond spread of 280 basis points at its peak.[19]

[17] The stress testing results were benchmarked against two sets of hurdle rates (Table 3). Given the findings were very similar for the number of failed banks and the capital shortfall, we refer to the first hurdle rate (Pillar I + Pillar II requirements) for ease of comparison with the NBP stress tests.

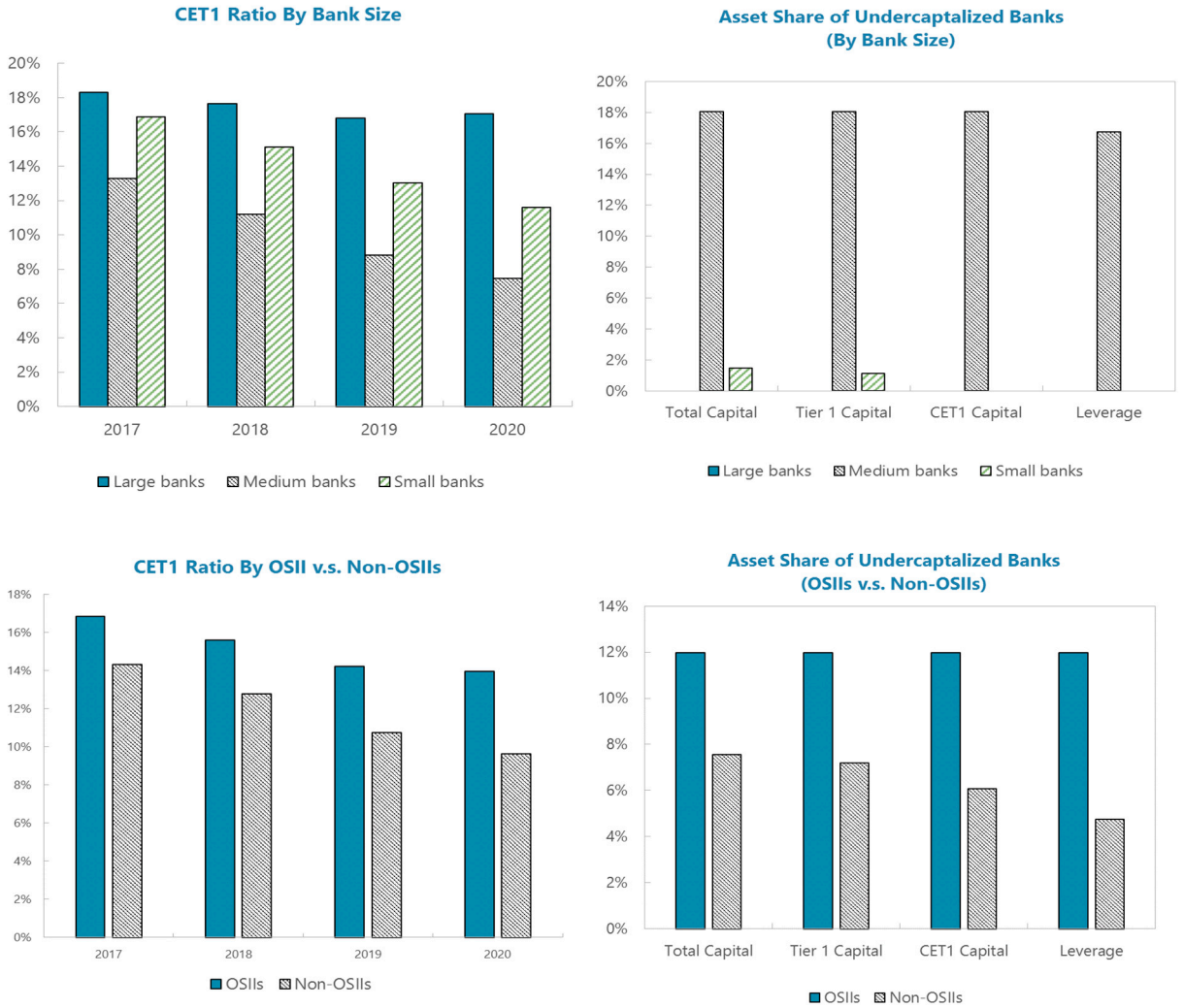
[18] The capital accumulation through net profits was more than offset by credit, funding and valuation risks under the adverse scenario.

[19] Valuation losses were applied to both HFT and AFS portfolios using a modified duration approach in the main stress testing scenarios. As a robustness check, we also considered a more conservative assumption where haircuts were applied to the HTM portfolios (11 percent of debt security holdings). The overall impact on the system is limited with a further decline of capital ratios by 0.2 percentage points.

Solvency Stress Test Results by Type of Banks

30. **By bank size, medium-sized banks are found to be the most vulnerable segment of the banking system (Figure 8), in part due to their weaker starting positions.** The CET1 ratio for medium-sized banks declined from 13 percent to 7 percent. Six out of fourteen medium-sized banks could not meet the regulatory minimum capital requirement, accounting for 18 percent of commercial bank assets.

Figure 8. Poland: Solvency Stress Testing Results by Type of Banks
(Adverse Scenario)



Source: IMF staff calculations.

31. **While the capital ratios for OSIIs are generally higher compared with non-systemic banks, four OSIIs are found to be relatively weak.** The CET1 ratio for OSIIs declined from 17 percent to 14 percent (Figure 8), with four OSIIs not meeting the regulatory capital requirements and the leverage ratio. The asset share of under-capitalized OSIIs accounted for about 12 percent of commercial banks assets.

Integrated Solvency and Interbank Contagion Results

32. **The solvency stress test results were integrated with the interbank analysis to capture the second-round contagion impact from counterparty exposures.** The integration of solvency stress tests and interbank contagion analysis was conducted in collaboration with the NBP.[20] Two sets of simulations were considered using confidential interbank counterparty information. In the first simulation, the triggering banks for interbank contagion were those with a Tier 1 capital ratio below 6 percent (after solvency stress tests), with a threshold of 6 percent for determining secondary failures. In the second simulation, a threshold of 3.5 percent was used for triggering banks and secondary failures.

33. **The second-round impact from interbank contagion due to the initial failure in the solvency stress test was quite limited.** In both simulations, the second-round impact from interbank contagion would reduce the system-wide Tier 1 capital ratio by 0.1 percentage points to 12.8 percent. For most commercial banks, the impact from interbank contagion was contained with limited impact on capital ratios, except one small bank with sizable interbank exposures.

E. Sensitivity Analysis

34. **Sensitivity stress tests were carried out to assess the vulnerability of the banking system to single factor shocks.** The FSAP team conducted sensitivity analysis for commercial banks to evaluate the effects of additional exchange rate shocks, interest rate shocks and counterparty risk shocks. The NBP conducted sensitivity analysis for cooperative banks to capture the impact of counterparty risk shocks, credit shocks and interest rate shocks.

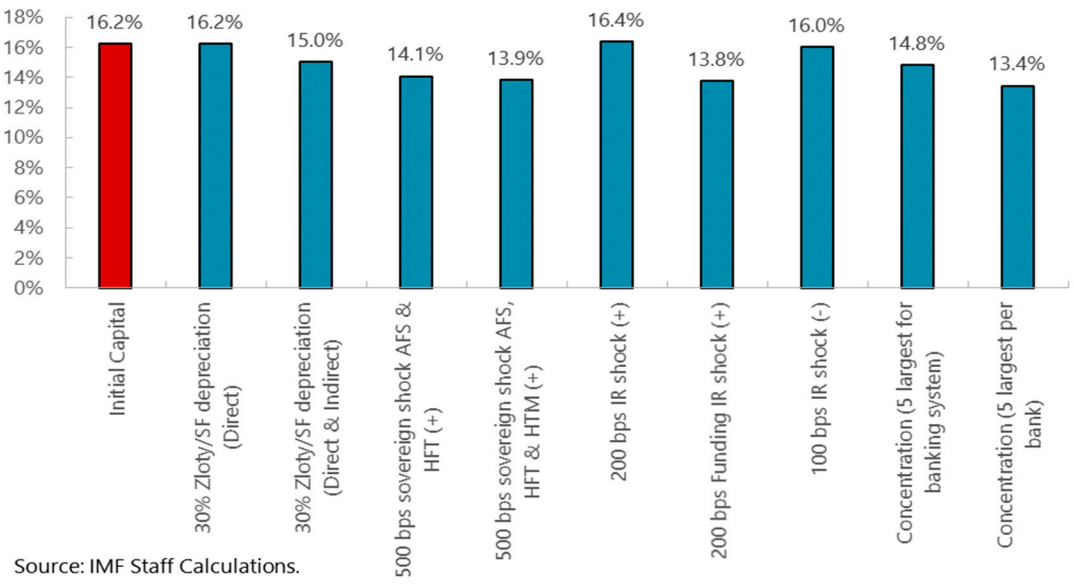
Commercial Banks

35. **The sensitivity analysis for commercial banks complemented the scenario-based solvency stress testing and assessed exchange rate, interest rate and concentration risks (Figure 9).** The exchange rate shock captured a 30 percent depreciation of the Zloty against the Swiss Franc to assess the vulnerability of the FX mortgage portfolio under extreme stress. The interest rate shocks included an upward shift in interest rate and funding rates by 200 basis points (bps), a downward shift in interest rate by 100 bps, and a 500 bps increase the government bond yield. Finally, the counterparty risk shock (concentration risk) assessed the impact of the

[20] The NBP carried out interbank contagion analysis due to the confidentiality of counterparty exposure data. For details on contagion analysis, see Page 36.

simultaneous default of the five largest non-financial borrowers in the banking system and for each bank.[21]

Figure 9. Poland: Results from Single Factor Sensitivity Analysis



- *Exchange rate shock*: A 30 percent depreciation of the Zloty against the Swiss Franc was applied to both the net open positions (direct) and the mortgage loan portfolios through the satellite model for NPL ratios (indirect impact). The Tier 1 capital ratio declined by 120 bps in the combined shocks, with all banks meeting their Tier 1 capital ratio.[22]

- *Interest rate shocks:* A parallel upward (200 bps) and downward (100 bps) shift in interest rates would have a limited impact on the Tier 1 capital ratio. A 200 bps increase in funding shock and

[21] As in the scenario-based stress test, the results from the sensitivity analysis were benchmarked against two sets of hurdle rates (Table 3). Given the findings were very similar for the number of failed banks and the capital shortfall, we refer to the first hurdle rate (Pillar I + Pillar II requirements) for ease of comparison with the NBP stress tests.

[22] The impact of the exchange rate shocks appears contained for several reasons. First, mortgage loans in general have much lower NPLs than other types of loans. Furthermore, FX-denominated mortgages have higher quality than zloty-denominated ones, as borrowers of FX mortgages tend to be higher income households. The NPL ratios of FX mortgages have consistently been lower than zloty-denominated mortgages until recently, due to the faster amortization of FX loans. Second, both banks and borrowers exposed to FX mortgages have been building buffers due to the tightening in prudential regulations since 2006. While the impact of exchange rate shocks appears limited, legislative proposals on FX mortgages may exacerbate pressure on bank profitability and capital. See Annex VI for details.

a 500 bps rise in sovereign bond yield (conservative assumption applied to all HFT, AFS, and HTM portfolios) could lead to the failure of one bank.[23]

- *Concentration risk shocks*: the simultaneous default of the five largest borrowers for each bank would have a sizable impact on the banking system, leading to a decline in Tier 1 ratio by 2.8 percentage point and the failure of eight banks.

Cooperative Banks

36. **Sensitivity analysis for cooperative banks assessed their resilience to credit, interest rate and concentration risks.** The sensitivity analysis for cooperative banks were conducted by the NBP, using single factor shocks agreed with the FSAP team. The counterparty/concentration risk shocks captured the simultaneous default of the five largest non-financial borrowers for each bank, and for the cooperative bank sector. Credit risk shocks included 1) an increase in the coverage of impaired loans of cooperative banks to the same level as commercial banks; and 2) a 50 percent impairment on a given percentage of performing loans to the non-financial sector. The interest rate shocks included an upward shift by 200 basis points, a downward shift by 100 basis points, and a 300 basis points parallel widening of the government bond yield.

37. **The cooperative sector is generally resilient to interest rate risks, although there is some evidence of credit and concentration risks.** The interest rate shocks considered have a limited impact on capital ratios. On credit risks, an increase in the provisioning coverage ratio of cooperative banks to the same level as commercial banks has a limited impact, but a sharp deterioration in the quality of 10 percent of loans (from performing to nonperforming) could result in a breach of minimum capital ratios for 30 percent of the cooperative banking sector. On concentration risk, the simultaneous default of the 5 largest borrowers for each cooperative bank could have a sizable impact, leading to a breach of minimum capital ratios for 61 percent of the cooperative banking sector (5 percent of the total banking system assets).[24]

F. Regression Analysis on Bank Profitability

38. **While Polish banks are generally more profitable compared with many other European banks, the return on equity remains slightly below the cost of equity.** The return on equity for the banking system is 10.4 percent compared with the EU average of 6.1 percent. However, the cost of equity for Polish banks quoted in the Warsaw Stock Exchange is estimated to be around 11 percent, slightly above the return for banks.[25]

[23] Two sovereign bond yield simulations were conducted: 1) a 500 bps rise in sovereign bond yield to HFT and AFS portfolios according to valuation standards (no bank failure in this simulation); and 2) a 500 bps rise in sovereign bond yield to HFT, AFS, and HTM portfolios, which is a conservative assumption as HTM portfolios are not required to be marked-to-market according to accounting standards.

[24] Cooperative banks tend to be smaller than commercial banks, with a less diversified client base.

[25] The NBP's Financial Stability Report (Dec 2017), (Fig 2.52, page 81) suggests a cost of equity of around 11 percent.

39. **The regression analysis on bank profitability examined the determinants of profitability in Poland, accounting for cyclical and structural factors.** The panel regression analysis controls for bank characteristics, business models, industry structures, macroeconomics and cyclical factors and monetary policy (Annex VII). Regression-based profitability analysis complemented the solvency stress tests that examined the composition of profitability through bank balance sheets, by considering additional cyclical and structural macrofinancial factors. The dependent variables were headline profitability measures including ROAE and ROAA, and the estimation sample covers the 34 commercial banks that were included in the solvency stress tests.[26]

40. **Regression results suggest that Polish banks' profitability was driven by a combination of structural and cyclical factors, including efficiency and interest rates.** As expected, the cost to income ratio was found to be negatively related to profitability, with less efficient banks under profitability pressures. Excess capacity measured by the number of bank branches per capita is negatively associated with profitability, as higher branches drive up operating costs for banks. In cross-country comparison, the branch density in Poland appears to be relatively high compared with several other European countries (Annex I).[27] Short-term interest rate is positively related to profitability (in particular ROAA), as the low interest rate environment puts downward pressure on bank profitability.

BANKING SECTOR LIQUIDITY STRESS TESTS

41. **Short-term and long-term liquidity stress tests were conducted using Basel III standards.** Three liquidity stress tests were envisioned: the liquidity coverage ratio (LCR), the net stable funding ratio (NSFR), and a net cash flows-based liquidity stress tests. However, due to data limitations only the LCR and NSFR tests could be conducted. Four stress scenarios were considered for the liquidity coverage ratio (LCR) tests. The baseline event replicated the self-reported bank stress tests based on CRR-recommended weights. The retail event applied higher run-off rates to stable deposits and other retail deposits, while the wholesale event applied higher run-off rates to operational and non-operational deposits. The combined event applied the retail and wholesale events' run-off rates jointly with the same haircuts applied to assets as used in the solvency test.

A. Funding Structure and Risks

42. **Despite the comfortable starting point of liquidity ratios, the stress test aimed to capture risks associated with the short maturity of deposits, concentration in less stable deposits and the limited secondary market trading of 'liquid' assets.** As of December 2017, the loan-to-deposit ratio for commercial banks was about 102 percent and declining. Loans are funded

[26] The bank-by-bank supervisory data was provided by the NBP. The macroeconomic variables were taken from the IMF International Financial Statistics, the IMF World Economic Outlook database and Haver Analytics.

[27] Based on the ECB Structural Statistics Database, bank branches per capita in Poland was higher compared with Hungary, Romania and the Czech Republic, but remained below that of Germany at the end of 2016.

mostly through inexpensive household deposits in local currency (Figure 10). However, deposits are mostly retail and concentrated in short maturities with little wholesale funding of either secured or unsecured nature by financial or non-financial customers. Vulnerabilities stem from the short deposit maturities and the high reliance on less stable deposits at some banks. About 70 percent of deposits have maturities of less than 30 days and only 31 percent of funding is classified as stable (according to EBA reporting templates), making the system vulnerable to sudden outflows.[28]

B. LCR-Based Liquidity Stress Test

Scenarios and Methodology

43. **Four scenarios were considered in LCR-based liquidity stress tests: baseline Basel CRR, adverse retail, adverse wholesale, and a combination of adverse retail and wholesale scenarios.**[29] The cut-off date for liquidity stress testing was December 2017 and a minimum threshold of 100 percent was applied to the LCR (January 2018 binding level).

44. **The baseline scenario aimed at replicating banks' self-reported stress tests based on CRR recommended stress weights.** While the results were similar to bank-reported results, they were not identical. The differences are explained by banks utilizing different weights from each other as CRR weights allow for some margin of interpretation, especially in the critical run-off rates for deposits subject to higher outflows (see Table 4, first column).

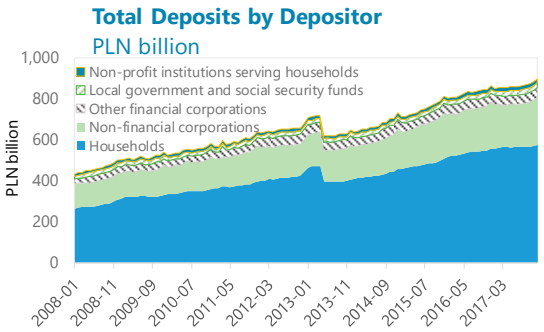
45. **The FSAP stress tests reveal that weights used in the self-reported bottom-up stress tests (by banks) were not identical across banks as in a top-down exercise**, even though the statistical modes of the weights were those recommended by the CRR. While the CRR only allows for bank discretion for deposits subjects to higher outflows (categories 1 and 2), discretion was observed for other outflow categories.

[28] Among the funding sources, 67 percent of retail deposits are classified as stable (Figure 10).

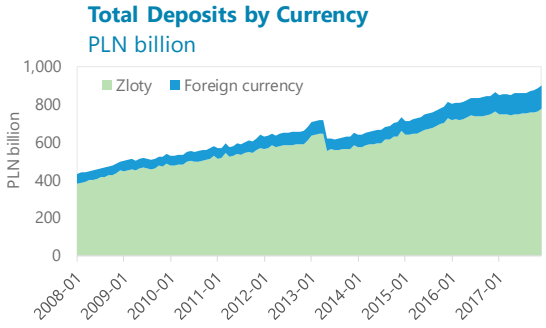
[29] See the stress testing matrix (STeM) for liquidity stress testing for details on the methodology. Calculations used FINREP/COREP data templates as submitted by banks on EBA's Implementing Technical Standards (ITS) reporting templates, including C72, C73, C74 for LCR. These were aggregated and mapped to IMF templates. Bank-by-bank supervisory data was provided by the NBP.

Figure 10. Poland: Bank Funding Structure

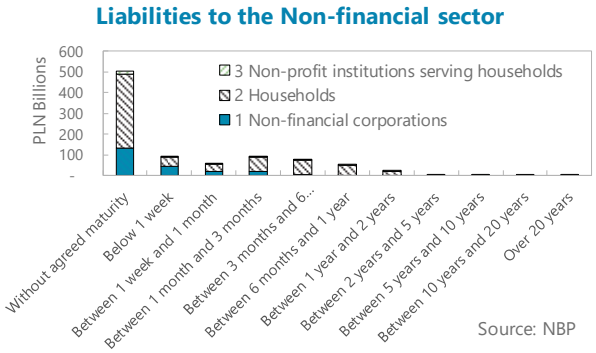
Loans are funded mostly by household deposits…



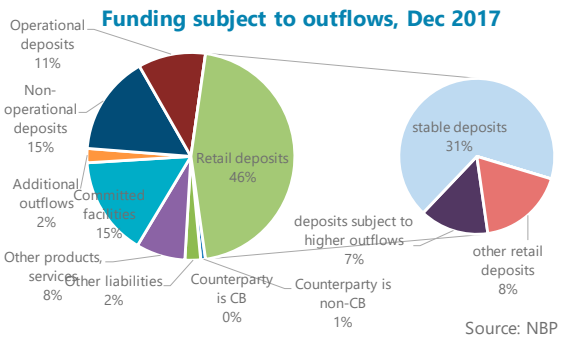
…which are mostly in local currency.



However, deposits have short maturities…



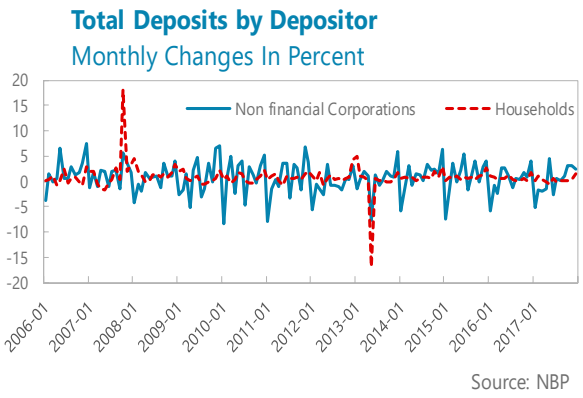
…and stable deposits only account for 31 percent of funding.



46. **The adverse scenarios considered three events that were calibrated using historical data**. In the retail event, higher run-off rates were applied to stable deposits and other retail deposits. These were calibrated as the highest run-off rate observed in the period of analysis (Figure 11). Similarly, for the wholesale event, higher run-off rates were applied to operational and non-operational deposits. The data seemed to indicate past monthly outflow events of around 15 percent, mostly in household deposits and in all currencies. In the combined (extreme) event, higher run-off rates were applied to stable deposits, other retail deposits, operational and non-operational deposits. Haircuts on liquid assets were derived using the adverse scenario from the solvency stress tests. Lastly, standard CRR weights were applied to the inflow roll-off rates through all events. A summary of the scenario assumptions is presented in Table 4.

Figure 11. Poland: Stability of Deposits

Largest outflows occurred in household deposits



Volatility can affect deposits in any currency

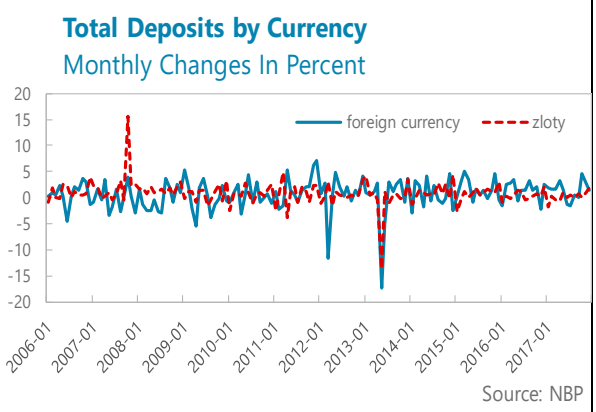


Table 4. Poland: Summary of LCR Assumptions

CRR weights (recommended)		Event 1 CRR weights (used)	2 Retail Event	3 Wholesale Event	4 Combined
A. Eligibility of liquid assets (1-haircut)					
	Central government assets	100%	97%	97%	97%
	Regional government / local authorities assets	100%	97%	97%	97%
B. Outflows (over 30 days)					
	Retail deposits				
100%	deposits where the payout has been agreed within the following 30	100%	100%	100%	100%
	deposits subject to higher outflows				
10%-15%	category 1	15%	15%	15%	15%
15%-20%	category 2	20%	20%	20%	20%
5%	stable deposits	5%	10%	5%	10%
10%	other retail deposits	10%	15%	10%	15%
	Operational deposits				
	maintained for clearing, custody, cash management or other comparable services in the context of an established operational relationship				
5%	covered by DGS	5%	5%	50%	50%
25%	not covered by DGS	25%	25%	100%	100%
	maintained in the context of IPS or a cooperative network				
25%	not treated as liquid assets for the depositing institution	25%	25%	25%	25%
100%	treated as liquid assets for the depositing credit institution	100%	100%	100%	100%
25%	maintained in the context of an established operational relationship	25%	25%	100%	100%
25%	maintained to obtain cash clearing and central credit institution servi	25%	25%	100%	100%
	Non-operational deposits				
100%	correspondent banking and provisions of prime brokerage deposits	100%	100%	100%	100%
100%	deposits by financial customers	100%	100%	100%	100%
	deposits by other customers				
20%	covered by DGS	20%	20%	40%	40%
40%	not covered by DGS	40%	40%	60%	60%
C. Inflows (over 30 days)					
		Used CRR standard weights for all other			

Source: IMF staff estimates

LCR Stress Test Results

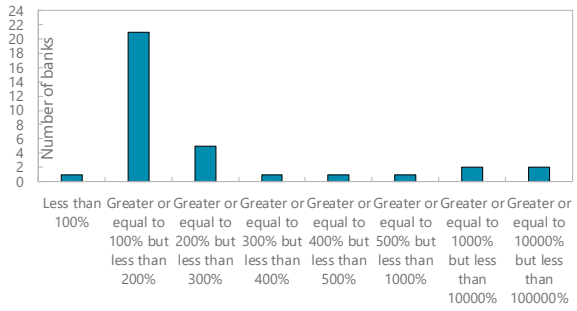
Commercial Banks

47. **In the baseline event, the system LCR was healthy but one medium-sized domestic bank failed marginally (Figure 12).** The system LCR was 149 percent and five banks had an LCR above 500 percent. These were small subsidiaries of domestic and foreign banks funded through non-operational deposits or other unsecured funding. Most banks had an LCR between 100 and 200 percent, and the liquidity shortfall in the bank that failed was negligible.

Figure 12. Poland: LCR Results: Baseline Scenario (CRR Weights)

System LCR is quite healthy.

System LCR under Event 1=149%



Source: IMF staff estimates

One medium domestic bank fails marginally.

System LCR under Event 1=149%

By Size	Large Banks	Medium Banks	Small Banks	Total
Total banks tested	5	14	15	34
Banks with LCR <100	0	1	0	1
(Percent of commercial bank assets)	0.0	1.7	0.0	1.7

By Ownership	Foreign Controlled	Domestic Controlled	Total
Total banks tested	21	13	34
Banks with LCR <100	0	1	1
(Percent of commercial bank assets)	0.0	1.7	1.7

Liquidity shortfall in percent of 2017 GDP	0.0

Source: IMF estimates

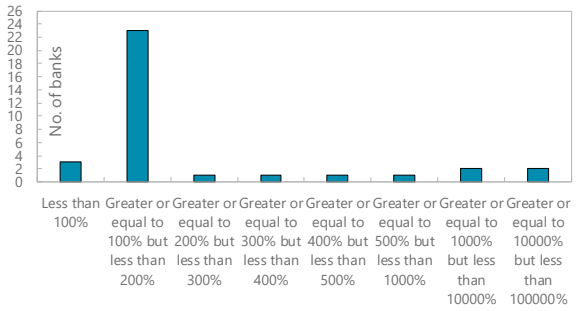
48. **At the aggregate level, banks were found to be resilient to the adverse retail event, but the wholesale and combined scenarios had a sizable impact on system liquidity (Figure 13).** The retail event revealed a resilient LCR remaining above 100 percent at the system level, with two medium-sized foreign banks failing with a liquidity shortfall of 0.5 percent of 2017 GDP. The wholesale event had a substantial impact as it affected eight banks including two large banks with sizable operational deposits. The combined (extreme) event had the largest impact on system liquidity, affecting 11 banks including three large ones. Nevertheless, the total shortfall, compared to 100 percent coverage, was still less than 3.6 percent of GDP.[30] Notably, the affiliating banks did not fail the LCR test as most of their deposits could not be treated as liquid assets by depositing cooperatives.

[30] It is worthwhile noting that the combined effect was not linear but larger than the combined separate effects of the retail and wholesale events.

Figure 13. Poland: LCR Results: Adverse Scenarios

System LCR remains healthy in the retail event

System LCR under Event 2=120%



Source: IMF staff estimates

Two medium foreign banks fail

System LCR under Event 2=120%

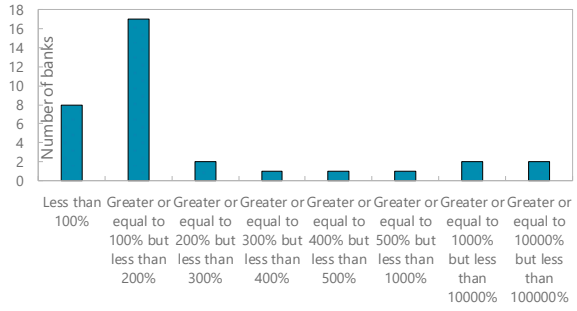
Banks By Size	Large	Medium	Small	Total
Total banks tested	5	14	15	34
Banks with LCR <100	0	3	0	3
(Percent of commercial bank assets)	0.0	9.5	0.0	9.5

Banks By Ownership	Foreign Controlled	Domestic Controlled	Total
Total banks tested	21	13	34
Banks with LCR <100	2	1	3
(Percent of commercial bank assets)	7.9	1.7	9.5
Liquidity shortfall in percent of 2017 GDP			0.5

Source: IMF estimates

System LCR falls below 100 percent in the wholesale event

System LCR under Event 3=94%



Source: IMF staff estimates

Event affects 2 large and 5 medium banks

System LCR under Event 3=94%

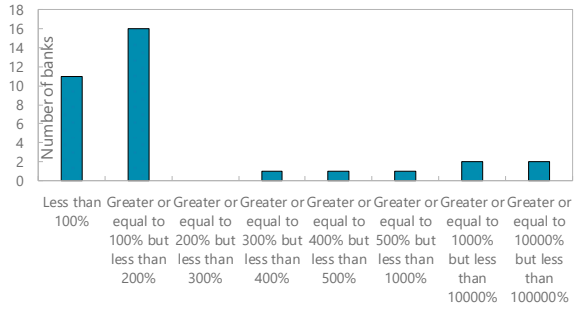
Banks By Size	Large	Medium	Small	Total
Total banks tested	5	14	15	34
Banks with LCR <100	2	5	1	8
(Percent of commercial bank assets)	31.4	13.4	0.7	45.6

Banks By Ownership	Foreign Controlled	Domestic Controlled	Total
Total banks tested	21	13	34
Banks with LCR <100	3	5	8
(Percent of commercial bank assets)	6.4	39.2	45.6
Liquidity shortfall in percent of 2017 GDP			2.8

Source: IMF estimates

System LCR falls further under 100 percent in the extreme event

System LCR under Event 4=88%



Source: IMF staff estimates

Another large, another medium and another small bank fail

System LCR under Event 4=88%

Banks By Size	Large	Medium	Small	Total
Total banks tested	5	14	15	34
Banks with LCR <100	3	6	2	11
(Percent of commercial bank assets)	40.5	14.9	0.9	56.4

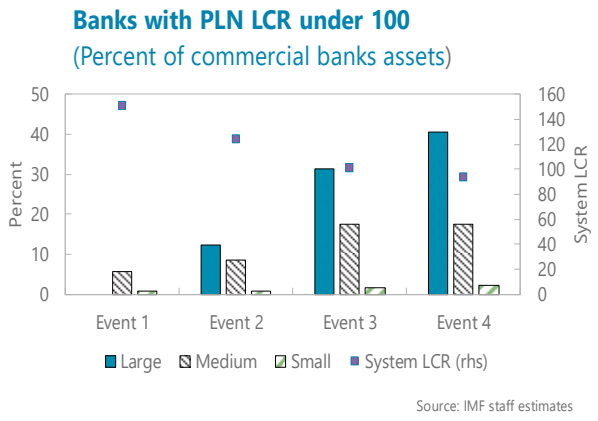
Banks By Ownership	Foreign Controlled	Domestic Controlled	Total
Total banks tested	21	13	34
Banks with LCR <100	5	6	11
(Percent of commercial bank assets)	17.0	39.4	56.4
Liquidity shortfall in percent of 2017 GDP			3.6

Source: IMF estimates

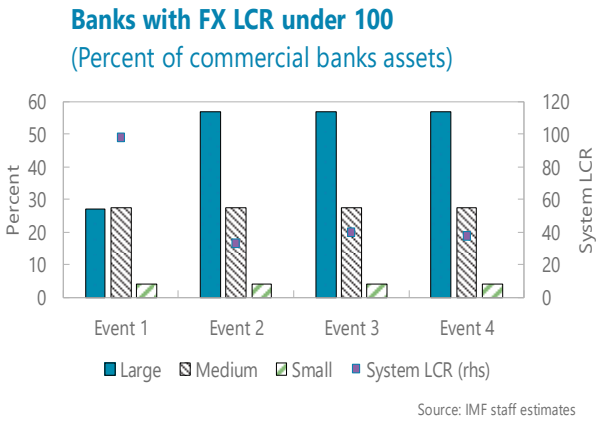
49. **LCR stress tests by currency showed resiliency in local currency but not in foreign currency (see Figures 14).** In general, commercial banks hold foreign currency loans that are partially hedged by FX swap markets and the convertibility of local currency assets. While system LCR in domestic currency was above 100 percent in most stress scenarios (with the exception of the extreme combined case), banks struggled to meet LCR requirements in foreign currency in the adverse scenarios. Specifically, all banks failed each of the stress events while the retail event had stronger consequences on bank's liquidity than the wholesale event, which indicates a need to lengthen the maturity of FX liabilities. The results must be taken with caution as currency-by-currency LCR data did not reconcile with the aggregate LCR data in foreign currency.[31]

Figure 14. Poland: LCR Results by Currency

While system LCR in domestic currency remains above 100 percent in most stress scenarios….



… banks struggle to meet LCR requirements in foreign currency in all three stress scenarios.



Note: Event 1 refers to the baseline scenario, and events 2, 3, and 4 refer to the adverse retail, wholesale, and combined stress scenarios, respectively.

Cooperative Banks

50. **The NBP carried out a top-down LCR stress tests on the cooperative banks using the same assumptions as for commercial banks.** Results were similar. Cooperative banks evidenced higher LCR levels than the commercial banks due to a higher surplus of deposits over loans. In addition, those banks that did not belong to a network held higher liquidity buffers in the form of NBP bills and/or government bonds. At an individual level, many cooperatives did not pass the stress test, but they were already exempt from complying with the LCR on an individual basis by the regulator.

[31] The discrepancy could be due to the fact that banks are only required to report positions in major foreign currencies.

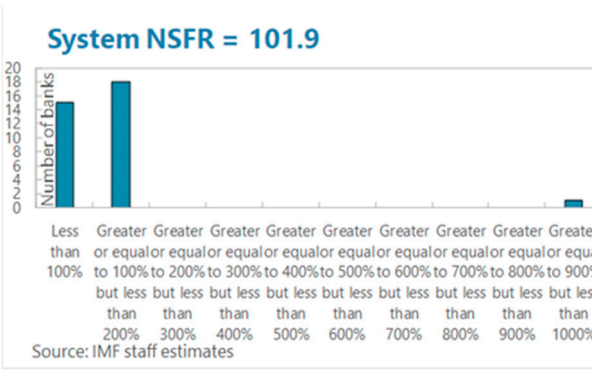
C. NSFR-Based Liquidity Stress Testing

51. **The FSAP analysis of the Net Stable Funding Ratio (NSRF) was constrained by data availability and quality.** The NSFR analysis was based on data submitted by banks on EBA ITS reporting templates.[32] However, the quality of the data is questionable as the results do not reconcile with results based on the confidential PFSA survey data on bank liquidity to which the FSAP team has no access.

52. **While there is uncertainty about the robustness of data provided to the FSAP team, NSFR tests results appear to indicate vulnerability to more protracted events (Figure 15).** There were differences in the mission team's results and those of the PFSA bank survey. The mission's results suggested that the system in aggregate barely passed the test, with almost half of the banks not meeting the proposed 100 percent coverage. However, the authorities' calculation of the NSFR was higher at around 120 percent using the PFSA bank survey data.

Figure 15. Poland: NSFR Results

System NSFR was barely sufficient



Almost half of the banks did not comply

System NSFR = 101.9

Banks By Size	Large	Medium	Small	Total
Total banks tested	5	14	15	34
Banks with NSFR <100	3	8	4	15
(Percent of commercial bank assets)	36.2	19.3	1.3	56.9

Banks By Ownership	Foreign Controlled	Domestic Controlled	Total
Total banks tested	21	13	34
Banks with NSFR <100	9	6	15
(Percent of commercial bank assets)	32.3	24.6	56.9
Liquidity shortfall in percent of 2017 GDP			6.0

Source: IMF estimates

CONTAGION AND SYSTEMIC RISK ANALYSIS

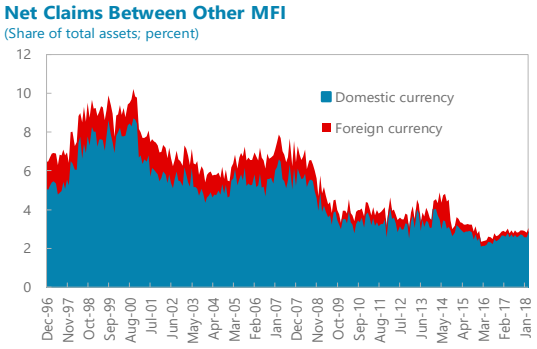
53. **The contagion and systemic risk analysis examined the interbank, cross-sectoral, and cross-border linkages based on both exposure and market data.** In each case the analysis was based on claims data from the NBP or BIS using the Espinosa-Vega and Sole approach and market-based data using the Diebold and Yilmaz approach.[33]

[32] Calculations used FINREP/COREP data templates as submitted by banks on EBA ITS reporting templates, including C60a, C60b, and C61 for NSFR.
[33] See Annex VIII for detailed methodology on contagion analysis.

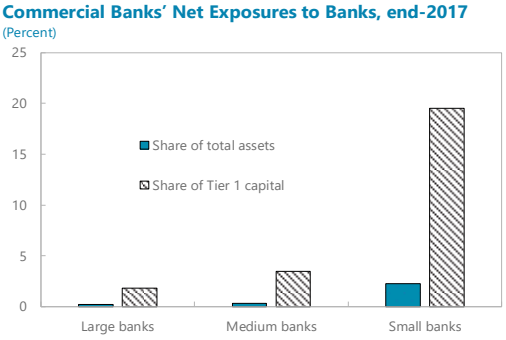
A. Connectedness Between Deposit-Taking Institutions

54. **Interbank exposures in Poland are generally contained.** Exposures between other Monetary and Financial Institutions (MFIs) have declined over time to about 3 percent of total assets at end-2017.[34] Among commercial banks, the small banks have the most substantial asset-side interbank linkages. However, commercial banks' exposures are contained regardless of bank size (Figure 16).

Figure 16. Poland: Interbank Exposures



Source: NBP and IMF staff calculations.



Note. Data on large exposures reported as prescribed by the Capital Requirements Regulation (CRR) of the EU.

55. **Cooperative banks' deposit in affiliating banks is a key vulnerability.** The cooperative banks are required to deposit a minimum amount of up to 9 percent of non-financial clients' deposits in affiliating banks. By end-2017, affiliating banks' total interbank deposits equaled 29 percent of total non-financial client deposits in cooperative banks. Meanwhile, interbank deposits financed as much as 71 percent of the affiliating banks' assets.

56. **Credit union interlinkages are non-systemic.** PFSA data indicate nearly no direct exposures of commercial and cooperative banks to credit unions by end-2017. Similarly, NBP data show that deposits in banks amounted to less than 5 percent of credit unions' total assets by June 2017. As credit unions represent only about 0.4 percent of total financial system assets, their credit and funding exposures represent a non-systemic contagion vulnerability in the financial system.

[34] Other monetary financial institutions (MFIs) include commercial banks, cooperative banks, credit unions, and money market funds, see https://www.nbp.pl/homen.aspx?f=/en/statystyka/bilans_zagr/bilans_zagr.html

57. **The mission examined interbank connectedness using the Espinosa-Vega and Sole (2010) approach.**[35] Due to data confidentiality, the NBP carried out the simulations using FSAP team support. The NBP simulated the spill-overs caused by the individual failures of 939 banks. The dataset contained pair-wise on and off-balance sheet exposures between all 34 commercial banks, 553 cooperative banks, and 352 foreign bank counterparties. While available data allowed for a distinction between loans only and all types of exposures, it did not distinguish between secured and unsecured exposures. Instead, the NBP assumed all exposures to be unsecured, potentially overestimating the severity of bank failures.

58. **The network analyses considered that failures may occur due to credit losses and losses of funding.** A first round of simulations was made assuming that failures only cause credit losses (credit shock). In line with common FSAP practice, these simulations assumed a 100 percent loss-given-default rate. This assumption was justified by the limitations related to data availability regarding the share of collateralized exposures in the Polish interbank market and the likely prospect of high uncertainty about asset values in times of severe stress. The second round of simulations assumed that a bank failure causes a loss of funding from the failed bank to other banks (funding shock). The simulations assumed that 35 percent of the lost funding could not be rolled over. To cover the funding shortfall, affected banks were assumed to sell liquid assets at a haircut of 50 percent. A third round of simulations assumed the combined credit and funding shocks.

59. **Network simulations reaffirmed the finding that interbank exposures in the Polish system are contained (Figure 17).** When only commercial banks were considered, failures of large banks have the most significant impact. Nevertheless, no more than one additional failure was induced in any of the simulations. The outward spillover, measured by the index of contagion,[36] was contained around or below 4 percent of Tier 1 capital. The small and medium-sized banks were the most severely affected in these simulations, as measured by the index of vulnerability.[37] The effects were mainly driven by the funding shock, reflecting a degree of dependence on funding from large banks among some small- and medium-sized banks within the same capital groups.

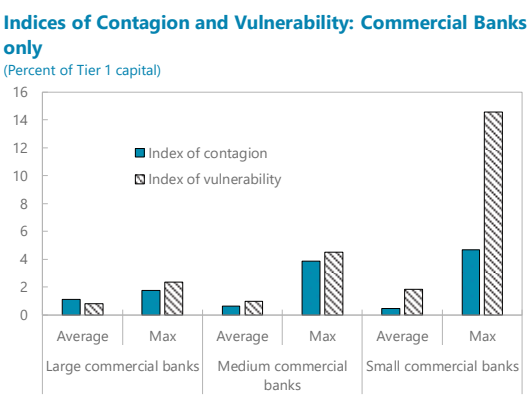
[35] See Espinosa-Vega, M., and Solé, J. (2010), *"Cross-Border Financial Surveillance: A Network Perspective"*, IMF Working Paper, WP/10/105.

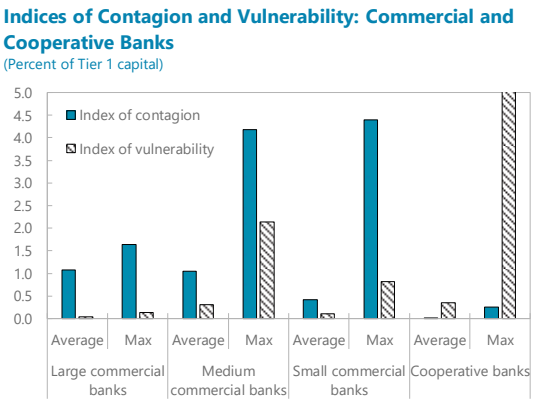
[36] The index of contagion is calculated in each simulation as the ratio of total induced losses to total Tier 1 capital.

[37] The index of vulnerability is calculated for each bank as the average loss in the simulations in percent of its original Tier 1 capital.

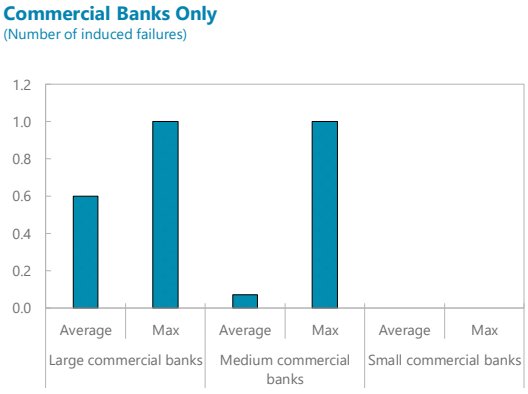
60. **The simulation outcomes highlight the importance of the cooperative banks' deposit exposures to affiliating banks (Figure 17).** When the simulations considered both the commercial and the cooperative banks, the average number of bank failures induced by the medium-sized banks rose to 38 while the maximum number rose to 338. These results reflected failures of cooperative banks due to credit losses caused by affiliating bank defaults, in combination with the structural features of the cooperative banking system. However, because of the limited size of the cooperative banking sector (about 5 percent of total financial system assets) the outward spillover of the medium-sized banks only increased marginally, as indicated by the index of contagion. Consistent with that finding, only one of the simulations lead to more than one round of induced failures (two rounds), indicating limited contagion when cooperative banks fail.

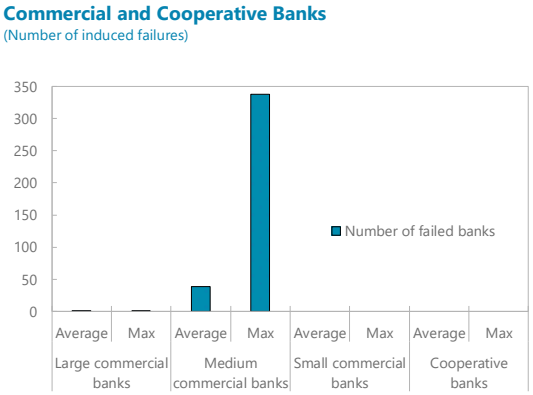
Figure 17. Poland: Results of Combined Credit and Funding Shock





Note. The maximum value of the y-axis has been set to 5 percent. The actual maximum value of cooperative banks' index of vulnerability is 100 percent.





Source: NBP.

61. **Simulations initiated by foreign bank failures gave insignificant results.** While 352 foreign counterparties were included in the simulations, only the failures of three of those banks induced an additional failure. In those cases, the average total assets of the additionally failed banks amounted to 0.5 percent of total system assets, indicating a limited impact of foreign bank failures.

62. **Commercial banks, cooperative banks and credit unions are also interconnected through the domestic financial safety net.** Banks and credit unions are required to make contributions to the Bank Guarantee Fund (BGF) to ensure that the restructuring and deposit guarantee funds have sufficient means to cover potential failures. In 2017 the average contributions to these funds amounted to 0.1 percent of total commercial bank assets, leading to a significant impact on profit and loss as the contributions are not tax deductible. The collective contributions to restore the funds following bank failures represents a direct channel of contagion between the institutions in the banking sector.

B. Cross-Sectoral Analysis

63. **The analysis of cross-sectoral interconnectedness was constrained by a lack of institution-specific data.** While the FSAP team had access to NBP data on the large exposures of commercial banks, no institution-by-institution nor counterparty-specific data were available on the exposures of non-banks in the financial sector. Instead, the FSAP team relied on the NBP Financial Stability Report, NBP Monetary Financial Statistics and PFSA data on total cross-sectoral exposures.

64. **The sovereign-bank nexus is material in Poland.** By end-2017, the state-controlled banks represented as much as 40 percent of deposit-taking institutions' total assets. Meanwhile, general government claims amounted to 20 percent of total assets of other MFIs. These interlinkages give cause to potential adverse distortions in the financial system and the economy (see Box 1 on the sovereign-bank nexus and Figure 18).

65. **Foreign ownership linkages are also significant.** Furthermore, foreign owners controlled 46 percent of banking sector assets and between 50–60 percent of insurance sector assets by June 2017 (Figure 19). The large presence of foreign owners exposes the domestic financial system to risks. The behavior of foreign-owned institutions may change for reasons that are unrelated to Polish conditions. Foreign-owned institutions could, at least in theory, choose to reduce risk-taking in Poland due to deteriorating external economic conditions or because of changes in financial group strategies. Such changes may result in bank deleveraging or asset portfolio reallocations, which could impact the Polish economy, or in divestment of the foreign banks' Polish operations.

Box 1. Sovereign-Bank Nexus

Strong links between the sovereign and the banking system can amplify shocks in the financial system through a number of channels: 1) *the sovereign exposure channel*—holdings of domestic government securities by banks, 2) *the safety net channel*—the backstops, guarantees and other potentially costly resolution polices, amplified where there is direct state ownership in the system, and 3) *the macroeconomic channel*—increases in sovereign risk have contractionary effects on economic activity with higher funding costs leading to a deterioration in bank asset quality, with potential negative feedback to the ability of the government to fund itself.

Sovereign-bank linkages are material in the Polish financial system:

- *The sovereign exposure channel:* The general government exposures of other monetary financial institutions in Poland amounted to 20 percent of their total assets by end-2017 (see Figure 18).[1] Prior to the introduction of FIAT in 2016, which exempted holdings of government securities, the exposure ratio was about 17 percent. The increase in sovereign exposures indicates that the asset tax may have incentivized banks to hold more government bonds and bills.[2] Under simple assumptions and based on the current fair value holdings, a 500 bps increase in government yields reduces aggregate Tier 1 capital by about 2.2 percentage points. Adjusting for the approximate 12 percent (relative) increase of sovereign debt holdings above trend following the FIAT introduction, the same yield shock reduces capital by 2.0 percentage points; a 0.2 percent lower impact than the current position.

- *The safety net channel:* By end-2017 the government directly or indirectly controlled 40 percent of the assets of deposit-taking institutions, up from 26 percent in 2015. The high level of direct ownership by the government increases its potential costs, for example through the need to inject capital in the event of a crisis emanating in the banking sector. Historically, the correlation between the market valuation of credit risk of the Polish sovereign and the banking sector has been very high, signaling a market perception of dependencies between the two (see Figure 18).

The strong sovereign-bank linkages could also have distortive effects. The FIAT risks incentivizing banks' holdings of sovereign debt rather than more productive investments. The sovereign-bank linkages could also strengthen the implicit government guarantees for banks, which could distort banks' funding costs. In addition, the linkages could bias banks' lending preferences to provide more credit to the government sector.[3] Furthermore, the linkages may undermine the sound banking supervision of government-controlled entities. In stressed scenarios, the flows of deposits in the system could be distorted as depositors may prefer government-controlled entities.

---

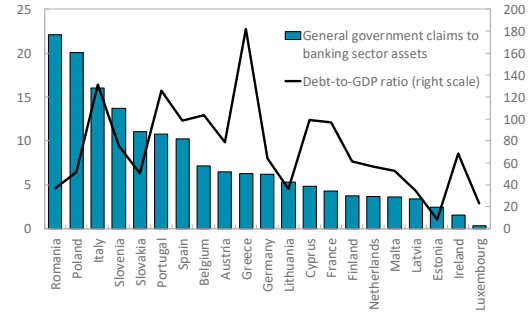
[1] As mentioned, other monetary financial institutions include commercial banks, cooperative banks, credit unions and money market funds. If we take commercial banks alone, their holding of government securities increased from around 20 percent of RWA at December 2015 to around 25 percent at December 2017. Both indicators suggest a rise in the holding of government securities by financial institutions.

[2] As shown in Figure 1, commercial banks dominate the Polish financial system, and the group of other monetary financial institutions.

[3] For more elaboration about the empirical evidence on this topic see Gonzalez-Garcia, J., Grigoli, F. (2013), "State-Owned Banks and Fiscal Discipline", IMF Working Paper, WP/13/206.

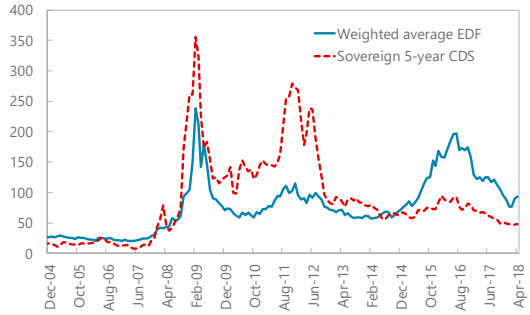
Figure 18. Poland: Sovereign-Bank Interlinkages

Sovereign Debt Exposures, end-2017
(Percent)



Note. The ratio for Poland reflects the ratio of total general government exposures to total assets in the aggregated balance sheets of other monetary financial institutions. The ratio for Romania reflects the ratio of total claims on the government sector to total assets of banks. For all other countries, the ratios reflect the claims on central government to total assets of other depositary corporations. World Economic Outlook GDP projections were used where public figures on 2017 GDP had not yet been published.

Market Perception of Credit Risk
(Basis points)



Note. The weighted average EDF was computed using the individual EDFs for nine commercial banks weighted using their total assets as of end-2017.

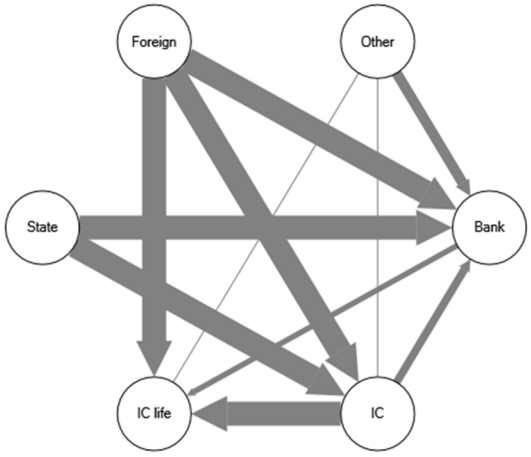
Sources: NBP Monetary and financial statistics, International Financial Statistics, IMF Financial Soundness Indicators, Financial Stability Report of the Romanian Central Bank, IMF World Economic Outlook database, Datastream, and staff calculations.

66. **Banks' exposures to non-banks in the financial system appear to be limited.** By end-2017, the average large exposures of commercial banks to non-bank financial institutions amounted to 1 percent of Tier 1 capital, while the largest exposure in the sample amounted to 25 percent of Tier 1 capital. Banks' credit and market risks associated with non-bank financial institutions therefore appear to be limited. Similarly, total bank liabilities to the financial sector amounted to 14 percent of total assets, which indicates a limited dependency on financial sector funding.

67. **Credit and liquidity exposures of non-banks indicate the central role of banks in the system (Figure 19).** Bank deposits amounted to 4–7 percent of total assets in the insurance and pension fund sectors by June 2017, reflecting the use of bank deposits in liquidity management. In addition, pension funds had substantial holdings of bank equity leading to a total exposure to the banking sector of about 41 percent of total assets by end-2017. Holdings of banking sector debt instruments made up 10 percent of open-ended funds' total investments.

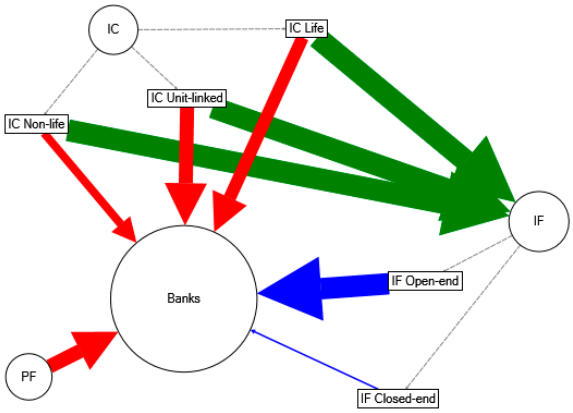
Figure 19. Poland: Cross-Sectoral Linkages

Ownership network, June 2017
(in percent of owned assets)



Note. Bank = commercial banks, IC = insurance companies, IC life = life insurance companies. The arrows point from the owner. The arrow size reflects ownership in percent of total sector assets (i.e. not the share of assets controlled by another entity). For reference, the largest arrow goes from "Foreign" to "IC life" representing 57 percent of the assets in the insurance life sector. The "other" category includes non-financial corporations and physical persons, as pension funds are not included in the chart. The coverage of the underlying in percent of total sector assets is 100 percent for the commercial banking sector (referred to as "Bank"), 90 percent of the general insurance sector and 97 percent of life insurance companies.

Non-bank financial institutions' cross-sectoral exposures excluding equity, June 2017
(in percent of creditors' total assets)



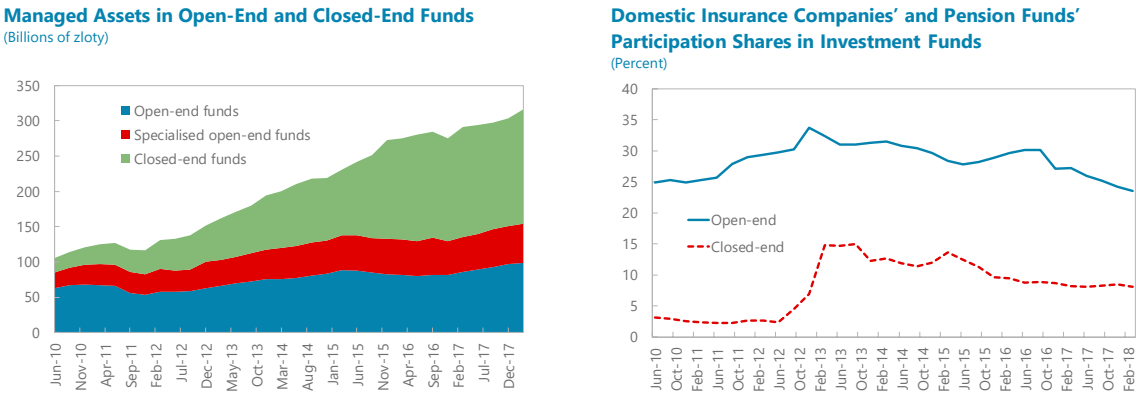
Note. IF = Investment funds. Dashed lines indicate sub-categories of sectors. Red arrows symbolize bank deposits. Green arrows symbolize investment fund shares. Blue arrows symbolize holdings of issued debt instruments. The arrows point from creditors to debtors. The size of the arrows reflects the share of claims in percent of the creditor's total assets.[1] The size of the circles reflects the percentage share of each sector of total system assets.

Source: NBP, PFSA, Banker's Almanac, and staff calculations.

[1] Pension funds' exposures reflect only bank deposits (6.7 percent of total assets), ignoring an unidentifiable item of non-treasury debt securities of 7.5 percent of total assets.

68. **Contagion vulnerabilities between non-bank financial institutions appear limited.** Insurance companies in Poland invest a significant share of their assets in investment funds to reduce operational costs and for tax optimization purposes, as well as due to the significant role of unit-linked policies in the life insurance business. Investment fund holdings in percent of total investments were 77 percent for unit-linked policies, 17 percent of life insurance policies and 11 percent for non-life insurance policies by June 2017. Open-ended investment funds expose the system to the most significant risks as redemptions from these funds may have to be covered by fire-sales of illiquid assets in times of stress. However, the use of these funds has decreased significantly in the last years as their percentage share of total investment fund assets has declined from 81 percent in 2010 to 49 percent in 2018, largely reflecting insurance companies' increased use of closed-end funds (Figure 20). Furthermore, as unit-linked policies (which represented about 73 percent of total life insurance technical provisions by June 2017) are the largest users of open-end funds, and the risks associated with these funds are mostly held by the policy holders rather than the insurance companies.

Figure 20. Poland: Investment Fund Evolution and Linkages



Source: NBP.

C. Market Perception of Domestic Interconnectedness

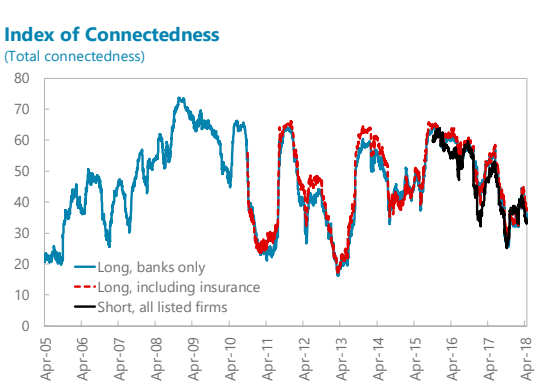
69. **The FSAP team analyzed interbank and cross-sectoral connectedness using the Diebold and Yilmaz (2014) approach.**[38] The methodology was applied to a dataset of daily equity log returns for 12 commercial banks and one insurance company from May 2015 to April 2018. To calculate longer time series of total connectedness the methodology was also applied on smaller samples of institutions for which longer time series are available.

[38] See Diebold, X., D., and Yilmaz, K. (2014), *"On the topology of variance decompositions: Measuring the connectedness of financial firms,"* Journal of Econometrics, no. 182, pp. 119–134.

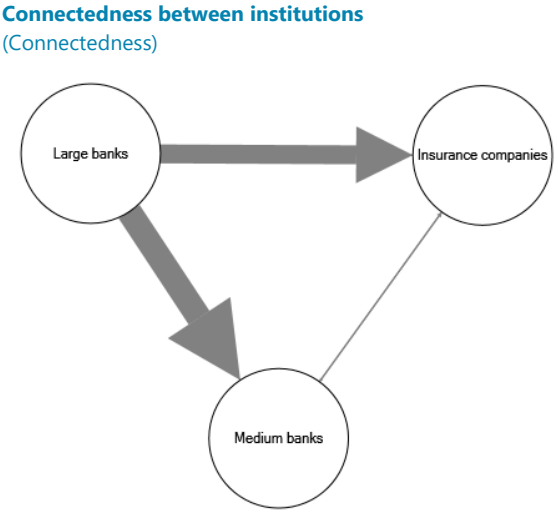
The methodology first estimates a Vector Autoregression (VAR) model on the time series of returns in the sample.[39] It then derives a measure of connectedness from the generalized variance decomposition of the VAR. The pairwise connectedness measure captures the extent to which unexpected variations[40] of one institution's equity price could explain those of another institution.

70. **According to market perceptions, the group of large banks are net transmitters of shocks in the domestic financial system (see Figure 21).** In other words, the outward spill-over from large banks to medium-sized banks and insurance companies tends to be higher than the outward spill-over from medium-sized banks and insurance companies to large banks. The historical evolution of the measure of total connectedness has been quite volatile in the past. While connectedness has been high in periods, the average level of connectedness in the Polish system appears to be relatively contained.[41]

Figure 21. Poland: Market-Based Estimates of Domestic Connectedness



Note. "Long, banks only" is based on data since November 2004 and includes five large banks and two medium-sized banks. "Long, incl. insurance" is based on data since May 2010 and includes five large banks, two medium-sized banks and one insurance company. "Short, all listed firms" is based on data since May 2015 and includes five large banks, seven medium-sized banks and one insurance company.



Note. The chart reflects connectedness estimated on the complete historical dataset from May 2015 to April 2018 (i.e. no rolling window). Note that the group "Insurance companies" is represented here by only the largest insurance company.

Source: Bloomberg and IMF staff calculations.

[39] Estimations are based on a VAR(3) model with a predictive horizon of 12 days. For the index of total connectedness, a rolling window of 100 days was used. Robustness was verified by testing several alternative model specifications.

[40] "Unexpected variations" here refers to the statistical concept of "innovations".

[41] The average level of domestic connectedness for Poland has been low in comparison to the domestic index of connectedness estimated for the Spain FSAP, to the index estimated in Diebold and Yilmaz (2014) and to the international index in this technical note (see Figure 22).

D. Cross-Border Interconnectedness

71. **The FSAP analysis of cross-border interconnectedness was constrained by a lack of data.** Poland does not report data to the BIS International Financial Statistics database. The BIS database only contained data on foreign banking system's total exposures to Poland. The FSAP team had access to an NBP dataset on bank-by-bank cross-border total exposures to other countries for Polish commercial banks. However, the data constraints did not allow for a granular analysis of Polish banks' credit exposures to foreign banking systems', nor a granular analysis of Polish banks' reliance on external funding.

72. **Polish banks' aggregate use of external funding has decreased significantly since the financial crisis (See Figure 22).** This evolution is largely due to the downsizing of Polish banks' foreign currency housing loan portfolios, reducing the need for foreign currency funding. According to the NBP Financial Stability Report almost all external liabilities were to financial institutions by June 2017. More than half of those liabilities were to related entities, i.e., intra-group funding of subsidiaries of foreign banks.

73. **Polish banks generally have small cross-border exposures on the asset-side (see Figure 22).** External assets of other MFIs amounted to 4 percent by March 2018. According to the cross-border exposures dataset provided by the NBP, the average total cross-border exposure to one single country among the top-15 exposures of commercial banks was 2 percent of Tier 1 capital by end-2017. The largest exposure to one country among the commercial banks was 93 percent of Tier 1 capital. This implies that no bank fails due to a credit shock caused by the failure of another country using the Espinosa-Vega and Sole approach.

74. **Foreign banks' exposures to Poland are generally contained (Figure 22).** Considering the group of 15 foreign banking systems with the largest exposures to Poland, the average exposure amounted to 10 percent of Tier 1 capital by June 2017.[42] Portugal had the largest total exposure to Poland amounting to 58 percent of deposit-takers' Tier 1 capital.[43] Most likely this exposure is largely due to the presence of foreign-owned subsidiaries in Poland. The results imply that no foreign banking system would fail due to a credit shock caused by the failure of Poland using the Espinosa-Vega and Sole approach.

75. **The FSAP team also applied the Diebold and Yilmaz methodology to assess the market perception of the relation of the Polish banking system to peers.** The analysis was based on the same assumptions as for the analysis of domestic contagion risks (see methodology

[42] The ratio was derived by dividing total consolidated ultimate-basis cross-border exposures to Poland (from BIS data) by total Tier 1 capital for other deposit-taking institutions from IMF Financial Soundness Indicators.

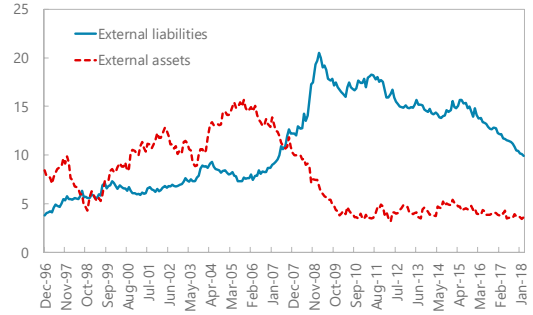
[43] As country-level data is used, Portugal's exposure cannot be described in further detail. One likely explanation is that exposures derive from the presence of Portuguese banking groups in Poland. For example, Banco Comercial Português is present in Poland through Bank Millenium.

and assumptions above). The dataset contained the two-day averages[44] of daily log returns of the MSCI equity indices of a group of 19 of the most important counterparty countries in terms of trade and financial claims.[45]

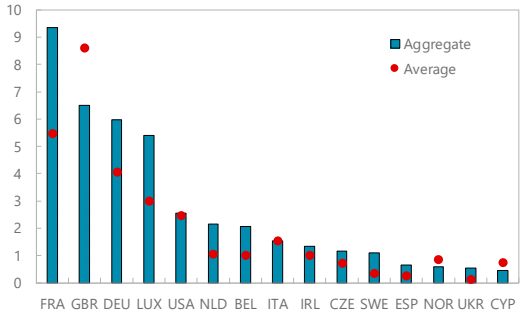
76. **The Polish banking system appears to be a net recipient of shocks according to market pricing (see Figure 22).** In other words, the outward spill-over of shocks from foreign banking systems to Polish banks tends to be higher than the outward spill-over from Polish banks to foreign banking systems. The results showed that Poland was a net recipient of shocks in relation to almost all countries. Interestingly, however, the analysis showed that the Polish banking system has tended to be a net transmitter of shocks to the Portuguese banking system, which would be in line with the finding of significant cross-border exposures for the Portuguese banking system to Poland.

Figure 22. Poland: Cross-Border Exposures

External Assets and Liabilities of Other MFI
(Percent of total assets)

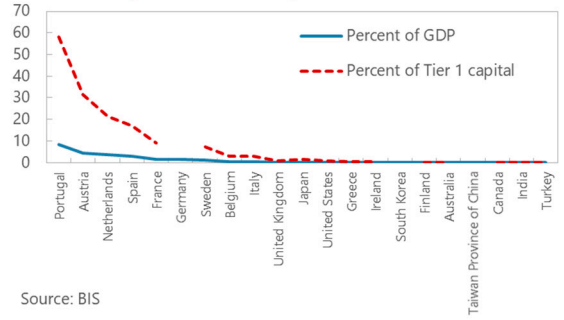


Polish Banks' Consolidated Total Foreign Risk Gross Exposures, end-2017
(Percent of Tier 1 capital)



Note. The exposures are reported on the ultimate risk basis and include both on-balance and off-balance positions.

Foreign Banking System's Consolidated Total Gross Exposures to Poland, June 2017

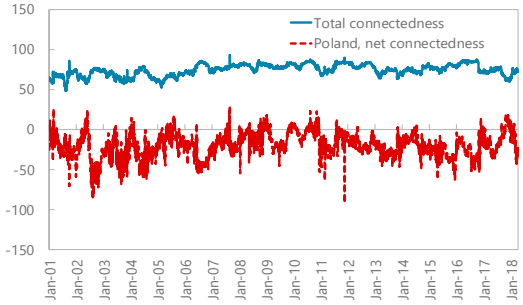


Source: BIS

Note. The exposures are reported on the ultimate risk basis and include both on-balance and off-balance positions.

Source: NBP and Datastream.

Index of Connectedness
(Percent)



Note. The index of connectedness was computed based on the Diebold and Yilmaz (2010) approach using two-day average equity returns.

[44] Two-day averages were used to account for any time-zone differences between countries.

[45] The countries were Austria, Belgium, Czech Republic, France, Germany, Italy, Ireland, Japan, Netherlands, Norway, Poland, Portugal, Russia, Slovenia, Spain, Sweden, Switzerland, the UK, and the US.

CONCLUSIONS AND POLICY RECOMMENDATIONS

77. **The banking system in Poland shows resiliency to adverse shocks at the system level, however, some medium-sized banks including four OSIIs show weakness.** The main contributing factors to the decline in capital ratios under the adverse scenario are credit risks, funding interest rate risks and valuation risks on bond portfolios. The necessary recapitalization need would be around 0.5 percent of GDP. The identified weakness in medium-sized banks was in part due to weaker starting positions. Four OSIIs, including the affiliating banks for cooperative banks are found to be relatively weak. Furthermore, the cooperatives banking sector is exposed to credit and concentration risks, as shown by the simulated default of the five largest borrowers.

78. **The banks system appears resilient to short term liquidity risks in domestic currency.** At the aggregate level, banks were found to be resilient to the adverse retail event, but the wholesale and combined scenarios had a sizable impact on system liquidity. The combined extreme event compounded costs that nevertheless totaled still less than 3.6 percent of GDP. The LCR by currency showed resiliency in local currency but not in foreign currency. While there is uncertainty about the robustness of data provided to the FSAP team, NSFR tests results appear to indicate vulnerability to more protracted events.

79. **Contagion risks in the Polish financial system and generally appear to be contained.** However, the finding that adverse shocks to affiliating banks could spill-over and cause severe distress among cooperative banks reinforces the need to improve the resilience of affiliating banks. Moreover, the sovereign-bank nexus in Poland is significant due to banks' sizable holdings of sovereign securities and ownership linkages. In part, the sovereign-bank nexus has become more material because of the FIAT that incentivized sovereign holdings.

80. **The mission recommends addressing the identified weakness in medium-sized banks and OSIIs, strengthening the monitoring of FX liquidity risks, redesigning the FIAT and closing remaining data gaps.** The policy recommendations are based on the findings from the risk analysis, aimed to strengthen the resilience of Poland's financial system, and to highlight areas that warrant further supervisory and regulatory attention.

- *Address the identified weakness in medium-sized banks and OSIIs*, including the affiliating banks for cooperative banks, given their systemic importance in the banking system and strengthen the supervision and oversight of the relevant OSIIs and other weak banks.

- *Improve data for credit risk analysis*, by collecting PD, LGD data and moving towards PD, LGD based credit risk models, in particular with the introduction of IFRS 9 that requires the estimations of expected losses and other forward-looking risk measures.

- *Improve monitoring of FX liquidity risks* by ensuring LCR and NSFR currency-by-currency reporting;

- *Ensure banks' readiness for the upcoming* CRR II *implementation timeframe*. In addition, ensure that in practice banks are using common parameters for the LCR, to promote comparability across banks.

- *Replace the FIAT with a Financial Activities Tax (FAT)*, which would be less distortionary for the private sector and the economy than a tax on assets (IMF, 2010), addressing both stability and efficiency concerns.[46]

- *Address data gaps in contagion analysis*, by improving the collection of more granular data on 1) counterparty-specific asset- and liability-side exposures and loss-absorbing capacity to improve the analyses of intra-sector and cross-sectoral contagion; 2) asset- and liability-side cross-border exposures to foreign banks; and 3) banks' secured and unsecured interbank exposures.

[46] The recommendation of replacing the FIAT with the FAT is consistent with the Poland Article IV Staff Reports (2016 and 2017). See IMF paper (2010) "A Fair and Substantial Contribution by The Financial Sector."

Annex I. Financial Soundness Indicators

Annex I. Table 1. Poland: Financial Soundness Indicators (Commercial Banks)

(in Percent)

	2015Q1	2015Q2	2015Q3	2015Q4	2016Q1	2016Q2	2016Q3	2016Q4	2017Q1	2017Q2	2017Q3	2017Q4
Asset Quality												
NPLs to total loans	6.8	6.6	6.6	6.2	6.4	6.3	6.3	6.0	6.0	6.0	6.0	5.9
Loan loss reserve to NPLs (Coverage)	55.3	55.7	56.2	56.8	57.2	57.7	57.8	56.2	56.8	57.0	57.0	57.7
LLR to total loans	3.7	3.7	3.7	3.5	3.7	3.6	3.6	3.4	3.4	3.4	3.4	3.4
Prov for loan loss to total loans	0.7	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	1.9	1.4
Annualized loan growth	10.3	11.7	11.4	9.2	4.2	3.0	3.0	2.6	5.5	3.2	5.0	3.0
Texas ratio	0.4	0.4	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.3
Profitability												
Net Interest Margin	2.5	2.4	2.4	2.5	2.6	2.5	2.6	2.5	2.7	2.7	2.8	2.7
Efficiency (cost/income)	38.6	40.3	41.0	44.8	45.9	42.9	44.2	44.6	50.2	47.4	46.1	46.0
ROAA	1.2	1.1	1.1	0.9	0.9	1.1	1.0	0.9	0.7	0.8	0.9	0.8
ROAE	18.5	16.8	15.8	13.2	12.4	15.7	14.0	13.0	9.3	11.4	11.7	11.3
Trading gains to income	6.1	5.7	5.6	5.8	5.7	5.4	5.7	5.7	4.9	4.6	4.6	4.6
Liquidity and Funding												
Loan-to-deposit (LTD)	110.4	112.1	109.1	107.0	105.0	105.2	105.1	102.9	104.6	105.1	106.0	102.4
Liquid assets / total assets	20.6	21.3	21.2	21.7	22.6	22.1	21.9	22.6	21.3	21.1	20.9	22.2
Liquid assets / short term liabilities	22.8	23.7	23.6	24.1	25.3	24.8	24.6	25.3	23.9	23.7	23.6	25.0
Wholesale funding	23.7	23.9	22.7	20.5	20.2	19.4	19.1	18.6	18.8	18.3	18.4	17.6
Capital Adequacy												
Capital adequacy ratio (CAR)	14.8	15.2	15.5	15.9	16.6	17.0	17.2	17.1	17.4	18.0	18.0	18.1
Tier 1 capital ratio (Tier 1 capital to RWA)	13.5	13.9	14.2	14.6	15.1	15.3	15.6	15.5	15.8	16.5	16.5	16.2
Financial Leverage (times)	10.0	9.8	9.8	9.7	9.4	9.3	9.2	9.4	9.2	8.9	8.9	8.8
Foreign currency (FX)												
FX loans to total loans	31.2	31.3	30.4	30.2	29.4	29.5	28.4	28.7	26.9	25.8	25.0	23.5
FX deposits to total deposits.	10.7	10.8	10.7	10.7	11.1	11.3	11.9	11.8	12.6	13.0	12.7	13.4

Source: NBP

Annex I. Table 2. Poland: Financial Soundness Indicators (Cooperative Banks)

	Dec-15	Dec-16	Jun-17	Sep-17	Dec-17
Asset Quality					
NPLs to Loans	6.7	7.7	7.8	8.0	8.3
Prov to NPLs	30.1	31.3	31.5	32.3	42.3
Loan Growth	7.8	4.0	6.2	6.3	3.9
Asset Growth	49.1	11.9	4.5	4.9	7.8
Profitability					
Return on Avg Assets	0.4	0.5	0.7	0.7	0.6
Liquidity					
Loan to Deposits	68.8	63.7	65.0	65.2	60.8
Capital					
Capital to Asset Ratio	9.0	8.4	8.7	8.6	8.3

Source: NBP

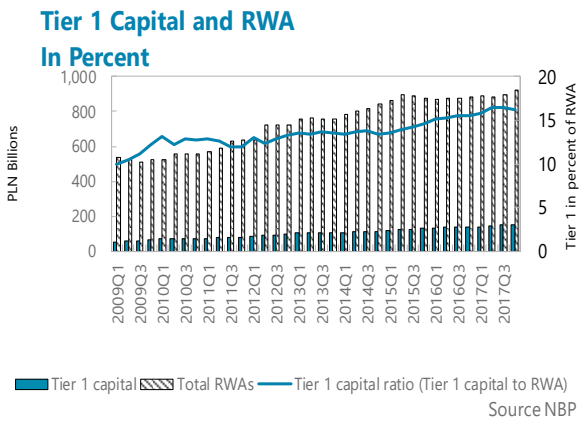
Annex I. Table 3. Poland: Financial Soundness Indicators (Commercial Banks by Ownership)

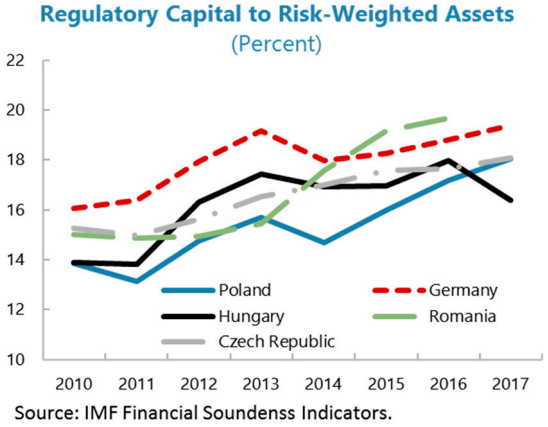
(2017Q4, in Percent)

	State-controlled	Domestic private	Foreign-controlled
Asset Quality			
NPLs to total loans	5.8	12.5	4.9
Loan loss reserve to NPLs (Coverage)	59.6	42.0	62.3
LLR to total loans	3.5	5.3	3.0
Prov for loan loss to total loans	1.3	3.3	1.1
Annualized loan growth	4.9	-0.7	2.1
Texas ratio	0.3	0.8	0.3
Profitability			
Net Interest Margin	3.0	2.0	2.6
Efficiency (cost/income)	45.4	41.2	47.2
ROAA	1.0	-0.3	0.9
ROAE	12.9	-6.4	12.2
Trading gains to income	4.0	2.0	5.4
Liquidity and Funding			
Loan-to-deposit (LTD)	100.1	115.3	102.5
Liquid assets / total assets	20.5	18.9	24.0
Liquid assets / short term liabilities	23.2	20.4	27.3
Wholesale funding	12.2	36.9	18.3
Capital Adequacy			
Capital adequacy ratio (CAR)	18.4	13.1	18.7
Tier 1 capital ratio (Tier 1 capital to RWA)	17.0	10.6	16.5
Financial Leverage (times)	8.6	13.2	8.4
Foreign currency (FX)			
FX loans to total loans	17.3	19.5	28.9
FX deposits to total deposits	13.4	13.4	13.4

Source: NBP

Annex I. Figure 1. Poland: Capital

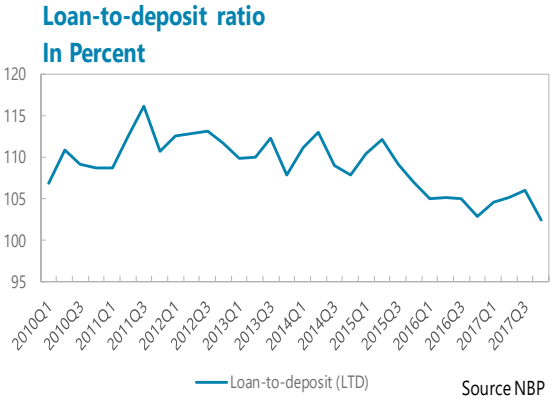




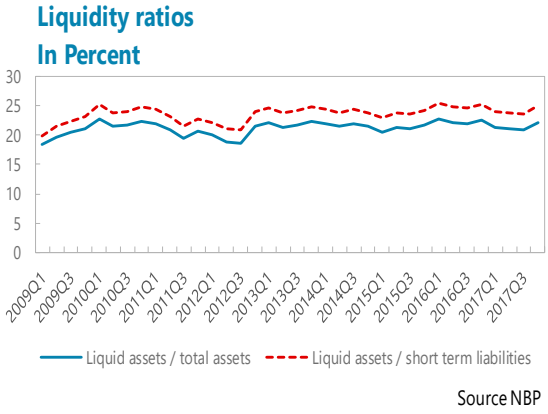
Note: the NBP data is for commercial banks only; the IMF data refers to the banking sector.

Annex I. Figure 2. Poland: Bank Liquidity

The loan to deposit ratio has declined in recent years…



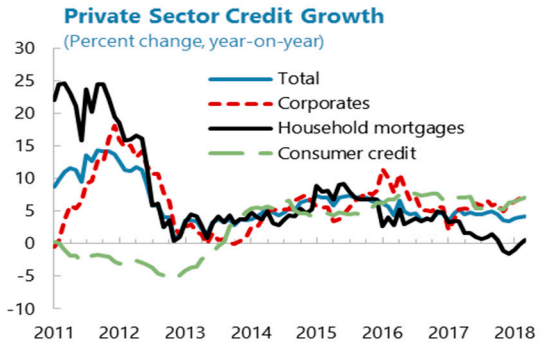
…while the liquidity ratios have been quite stable.



Note: the NBP data refers to commercial banks only.

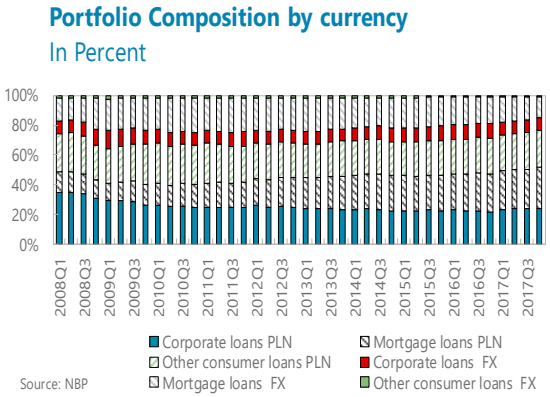
Annex I. Figure 3. Poland: Credit Growth and Asset Quality

Credit growth remains relatively low…

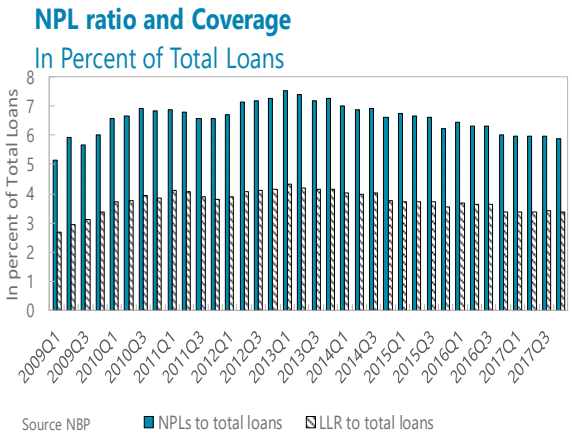


Sources: Haver Analytics, Bank of Poland, and IMF staff calculations.

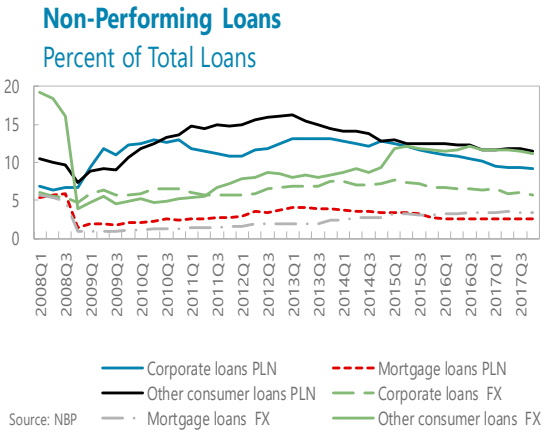
…and the share of FX mortgages is declining.



The NPL ratio has continued to moderate…



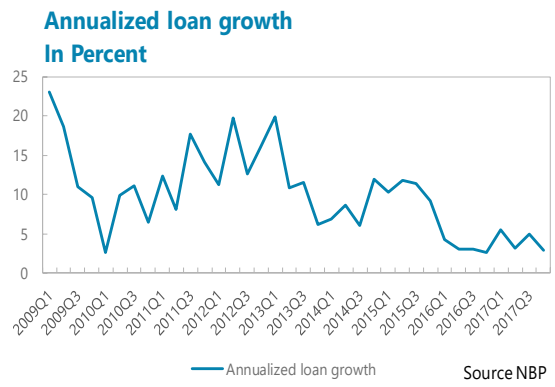
…with the NPL ratio in mortgages being the lowest loan segment.



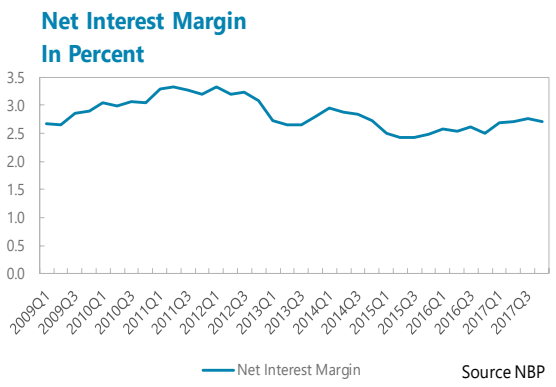
Note: credit growth refers to the banking sector; all other charts refer to commercial banks.

Annex I. Figure 4. Poland: Bank Profitability

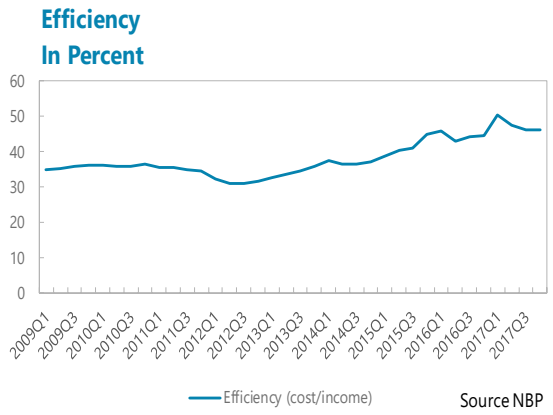
Asset growth has slowed...



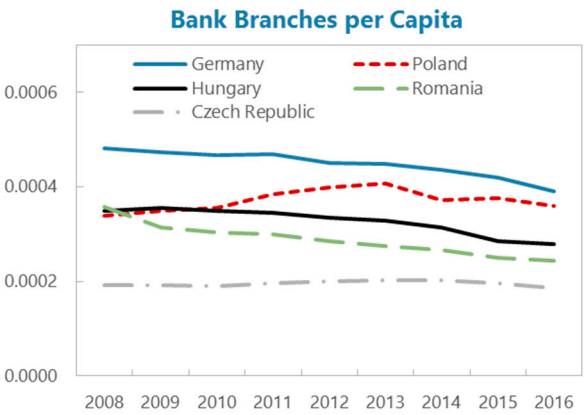
...while NIMs, though still sound, show moderation.



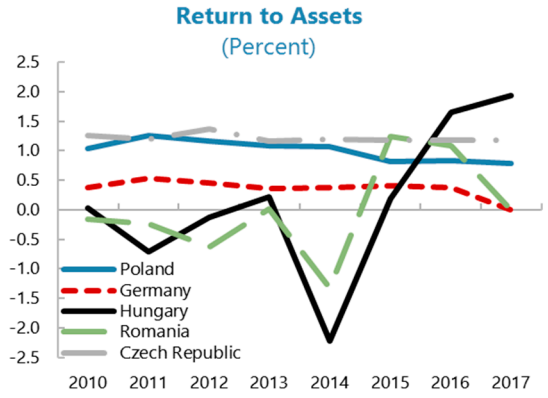
And costs have risen in part due to the FIAT....



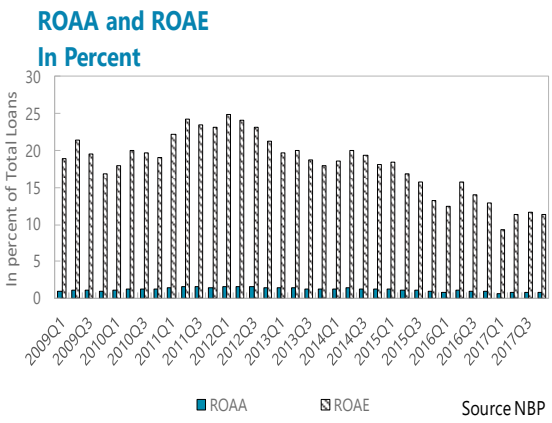
...with relatively high branch density.



Though little affected by the crises, the return on assets has declined in recent years....



...with similar trends in the return on equity.



Note: the NBP data is for commercial banks only; ECB and FSI data is for the banking sector.

Annex II. Risk Assessment Matrix

Annex II. Table 1. Poland: Risk Assessment Matrix

Source of Risks	Overall Level of Concern	
	Likelihood of realization in 1–3 years	Expected Impact
External		
Tighter and more volatile global financial conditions.	**High/Medium** Financial market stress arises from politically driven de-globalization initiatives in Europe and the United States. Tighter global financial conditions: Fed normalization and tapering by the ECB increase global rates and the term premia, strengthen the U.S. dollar and the euro vis-a-vis the other currencies, and correct market valuations. Adjustments could be disruptive if there are policy surprises. Higher debt service and refinancing risks could stress leveraged firms, households, and vulnerable sovereigns, including through capital account pressures in some cases. European bank distress: Strained bank balance sheets amid a weak profitability outlook could lead to financial stress to some euro area banks, with possible knock-on effects, including a sell-off in stock markets.	**High/Medium** Significant further strengthening of the U.S. dollar and a faster-than-anticipated U.S. monetary policy normalization could put pressure on the capital account. Investors could reallocate assets away from Poland with a rise in risk aversion, resulting in capital flow reversals and zloty depreciation. A depreciation could adversely impact the quality of foreign currency loans (including in Swiss Francs). Tighter financial conditions could lead to a decline in credit supply. Increased default risk for banks would further impair profitability. Substantial increases in high spread euro area sovereign yields would cause valuation losses in banks. Banks would take a hit in capital ratios, as interest and trading income deteriorate further. Alternatively, banks may search for yield and take up excessive risks.
Policy and geopolitical uncertainties.	**High** Policy uncertainties in the US and Europe could slow down or even reverse cross-border integration, international trade liberalization and financial flows. Two-sided risks to U.S. growth with difficult-to-predict policies and global spillovers. In Europe, uncertainty associated with negotiating post-Brexit arrangements. Policy divergence could lead to rising global imbalances and exacerbate exchange rate and capital flow volatility.	**Medium** Potential damage to global supply chains, reduced trade and FDI, and increased capital flow volatility could adversely impact the Polish economy and financial markets. Uncertainty can weigh on market sentiment, lead to confidence losses and dampen private consumption and investment. Bank credit losses and NPLs could increase as growth slows, which would impact banks' capital position and profitability.

Annex II. Table 1. Poland: Risk Assessment Matrix (continued)		
Source of Risks	**Overall Level of Concern**	
	Likelihood of realization in 1–3 years	**Expected Impact**
Weaker-than-expected growth in key advanced and emerging economies.	**Medium** Structurally weak growth in key advanced economies: Low productivity growth (US, the Euro Area, and Japan), a failure to fully address crisis legacies and undertake structural reforms, and persistently low inflation (the Euro Area, and Japan) undermine medium-term growth in advanced economies. Significant China slowdown and its spillovers: Efforts to rein in financial sector risks, though desirable, expose vulnerabilities of indebted entities and reduce near term growth. Weak domestic demand would lower commodity prices, roils global financial markets, and reduces global growth. Significant slowdown in other large EMs/frontier economies: Resource misallocation and policy missteps could exacerbate the impact of declining productivity and potential growth. The turning of the domestic credit cycle could generate disorderly household and corporate deleveraging and increase default probability.	**High/Medium** Significant trade linkages with Europe would weaken growth in Poland through lower exports and adverse confidence effects. Indirect trade linkages to China through the German supply chain would lower Polish exports to Germany and other CEE countries. A global recession would fuel credit and market risk and deteriorate asset quality. The correction of overvalued asset prices triggers wealth and confidence effects which weigh on consumption and investment. Provisioning needs for banks would increase considerably, negatively affecting already low profitability. Some banks may search for yield and take up excessive short-term risks in an environment of higher financial market volatility.

Annex II. Table 1. Poland: Risk Assessment Matrix (concluded)

Source of Risks	Overall Level of Concern	
	Likelihood of realization in 1–3 years	Expected Impact
Domestic		
Domestic policy uncertainty and slippages	**Medium** Inflation could accelerate faster than expected which would require more abrupt tightening. Rapid tightening of interest rate could dampen domestic consumption and investment. Fiscal slippages and the weakening of key institutions could result in rating downgrades and increase the perceived risk and uncertainties. The interaction of fiscal and financial sector policy missteps could result in a vicious cycle of weaker public finances and financial sector health and lower growth. Policy uncertainties surrounding the final solution to address consumer protection concerns associated with swiss franc mortgage loans and the potential cost could impact bank balance sheet and confidence.	**High** Tighter domestic financial condition could dampen credit and increase NPL ratio and impair asset quality. Tighter financial conditions both externally and domestically would hurt consumption and investment. Rating downgrades could push up financing costs and banks' funding costs. Higher cost would then impact bank profitability and its ability to accumulate capital. A rise in Polish sovereign bond yield could also lead to valuation losses for banks as they hold a sizable share of domestic government bond. Potential costly solution to swiss franc mortgage loans could further impair bank profitability.

Note: The Risk Assessment Matrix (RAM) shows events that could materially alter the baseline path (the scenario most likely to materialize in the view of IMF staff). The relative likelihood of risks listed is the staff's subjective assessment of the risks surrounding the baseline ("low" is meant to indicate a probability below 10 percent, "medium" a probability between 10 and 30 percent, and "high" a probability of 30 percent or more).

Annex III. Cyber Risks

Cyber risks are monitored under financial institutions' operational risk management framework in Poland.[1] The type of cyber risks analyzed by the authorities and financial intermediaries include malware, phishing, Distributed Denial of Service (DDoS) attacks, advanced persistent threat (APT), data confidentiality and integrity breaches, among others. For the central counterparty (CCP), the monitoring of cyber risks is particularly important, given the legal requirement that the maximum recovery time for the CCP's critical functions shall not exceed two hours.

Financial intermediaries use business impact analysis and stress tests to assess the impact of potential cyber events. For the commercial bank, annual business impact analysis and stress tests with cyber risk scenarios are performed, with a focus on APT and DDoS type of threats. The CCP uses a model-based approach to consider cyber risk scenarios including hacking, theft or loss of data and breaches in their impact analysis. In addition, financial intermediaries developed Business Continuity Plans and Disaster Recovery Procedures to mitigate the impact of emergency events, including cyberattacks. While financial intermediaries have not purchased dedicated *cyber insurance*, cyber risks are covered by other insurances that target fraudulent activities and IT crimes.

The authorities have made efforts to collect information related to cyber risks, however, more granular information could only be gathered with new regulations. Currently, the NBP in cooperation with the European Central Bank (ECB) and the PFSA collect cyber-related self-assessments, as part of the Cyber Resilience Strategy developed by the ECB. The PFSA collects information on security incidents and electronic banking through the quarterly reports of key risk indicators from all commercial and cooperative banks in Poland. However, detailed information on the number, type of cyber-attacks and the incurred losses could only be collected with the issuance of the necessary domestic executive regulations.

At the current juncture, cyber risks are not considered systemic by the PFSA. The PFSA estimated the potential loss exposure in electronic banking channel (due to lawsuits) to be about 26 million Zloty for commercial banks, and 1.6 million Zloty for cooperative banks in 2017, accounting for about 0.001 percent of GDP in total. However, losses from potential disruption of services or indirect reputational impact from cyber risks could be much higher.

[1] The annex on cyber risks is based on questionnaire responses from the NBP, the PFSA, and financial intermediaries including the CCP and one commercial bank.

Annex IV. Solvency Stress Test—Credit Risk Estimations

For credit risk estimations, NPL ratios were projected for individual banks for three exposure classes: corporate, mortgage and consumer. The bank-by-bank historical information was provided by the NBP at quarterly frequency from 2008Q1 to 2017Q4, and the macroeconomic series were taken from the IMF International Financial Statistics, the IMF World Economic Outlook database and Haver Analytics.

The NPL ratios were transformed using logistic transformation to capture non-linearities and to ensure that the projections were bounded between 0 and 1. The logistic transformation captures the non-linearities between the NPL ratios (dependent variable) and macrofinancial variables (explanatory variables). Specifically, the following logistic transformation was applied to the original NPL ratios:

$$Y_{k,j,t} = \ln\left(\frac{NPL_{k,j,t}}{1 - NPL_{k,j,t}}\right),$$

where $NPL_{k,j,t}$ denotes the NPL ratio for bank *k*, exposure class *j*, at time *t*.

The panel regressions are estimated with the Arellano-Bover/Blundell-Bond linear dynamic panel-data estimator with robust standard errors[1], specified as follows:

$$Y_{k,j,t} = \alpha + \vartheta_k + \delta Y_{k,j,t-1} + \phi' X_t + \varepsilon_{k,j,t} \qquad (1)$$

where $Y_{k,j,t}$ captures the logistic transformation of the NPL ratio for bank *k*, exposure class *j*, at time *t*, and X_t is a vector of macro-financial variables specified in the stress testing scenarios. $Y_{k,j,t-1}$ is the vector of lagged dependent variables and $\varepsilon_{k,j,t}$ represents independently and identically distributed error term. A dynamic panel regression was estimated for each exposure class *j*.

Bayesian model averaging (BMA) for panel regressions was used to guide the selection of variables and lags, where appropriate. Following the approach in Japan FSAP (2017), the regressors that found to be most significant using Bayesian model averaging were then used as inputs for dynamic panel GMM estimations.

The projected logit NPLs under baseline and adverse scenarios were then transformed into NPL ratio forecasts. Specifically, the projected NPL ratios were computed using the inverse of the logistic function:

[1] A dynamic panel regression is specified due to the persistence in profitability and some income components. An alternative fixed effect static panel was specified as a robustness check and the results were found to be broadly similar. The Arellano-Bover/Blundell-Bond system estimator is an extension of the Arellano-Bond estimator that accommodates large autoregressive parameters and a large ratio of the variance of the panel-level effect to the variance of idiosyncratic error. The Arellano-Bover/Blundell-Bond system estimator is designed for datasets with many panels and few periods, which is the case for our datasets.

$$NPL_{k,j,t}^{Proj} = \frac{1}{1 + \exp(-Y_{k,j,t}^{Proj})}$$

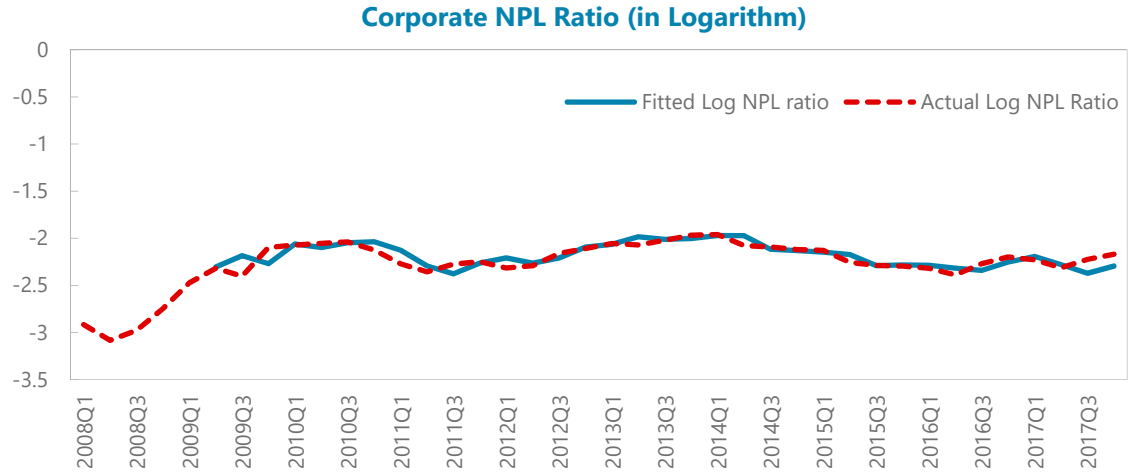
Estimation results suggest that NPL ratios are sensitive to GDP growth, changes in unemployment rates, exchange rates, wage growth and interest rates. The satellite model for corporate exposure showed that a decline in real GDP and equity prices and a rise in the unemployment rate could lead to an increase in corporate sector default rate. Mortgage default rates were sensitive to the unemployment rate, house price changes and movements in the Swiss Franc/Zloty exchange rate, due to the remaining Swiss Franc mortgage loans on banks' balance sheet. Exchange rate risks associated with the Swiss Franc appreciation was in part captured by the satellite model for mortgage loans. Consumer loan default rates were associated with wage growth and long-term interest rates (Annex IV. Table 1 and Annex IV. Figure 1).

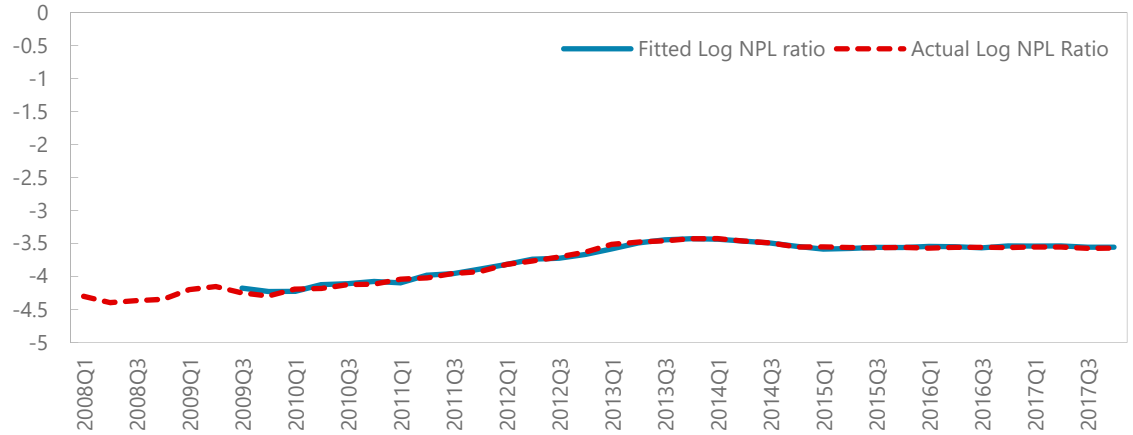
Annex IV. Table 1. Poland: NPL Estimation Equations

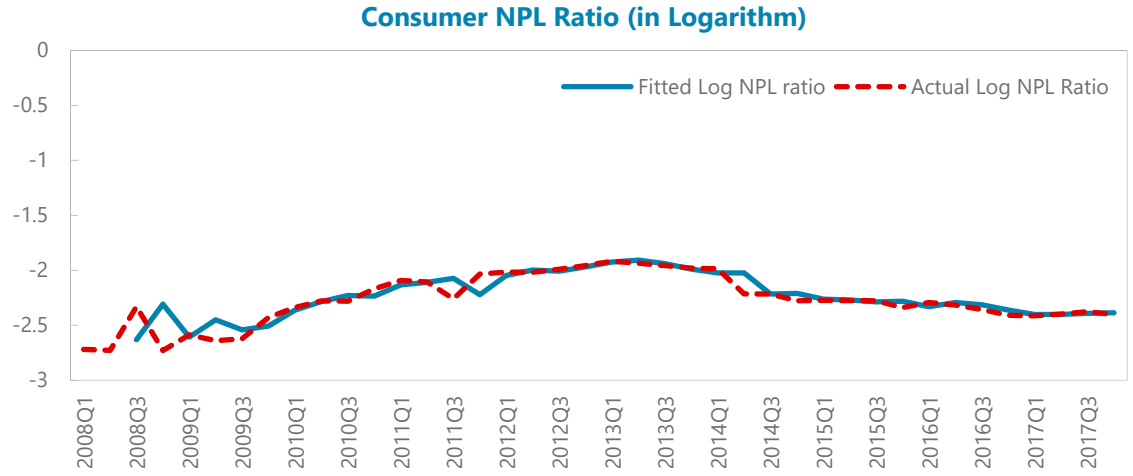
Variables	(1) Corporate	(2) Mortgage	(3) Consumer
Lagged dependent variable	0.899***	0.883***	0.821***
	(0.12)	(0.04)	(0.06)
GDP growth (t-2)	-0.0172*		
	(0.01)		
Annual change in unemployment rate (t-1)	0.0280**		
	(0.01)		
Annual change in unemployment rate (t-2)		0.0329*	
		(0.02)	
Swiss Franc/Zloty exchange rate (t-2)		0.0863**	
		(0.04)	
Wage growth (t-2)			-0.0100*
			(0.01)
YoY Change in Equity Prices	-0.00151*		
	(0.00)		
YoY Change in House Prices		-0.00246**	
		(0.00)	
Long Term Interest Rates			0.0273***
			(0.01)
Constant	-0.14	-0.700***	-0.463***
	(0.24)	(0.20)	(0.11)
Observations	1,055	828	1,092
Number of Banks	31	26	30

Note: Robust standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1.
Arellano-Bover/Blundell-Bond linear dynamic panel-data estimation with robust standard errors.

Annex IV. Figure 1. Poland: In-Sample Fit of Credit Risk Satellite Models







Annex V. Solvency Stress Test—Funding Rate Estimations

Bank funding costs are estimated based on market funding conditions using dynamic panel regression model. The bank-by-bank historical information was provided by the NBP at quarterly frequency from 2008Q1 to 2017Q4, and the macroeconomic series were taken from the IMF International Financial Statistics and Haver Analytics. The funding cost estimations were based on Arellano-Bover/Blundell-Bond linear dynamic panel-data estimator with robust standard errors, for 34 commercial banks in the solvency stress testing sample, specified as:

$$Y_{k,t} = \alpha + \vartheta_k + \delta Y_{k,t-1} + \phi' X_t + \varepsilon_{k,t} \qquad (1)$$

where $Y_{k,t}$ captures the funding rate for bank *k,* at time *t,* and X_t is a vector of macro-financial variables specified in the stress testing scenarios. $Y_{k,j,t-1}$ is the vector of lagged dependent variables and $\varepsilon_{k,j,t}$ represents independently and identically distributed error terms.

Bank funding rates are significantly associated with short-term and long-term interest rates. Regression results suggest that an increase in short-term and long-term interest rates could lead to a rise in funding costs for banks (Annex V. Table 1 and Annex V. Figure 1).

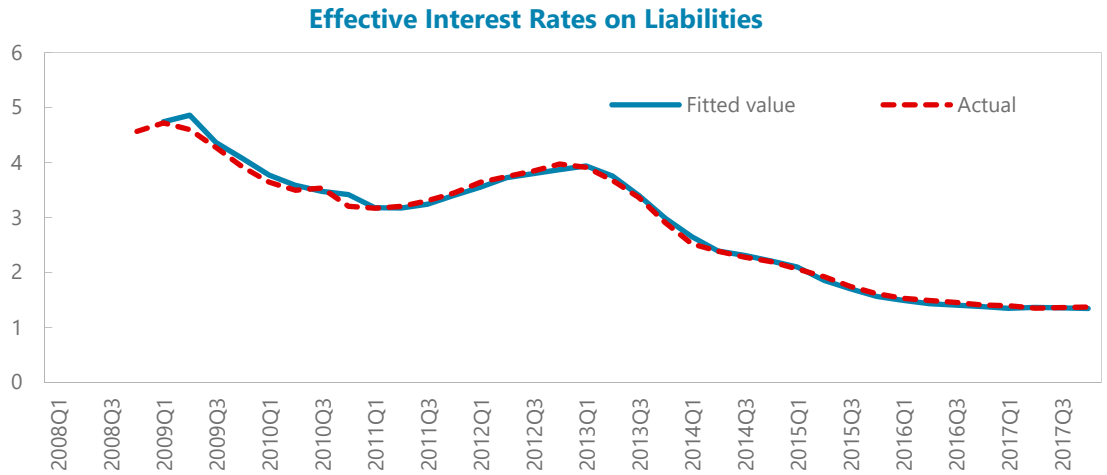
Annex V. Table 1. Poland: Funding Rate Estimation

Variables	Effective Interest Rate on Liabilities
Lagged dependent variable	0.677***
	(0.03)
3-month Wibor (t-2)	0.224***
	(0.03)
Long term interest rate (t-2)	0.0500***
	(0.02)
Constant	-0.111**
	(0.06)
Observations	1,194
Number of Banks	34

Note: Robust standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1.

Arellano-Bover/Blundell-Bond linear dynamic panel-data estimation with robust standard errors.

Annex V. Figure 1. Poland: In-Sample Fit of Funding Rate Satellite Model



The relationship between changes in funding rates and in lending rates in the adverse scenario was then estimated using quantile regressions (at 80 percent quantile). The imperfect pass-through of changes in funding rates to lending rates implies a tightening in interest rate margins for banks in the stress testing scenario (Annex V. Table 2).

Annex V. Table 2. Poland: Quantile Regression for Lending Rates

Variables	Change in Effective Interest Rate on Assets
Change in Effective Interest Rates on Liabilities	0.521***
	(0.06)
Constant	-0.045*
	(0.03)

Note: Robust standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1.
Method: Quantile regression (tau = 0.8); Sample (adjusted): 2009Q4 to 2017Q4.
Adjusted R-squared: 0.505.

Annex VI. Background Risk Analysis of FX Mortgages[1]

1. **Mortgage loans extended in foreign currency (FX mortgages), mostly in Swiss franc, became popular in Poland in the run-up to the Global Financial Crisis (GFC).** As in other regional peers, Poland had seen a boom of Swiss franc-denominated mortgages prior to the GFC, thanks to the sizeable differential between the Swiss and Polish interest rates and a favorable PLN/CHF exchange rate. The size of the FX mortgage portfolio grew from 2 percent of GDP (around 60 percent of total outstanding housing loans) at end-2004 to 11 percent of GDP (around 70 percent of total outstanding housing loans) by end-2008 (Annex VI. Figure 1). At its peak, the FX mortgage portfolio was relatively wide-spread across the banking sector, with medium-sized and foreign-controlled banks (that are incorporated in Poland) most exposed, and borrowers tended to be wealthier households.

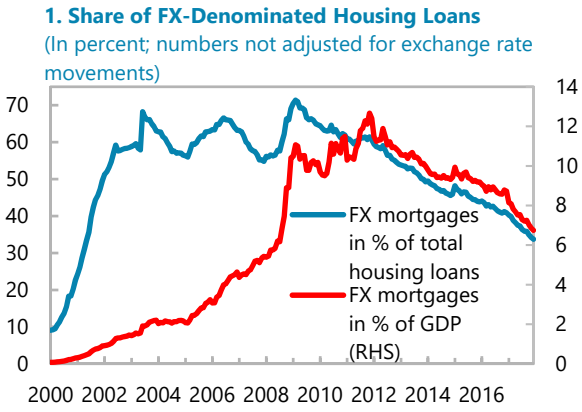
2. **The FX mortgage portfolio has been performing well in the last decade, even during stress episodes—the resilience of the portfolio has been supported by both domestic and external factors.** FX mortgages have had relatively low NPL ratios in the last decade (below 4 percent), even during stress episodes (Annex VI. Figure 1). Notably, when the zloty depreciated significantly during the GFC and following the Swiss National Bank's (SNB) removal of the exchange rate cap on Swiss franc in early 2015, the NPL ratios of this portfolio rose only moderately. Both domestic and external factors have contributed to the resilience of FX mortgages. During the 2015 episode, a key external mitigating factor was the simultaneous reduction in Swiss LIBOR rate, which partially offset the increase in debt service due to the Swiss franc appreciation. Domestically, prudential regulations on FX mortgages have been tightened in steps since 2006, requiring banks to be more diligent in risk assessment and informing customers of all relevant risks, to build buffers on both banks' and borrowers' side (e.g., FX mortgage loans can only be offered to borrowers with higher income buffers; measures have been taken to raise capital requirements for banks exposed to FX mortgages), to limit borrowers' risk exposure, and to eventually ban new FX mortgage loans to unhedged borrowers effectively from 2013.[2] As a result, the stock of FX mortgages started to decline from early 2012 (with an average annual amortization rate of 8 percent in recent years), reaching 6½ percent of GDP by end-2017.

[1] Appendix VI is based on the Background Note on the "Risk Analysis of Foreign-Currency Mortgages."

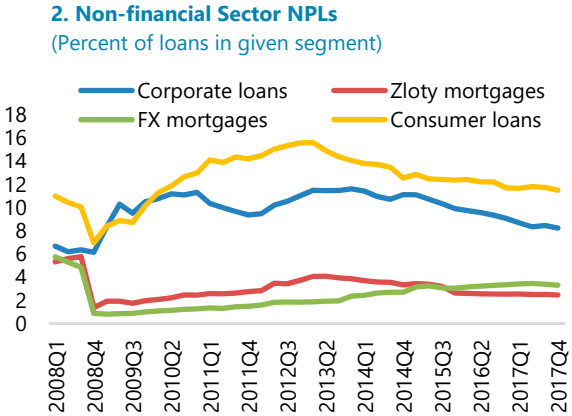
[2] For details, see Box 1 of the Background note on the "Risk Analysis of Foreign-Currency Mortgages."

3. **Despite the resilience of the portfolio, its risk profile deteriorated after the stress episodes, and public debate intensified on potential measures to protect FX mortgage borrowers.** Average LTV ratios for FX mortgage loans increased considerably after the 2015 Swiss franc appreciation, especially for those granted during 2007–08.[3] By end-March 2015, the share of Swiss franc mortgages with LTV higher than 80 and 100 percent reached 68 and 53 percent of total Swiss franc mortgages outstanding.[4] Debt service burden on Swiss franc mortgages also rose considerably. Public concerns on the risks associated with the FX mortgage portfolio have thus increased. While the NBP concluded after the 2015 Swiss franc appreciation that the FX mortgage portfolio posed no systemic risk to banking sector stability,[5] there was an increasing call for measures to protect FX mortgage borrowers as some of the loans were seen to be extended without adequate consumer information.

Annex VI. Figure 1. Poland: FX Mortgages



Sources: National Bank of Poland, and IMF staff calculations.



Sources: National Bank of Poland, and IMF staff calculations.

[3] See the NBP *Financial Stability Report*, January 2015. An additional reason for the increase in the LTV ratios of FX mortgages granted during 2007-08 was the decline in housing prices after 2007.

[4] Based on PFSA survey data including banks with FX loans over 10 percent of total loans.

[5] See the NBP *Financial Stability Report*, January 2015.

4. **Several legislative proposals have resulted from the public debate, but the final decision remains pending.** Four draft bills are currently under Parliamentary discussion. Two of them involve some form of mandatory conversion, submitted by the Civic Platform and Kukiz'15, respectively.[6] The other two were submitted by the President's office in August 2016 and August 2017, respectively. The August 2016 proposal from the President's office requires banks to repay "excessive" FX spreads charged to FX mortgage borrowers. This proposal is assessed to cost between 4 to 9 billion zloty (up to three-quarters of the 2016 banking sector profits)—though less costly than the proposals involving mandatory conversion, it could still exert pressures to banking sector profitability. The August 2017 proposal from the President is to establish a dedicated "Restructuring Fund" with contributions from banks with FX mortgage portfolios—the quarterly contributions (capped at 0.5 percent of the FX mortgage stock) can be used to reimburse banks for costs incurred during FX mortgage restructuring, thus incentivizing banks to offer conversion. Under this proposal, the contribution would be capped at 2¾ billion zloty for the first year, with the current stock of FX mortgages. However, the cumulative cost is difficult to estimate, as the speed of conversion is uncertain, and the cost of each conversion could vary from case to case. Currently, borrowers have little incentive to convert given the substantial interest rate differential. Meanwhile, the FSC-M released nine recommendations in early 2017 to further mitigate risks associated with FX mortgages and to enhance banking sector resilience more generally. The key ones include increasing the risk weight for FX mortgages to 150 percent, imposing a 3 percent systemic risk buffer (from zero percent) regardless of banks' FX mortgage exposure, and requiring additional capital for banks with FX mortgage portfolios. Most of the recommendations have been in effect since late 2017 or early 2018, while progress in voluntary FX mortgage conversion has been limited so far.

5. **The FSAP assesses that risks associated with the FX mortgage portfolio has declined and no systemic policy response is warranted.** The improvement in the quality of the FX portfolio is supported by robust wage growth, favorable Swiss franc interest rates, and income buffers of FX mortgage borrowers. Further tightening in prudential regulations following the implementation of the 2017 FSC recommendations strengthens banks' resilience to exchange rate shocks. The FSAP stress tests show that the impact of a significant exchange rate depreciation on the banking sector solvency is generally contained in aggregate, though pockets of vulnerability exist. Such vulnerabilities, as with any other loans, should be addressed case by case—a systemic policy response is not warranted.

[6] The draft bill submitted by the Civic Platform requires conversion of FX mortgages into zloty-denominated ones at the exchange rate of the day when the restructuring agreement is signed, and the cost shall be divided between banks and borrowers. The bill submitted by Kukiz'15 requires conversion at the exchange rate of the day when the mortgage loan agreement was signed with banks bearing the cost. These two draft bills, though remain under discussion, are deemed less likely to be implemented.

6. **Scenario analysis can be used to gauge the possible range of the cumulative costs if the proposed "Restructuring Fund" is established.** A "no conversion" scenario and a "fast conversion" scenario provide the upper and the lower bound of the cost, respectively (assuming the contributions are set at the maximum level throughout the scenario period). In the "no conversion" scenario, banks pay contributions proportional to a gradually amortizing stock, which defines the upper bound of the cost; in a "fast conversion" scenario, the stock would reduce more rapidly due to conversion, reducing contributions paid by banks. The speed of conversion depends on the amount of debt relief acceptable to both banks and borrowers. We assume that haircut rates that equalize the pre- and post-conversion debt service (in zloty terms) would be acceptable to borrowers, and the cumulative debt relief a bank is willing to offer each quarter is equal to its contribution. It is also assumed that only FX mortgages "at risk" (i.e., with LTV above 80 percent and DSTI above 50 percent) would be converted. Under these key assumptions, ranges of cost are calculated for both the main adverse scenario used in the solvency stress test, and the 30 percent zloty depreciation scenario in the sensitivity analysis:[7]

- ***Under the main adverse scenario, the three-year cumulative cost ranges between 7.3 and 8.1 billion zloty*** (0.2–0.3 percent of RWAs annually). The cumulative amount "at risk" after the shocks is around 26 percent of the end-2017 stock of FX mortgages, which could take 4½ years to convert. Significant haircuts (25–30 percent) are needed to equalize monthly installments pre- and post-conversion. The cost (relative to RWAs) is the highest for larger medium-sized and small banks, as well as for foreign-controlled banks.[8]

- ***Under the 30 percent depreciation scenario, the one-year cost ranges between 3 and 3.3 billion zloty*** (22–25 percent of net profits and other comprehensive income). The total amount "at risk" after the one-time shock is around 75 percent of the end-2017 stock of FX mortgages, which could take 11½ years to convert. A haircut rate of 29 percent is needed to equalize monthly installments pre- and post-conversion.

7. **In conclusion, risks associated with the FX mortgage portfolio has declined and no systemic policy response is needed.** As with any other loans, solutions to distressed FX mortgages should be case-by-case and risk-based. If any policy actions are to be taken to meet objectives other than addressing financial stability risks, they should aim to minimize the adverse impact on bank profitability and financial stability risks.

[7] For more details on the assumptions and calculations, see Box 3 of the Background note on the "Risk Analysis of Foreign-currency Mortgages."
[8] Bank-level cost distribution should be interpreted with caution, as the risk profile of FX mortgages is assumed to be the same across banks due to data limitation.

Annex VII. Regression Analysis on Bank Profitability

1. **The regression analysis on bank profitability considered a sample of 34 commercial banks in Poland, as in the solvency and liquidity stress tests.** The bank-by-bank data on balance sheet was provided by the NBP. The macroeconomic variables were taken from the IMF International Financial Statistics, the IMF World Economic Outlook database and Haver Analytics.

2. **The empirical analysis applies panel data techniques to examine the determinants of profitability.** The panel analysis controls for bank characteristics, business models, industry structures, macroeconomics and cyclical factors and monetary policy. The dependent variables are headline profitability measures including ROAE and ROAA.

3. **The panel regression is estimated with the Arellano-Bover/Blundell-Bond linear dynamic panel-data estimator with robust standard errors,**[1] specified as follows:

$$Y_{k,t} = \alpha + \vartheta_k + \delta Y_{k,t-1} + \phi' X_{k,t} + \Theta' I_t + \Lambda' M_t + \varepsilon_{k,t} \qquad (1)$$

where $Y_{k,t}$ captures headline profitability measures including ROAE and ROAA for bank *k* at time *t*. In order to take into account bank characteristics, we include a set of bank-fixed effects (ϑ_k) and a vector of (time-varying) bank-specific indicators $X_{k,t}$, capturing bank characteristics and bank business models. Banking industry structural indicators, $I_{j,t}$, take into account the extent of concentration in the banking industry. Finally, the macroeconomic and cyclical variables, $M_{j,t}$, capture GDP growth and the level of short-term interest rates, following Albertazzi and Gambacorta (2009).[2]

4. **Bank characteristics account for bank size, credit risk and cost efficiency, while business model variables capture the extent of retail banking.** Bank size is measured by the natural logarithm of total assets. Credit risk is measured by the loss provisioning ratio, and cost efficiency is defined as the cost-to-income ratio following Borio, Gambacorta and Hofmann (2015).[3] Excess capacity in a bank is captured by the number of bank branches per capita (population), which is also a measure of costs. Bank business model is proxied by a measure of income diversification, defined as the share of non-interest income over total revenue (ECB, 2015 and IMF, 2017);[4] and the deposit to total assets ratio that measures the extent of retail banking.

[1] A dynamic panel regression is specified due to the persistence in profitability and some income components. An alternative fixed effect static panel was specified as a robustness check and the results were found to be broadly similar.
[2] Albertazzi and Gambacorta (2009) "Bank Profitability and the Business Cycle", *Journal of Financial Stability*.
[3] Borio, Gambacorta and Hofmann (2015), "The influence of monetary policy on bank profitability" BIS Working paper, No. 514, October 2015.
[4] ECB (2015), "Bank Profitability Challenges in Euro Area Banks: The Role of Cyclical and Structural Factors", Financial Stability Review. IMF (2017), "Spain FSAP Technical Note: Determinants of Bank Profitability", IMF Country Report No. 17/339, 2017.

5. **The banking industry structural indicators, $I_{j,t}$, reflect concentration in the banking sector.** The top-five bank concentration (CR5) index is defined as the market share of the top five institutions in terms of assets (ECB, 2015). The CR5 index moves closely with the Herfindahl index, another measure of concentration and competition.

6. **Polish banks' profitability was driven by a combination of structural and macroeconomic factors.** The cost to income ratio is negatively related to profitability as it is inversely related to cost efficiency. As expected, the more efficient banks are found to be more profitable. Excess capacity measured by the number of bank branches per capita is negatively associated with profitability, as higher branches drive up operating costs for banks. Short-term interest rate is positively related to profitability (in particular ROAA), as the low interest rate environment puts downward pressure on bank profitability (Annex VII. Table 1).[5]

Annex VII. Table 1. Poland: Regression Results From Profitability Analysis

VARIABLES	ROAA	ROAE
Lagged Dependent Variable	**0.813*** **	**0.905*** **
	(0.01)	(0.03)
Average Assets (ln)	0.096	-0.439
	(0.13)	(1.04)
Cost to Income ratio	**-0.00650*** **	**-0.0459*** **
	(0.00)	(0.01)
Non-Interest Income to Revenue Ratio	-0.0572	0.362
	(0.07)	(0.23)
Bank Branch per capita	**-0.0400***	**-0.163** **
	(0.02)	(0.08)
3 month Wibor	**0.0551***	0.109
	(0.03)	(0.28)
Real GDP growth	-0.034	0.116
	(0.03)	(0.11)
Constant	-1.848	10.91
	(2.87)	(24.58)
Observations	1190	1190
Number of Banks	34	34

Note: Robust standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1. All independent variables are lagged by one quarter. Arellano-Bover/Blundell-Bond linear dyanmic panel-data estimation with robust standard errors.

[5] The deposit to asset ratio and the CR5 index are found to be insignificant in most cases. One potential explanation that the proxy for the retail banking is insignificant is that most banks operate under the retail banking model in Poland.

Annex VIII. Contagion Analysis Methodology

1. **Contagion risks were assessed using two different approaches.** The Espinosa-Vega and Sole (2010)[1] methodology was applied to assess contagion of shocks through balance sheet exposures. The Diebold and Yilmaz (2014)[2] methodology was applied to examine contagion of shocks according to market perceptions.

Network Analysis Framework

2. **The analysis based on Espinosa-Vega and Sole (2010) considered both credit and funding shocks.** The interbank analysis assessed the contagion of each individual bank's failure and the contagion of the collective failure of the banks failing the solvency stress test. The available data on interbank networks allowed the analysis to consider both shocks:

a. Credit shock: "Failure" of bank A incurs credit losses to bank B that has claims against A. The credit loss rate assumption controls for the severity of credit cost upon failure. A conservative loss-given-default rate of 100 percent was assumed to capture the impact of an extreme credit shock.[3]

b. Funding shock: "Failure" of bank A forces bank B (that has liabilities against A) to find alternative sources of funding. This results in a fire-sale of liquid assets by bank B to fill the funding gap. Bank B was assumed to lose 35 percent of the funding from bank A, which would be replaced by selling liquid assets at a 50 percent haircut.

3. **The cross-border analysis only considered the credit shock.** Poland does not report international banking statistics to the BIS. Therefore, the FSAP team only had NBP data on Polish banks' total cross-border claims and BIS data on foreign banking systems' total cross-border claims to Poland.[4] Using data on total claims (including all counterparty sectors, not only banks) the FSAP team was only able to analyze the effects of the credit shock assuming the collective failure of all cross-border exposures to each country.

[1] See Espinosa-Vega, M., and Solé, J. (2010), *"Cross-Border Financial Surveillance: A Network Perspective"*, IMF Working Paper, WP/10/105.

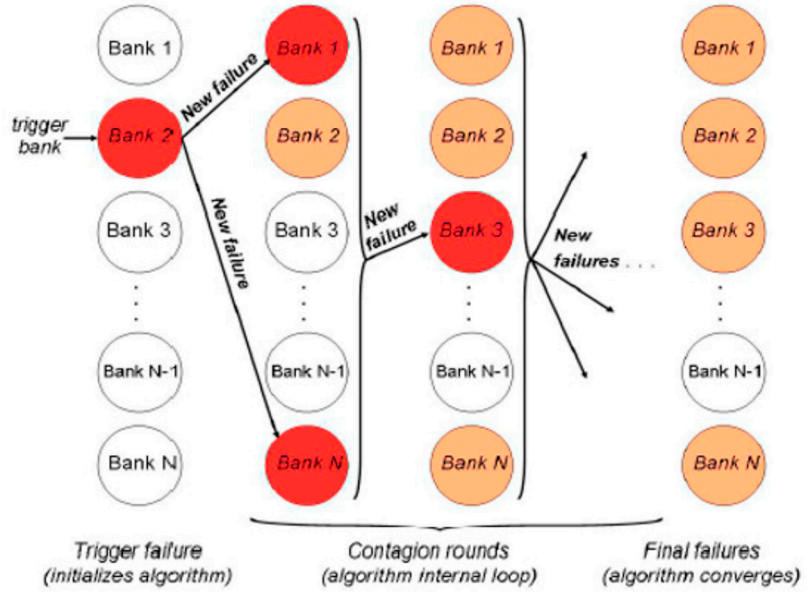
[2] See Diebold, X., D., and Yilmaz, K. (2014), *"On the topology of variance decompositions: Measuring the connectedness of financial firms"*, Journal of Econometrics, no. 182, pp. 119–134.

[3] A loss given default rate of 100 percent is also assumed in Espinosa-Vega and Sole (2010), the Spain 2017 FSAP, the Germany 2016 FSAP, the Italy 2013 FSAP and the 2012 Japan FSAP. Espinosa-Vega and Sole (2010) and Wells (2004) argue that network studies should consider higher loss-given-default estimates than typically assumed, as banks tend to face substantial uncertainty over recovery rates in the short run. The simulation results should be interpreted as the maximum possible impact of systemic instability.

[4] Consolidated exposures on the ultimate risk basis.

4. **A "failure" was assumed to happen when the incurred losses of a bank or banking system exceeded its Tier 1 capital.** In the interbank network analysis, additional rounds of contagion were allowed whenever the failure of one bank caused failures of other banks, triggering so-called "domino effects" (see Annex VIII. Figure 1).

Annex VIII. Figure 1. Poland: Network Analysis Based on Interbank Exposures



Source: Márquez and Martínez (2008) and authors.

Contagion Analysis with Market Data

5. **The Diebold and Yilmaz (2014) methodology estimates a Vector Autoregression (VAR) model with market data.** An interconnectedness measure is then derived from the Generalized Variance Decomposition (Pesaran and Shin, 1998) of the underlying VAR. In contrast to the traditional Cholesky and other structural identification strategies, the Generalized Variance Decomposition (GVD) does not impose any assumptions on the order of variables. Instead it relies on a largely data-based identification scheme ("let the data speak").

6. **The GVD conceptually measures the fraction of changes in one variable attributable to shocks to another variable.** For instance, the GVD analysis reveals that x percent of variation in equity A's (log) returns can be attributed to shocks (innovations) to equity B's (log) return.[5] Note that both A's contribution to B as well as B's contribution to A are calculated, and they are generally different.

[5] Hereafter, A's contribution to B refers to the contribution from A's innovations to B's variation, or B's variation attributable to innovations to A according to the GVD analysis.

7. **Two sets of estimations were conducted as part of the market-based contagion analysis.** The first set of estimations examined the interconnectedness between publicly traded banks and one insurer in Poland, while the second studied the interconnectedness among banking sector equity indices in 19 countries. The methodology was applied to daily log equity and index returns. For the cross-border analysis, average two-day log returns were used to control for the differences in trading hours due to different time zones (Forbes and Rigobon, 2002 and Malik and Xu, 2017).[6]

8. **The FSAP team derived a set of pair-wise directional connectedness measures between institutions and indices, based on the GVDs**. The pairwise connectedness measure captures the extent to which the returns of one institution or index could explain that of another one. Total connectedness describes the overall level of co-movement in a sample of variables. The net contribution of a variable describes its relative influence on the other variables in the sample.

[6] See Forbes, K. J. and Rigobon, R. (2002), "*No Contagion, Only Interdependence: Measuring Stock Market Comovements*," Journal of Finance, 57, 2223–2261; Malik, S. and Xu, T. (2017), "*Interconnectedness of Global Systemically-Important Banks and Insurers."* IMF Working Papers 17/210, International Monetary Fund.

Annex IX. Table 1. Poland: Stress Test Matrix: Solvency Risk (Using December 2017 Data)			
Banking Sector: Solvency Risk			
Domain		**Assumptions**	
		Top-down by FSAP Team	Top-down Sensitivity Analysis by the NBP
	Institutions included.	• 34 commercial banks	• 553 cooperative banks
1. Institutional Perimeter	Market share	• 85 percent of total banking sector assets	• 7 percent of total banking sector assets
	Data and baseline date	• European reporting templates (FINREP and COREP). • Supervisory data from the NBP, based on national reporting templates. • Macro-financial data from Haver Analytics, Datastream and WEO. • December 2017 data. • Scope of consolidation: perimeter of individual banks (including foreign subsidiaries).	• Supervisory data, based on national reporting templates (more detailed than FINREP and COREP). • December 2017 data. • Scope of consolidation: perimeter of individual banks.
2. Channels of Risk Propagation	Methodology	• Macroeconomic scenarios quantified using IMF Macro-financial model (Vitek, 2016). • Detailed balance sheet stress test, covering key risk-sensitive exposures. • Based on satellite models and methodologies developed by the FSAP team.	• Sensitivity analysis, covering counterparty, credit and interest rate risks.
	Satellite Models for Macro-Financial linkages	• Credit losses: the nonperforming loan ratios and provisioning ratios are estimated and projected by three main sectors: mortgage, other-consumer and corporate. The projections are based on various macro and financial variables, such as GDP growth,	• N/A.

Annex IX. Table 1. Poland: Stress Test Matrix: Solvency Risk (Using December 2017 Data) (continued)			
BANKING SECTOR: SOLVENCY RISK			
Domain		**Assumptions**	
		Top-down by FSAP Team	Top-down Sensitivity Analysis by the NBP
		unemployment rate, interest rates, house price growth and wage growth. • Funding costs are estimated and projected based on macro-financial factors such as 3-month Wibor and sovereign bond yields. • NPLs assumed to not provide any accrued interest.	
	Stress test horizon	• Three-year horizon: 2018–20.	• Instantaneous sensitivity analysis.
3. Tail shocks	Scenario analysis	• Macroeconomic scenario analysis: agreed between the FSAP team and the authorities. • The baseline scenario is based on the December 2017 World Economic Outlook (WEO) projections. • The adverse scenario features external financial market stress and growth slowdown and captures the macrofinancial impact of domestic policy uncertainty. The narrative assumes financial market stress and a tightening in financial conditions in systemic economies, heightened uncertainty and confidence losses in Europe and the United States, as well as protectionist measures in Europe and the United States that ultimately lead to growth slowdown, given constrained macroeconomic policy responses. It also assumes domestic policy slippages,	• N/A.

Annex IX. Table 1. Poland: Stress Test Matrix: Solvency Risk (Using December 2017 Data) (continued)			
BANKING SECTOR: SOLVENCY RISK			
Domain		**Assumptions**	
		Top-down by FSAP Team	Top-down Sensitivity Analysis by the NBP
		weakening in key institutions and heightened uncertainty weighing on confidence and consequently consumption, investment and output	
	Sensitivity analysis	• Sensitivity tests evaluate the effects of additional exchange rate shocks (30 percent Zloty depreciation); interest rate shocks; and counterparty risk shocks (simultaneous default of the five largest non-financial borrowers) for the commercial banking sector.	• Sensitivity tests evaluate the effects of counter party risk shocks (simultaneous default of the five largest non-financial borrowers); credit shocks and interest rate shocks for the cooperative banking sector.
4. Risks and Buffers	Risks/factors assessed	• Risks assessed include: credit, market (equity risks, exchange and interest rates), sovereign (repricing and spread risks), funding interest rate risk in the banking book and concentration risk.	• Risks assessed include: credit, interest rates and concentration risk.
	Behavioral adjustments	• Balance sheet grows in line with nominal GDP, with a floor set at zero, and accounting for differentiated risk weights for domestic and foreign currency mortgage portfolios. • Dividends are paid out by banks that remain adequately capitalized with positive profits throughout the stress, taking into account their FX mortgage exposures, in	• N/A.

Annex IX. Table 1. Poland: Stress Test Matrix: Solvency Risk (Using December 2017 Data) (concluded)			
Banking Sector: Solvency Risk			
Domain		**Assumptions**	
		Top-down by FSAP Team	Top-down Sensitivity Analysis by the NBP
		accordance to the dividend policy of the PFSA. • Invariant asset allocation, i.e., no change in business models, lending standards, or investment pattern in response to shocks (over three years).	
5. Regulatory and Market-Based Standards and Parameters	Calibration of risk parameters	• Based on credit models estimated by IMF staff. Credit losses are calculated through the estimation of satellite models using NPL ratios and historical provisioning ratios.	• N/A.
	Regulatory/ Accounting and Market-Based Standards	• CRD IV / CRR fully loaded levels for CET1. • Capital shortfalls to be measured in terms of CET1, T1, total capital and the leverage ratio.	• CRD IV / CRR fully loaded levels for CET1. • Capital shortfalls to be measured in terms of CET1, T1, total capital and the leverage ratio.
6. Reporting Format for Results	Output presentation	• System-wide capital shortfall • Number of banks and percentage of banking assets in the system that fall below certain ratios.	

Annex IX. Table 2. Poland: Stress Test Matrix: Liquidity Risk (Using December 2016 Data)			
BANKING SECTOR: LIQUIDITY RISK			
Domain		**Assumptions**	
		Top-down by the FSAP team	Top-down by the NBP
1. Institutional Perimeter	Institutions included	• 34 commercial banks (including domestic, state-owned and foreign-owned but excluding foreign-owned branches)	• 553 cooperative banks
	Market share	• 85 percent of total banking sector assets	• 7 percent of total banking sector assets
	Data and baseline date	• Latest data: December 2017. • Source: supervisory data (COREP/FINREP). • Scope of consolidation: perimeter of individual banks.	• Latest data: December 2017. • Source: supervisory data (NBP). • Scope of consolidation: perimeter of individual banks.
2. Channels of Risk Propagation	Methodology	• An extended Basel III LCR scenario with variants (retail/wholesale/combined shock).	• An extended Basel III LCR scenario with variants (retail/wholesale shock)
3. Risks and Buffers	Risks	• Funding liquidity (liquidity outflows). • Market liquidity (price shocks).	• Funding liquidity (liquidity outflows)
	Buffers	• Counterbalancing capacity. • Central bank facilities.	• Counterbalancing capacity. • Central bank facilities.
4. Tail shocks	Shocks	• Run-off rates calculated following historical events and LCR/NSFR rates. • Bank run and dry up of wholesale funding markets, taking into account haircuts to liquid assets.	
5. Regulatory and Market-Based Standards and Parameters	Regulatory standards	• Basel III liquidity standards for LCR and NSFR • For LCR, see: BCBS (2013), The Liquidity Coverage Ratio and liquidity risk monitoring tools, Basel, January 2013. • For NSFR, see: BCBS (2014), Basel III: The Net Stable Funding Ratio, October 2014.	
6. Reporting	Output presentation	• Liquidity ratios, disaggregated by type (domestic vs. foreign) and size of bank	

Annex IX. Table 3. Poland: Stress Test Matrix: Interconnectedness Analysis

Domain		Framework
Cross-border analysis	Data and Methodology	The FSAP team applies two approaches to examine interconnectedness and contagion, based on cross border exposure and market data: <u>Espinosa-Vega and Sole (2010) methodology</u> • Examine cross-border banking sector exposures, with the BIS consolidated banking statistics, NBP data and regulatory capital data from FSI as of 2017. Note that data on Polish banks' exposures are not available in BIS statistics, limiting the analysis to one simulation. • Simulation: Positions include aggregate total exposures. Consider the impact of credit shocks to total foreign claims using NBP and BIS consolidated statistics. • List of economies considered: France, United Kingdom, Germany, Czech Republic, Luxembourg, United States, Netherlands, Belgium, Italy, Ireland, Sweden, Austria, Switzerland, Portugal, Spain, Japan, Russia, South Korea, Greece, Australia, Canada, Taiwan Province of China, Finland, Turkey, Chile, Norway, Slovakia, Ukraine, and Cyprus. <u>Diebold and Yilmaz (2014) methodology</u> • Examine the cross-border interconnectedness between the banking sector in Poland and other countries with strong financial and trade linkages with Poland. • The data will be sourced in the beginning of May 2018 at daily frequency using as longtime series as possible. • Equity returns are computed as the average two-day log returns to control to the differences in trading hours due to time zones. • The interconnectedness measure is derived from the forecast error variance decomposition of the underlying VAR. • List of countries to be considered: France, United Kingdom, Germany, Czech Republic, United States, Netherlands, Belgium, Italy, Ireland, Sweden, Austria, Switzerland, Portugal, Spain, Japan, Norway, Slovenia, and Russia.

Annex IX. Table 3. Poland: Stress Test Matrix: Interconnectedness Analysis (concluded)		
Domain		**Framework**
Interbank market analysis	Data and Methodology	The NBP conducted the interbank market analysis. Espinoza-Vega and Sole (2010) methodology • Conduct three simulations separately for loans only and all exposures. • Examine the interconnectedness among the 34 commercial banks, 553 cooperative banks, and 352 foreign bank counterparties. • The source for the interbank bilateral exposure data and the regulatory capital data: the NBP (2017Q4). • Simulation 1: The standard Espinosa-Vega and Sole simulation testing contagion of each bank's failure. A bank is assumed to fail when losses exceed Tier 1 capital. • Simulation 2: The Espinosa-Vega and Sole simulation testing contagion due to the collective failure of the banks that fail the solvency stress test at the end of the horizon. Two thresholds will be tested: (i) a 6 percent Tier capital ratio in line with solvency stress test assumptions, and (ii) a 3.5 percent Tier 1 capital ratio in line with standard NBP assumptions. • Simulation 3: The Espinosa-Vega and Sole simulation testing contagion due to each foreign bank exposure's failure. A bank is assumed to fail when losses exceed Tier 1 capital.
Cross-sector analysis	Data and Methodology	Diebold and Yilmaz (2014) methodology • Bank and insurance linkages within Poland • Examine the spillover risks among publicly listed Polish banks and one insurance company • Use as daily equity returns from 15/08/2015 to May 2018 for publicly listed Polish banks and insurers. The index of connectedness will be constructed based on data from 12/05/2010 but with fewer institutions. Robustness checks are made to see that results of estimations on long and short-time series are consistent. • Interconnectedness measure is derived from the variance decomposition of the VAR.