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FINLAND

FINANCIAL SECTOR ASSESSMENT PROGRAM

TECHNICAL NOTE ON SYSTEMIC RISK ANALYSIS AND STRESS TESTING

February 2023

This Technical Note on Systemic Risk Analysis and Stress Testing for the Finland FSAP was prepared by a staff team of the International Monetary Fund as background documentation for the periodic consultation with the member country. It is based on the information available at the time it was completed on January 20, 2023.

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January 20, 2023

TECHNICAL NOTE

SYSTEMIC RISK ANALYSIS AND STRESS TESTING

Approved By
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Prepared By
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This report is based on the work of the Financial Sector Assessment Program (FSAP) mission that visited Finland in September 2022. The FSAP findings were discussed with the authorities during the Article IV consultation mission in consultation mission in September 2022 (the close of the FSAP) and in November 2022 (the Article IV Consultation).

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Glossary

AC	Amortized Cost
ARIMA	Autoregressive Integrated Moving Average
ASRF	Asymptotic Single Risk Factor
BIC	Bayesian Information Criterion
BNA	Bank Network Analysis
BoF	Bank of Finland
CDS	Credit Default Swap
CET1	Common Equity Tier-1
DSTI	Debt-Service-To-Income
DT	Downturn
ECB	European Central Bank
ECM	Error Correction Model
EDF	Expected Default Frequency
EUR	Euros
EURIBOR	Euro Interbank Offered Rate
FIN-FSA	Finnish Financial Supervisory Authority
FINREP	Financial Reporting
FSAP	Financial Sector Assessment Program
FVOCI	Fair Value through Other Comprehensive Income
FVPNL	Fair Value through Profit and Loss
GDP	Gross Domestic Product
GFC	Global Financial Crisis
GFM	Global Macrofinancial Model
HQLA	High-Quality Liquid Assets
ICT	Information and Communications Technology
IRB	Internal Ratings-Based
LCR	liquidity coverage ratio
LGD	Loss Given Default
LOTA	Liquid Assets Over Total Assets
LSI	Less Significant Institution
NBFI	Non-Bank Financial Intermediaries
NII	Net Interest Income
NIM	Net Interest Margin
Non-II	Non-Interest Income
NPL	Non-Performing Loan
NSFR	Net Stable Funding Ratio
OCI	Other Comprehensive Income
PBT	Profit Before Tax
PD	Probability of Default
PIC	Pension Insurance Company
PIT	Point-In-Time
POE	Provisions Over total credit Exposures
RAM	Risk Assessment Matrix

ROA	Return On Assets
rOCI	rest Other Comprehensive Income
RWA	Risk Weighted Assets
SFDR	Sustainable Finance Disclosures Regulation
SI	Significant Institution
SSM	Single Supervisory Mechanism
STA	Standardized Approach
TM	Transition Matrices
TTC	Through-The-Cycle
VECM	Vector Error Correction Model
WEO	World Economic Outlook

EXECUTIVE SUMMARY

Finland is a small open economy that is significantly exposed to global financial and economic conditions. Following the Global Financial Crisis (GFC), Finland entered a long recession led by the decline of its information and communications technology (ICT) sector. With the implementation of some structural reforms, Finland's competitiveness improved, as did growth and employment, albeit at a lower rate of growth. The economy was less significantly affected by the COVID-19 pandemic relative to other economies, thanks to its low exposure to service-intensive economic sectors, fiscal policy, and other interventions. However, Finland is now navigating a weaker economic outlook given the war in Ukraine, despite limited direct exposures to Russia.

Risks to financial stability emanate from a concentrated banking sector, household indebtedness, and interconnections in the Nordic region. The Finnish banking sector is large (the redomicilation of Nordea in 2018 has substantially increased the size of total banking assets), highly concentrated and dominated by a few institutions, and is highly connected with other financial systems in the Nordic region. Household debt has increased in recent years to its highest levels, exacerbated further by the pandemic. In the non-bank financial intermediaries (NBFI) sector, the Pension Insurance Companies (PICs) account for a large share of non-bank assets, have highly correlated portfolios and exhibit potential pro-cyclical behavior.

This Technical Note assesses systemic risk in the Finnish banking sector. The assessment is based on stress tests, which simulate the health of Finnish banks under a severe yet plausible (counterfactual) adverse scenario. The scenario includes global and regional inflationary pressures, monetary policy tightness, financial market turmoil (shocks to term and risk premiums), and a major slowdown of economic activity. The exercises covered four significant institutions (SIs), and three less significant institutions (LSIs) representing more than 93 percent of total banking assets. Four types of stress test exercises have been performed. A top-down solvency stress test, a liquidity stress test, a wholesale funding cost stress test, and a contagion and interconnectedness stress test. The latter has been focused on both domestic banking interconnectedness, as well as the interconnectedness of the Finnish banking sector with cross-border counterparties.

The analysis indicates that the Finnish banking system appears resilient to severe macro-financial shocks but remains vulnerable to liquidity shocks. The aggregate common equity tier 1 (CET1) ratio drops to 13.8 from 19.4 percent, still well above regulatory requirements. However, second-round effects show that decreased profitability and the deterioration of asset quality in combination with an increase in the risk-free rate can have a major impact in banks' bond yields and their access to wholesale funding. Furthermore, banks remain vulnerable to liquidity shocks due to their reliance on short-term wholesale funding, in particular sight deposits that are more susceptible to large withdrawals and outflows. Under a stressed liquidity scenario, the aggregate liquidity coverage ratio (LCR) falls to 79 percent, below the 100 percent threshold, in the case of large outflows. Domestic interconnectedness analysis shows that contagion risks stemming from domestic interbank exposures are very limited. However, cross-border analysis reveals that the

Finnish banking sector is vulnerable to a potential systemic event in Nordic countries due to strong linkages and high exposures.

The Finnish authorities could consider using available policy tools to minimize wholesale funding related risks to banks. The authorities should encourage Finnish banks to adjust their funding structure to be more reliant on longer term wholesale funding sources that are less susceptible to outflow risk. They may also consider asking banks to hold liquidity buffers to cover a predetermined threshold of wholesale funding outflows over to five days horizon. Furthermore, even if the Finnish banking sector is solvent, the authorities should closely monitor banks' banking and trading books and intervene early to mitigate a potential increase of banks' risk premia due to deterioration in their asset quality.

Finally, the Finnish authorities are encouraged to collaborate with other Nordic authorities to conduct a coordinated Nordic-wide stress test exercise. The exercise should cover both banks and the NBFI sector and should focus on areas that are not covered by the biannual EU-wide stress test exercise. It is recommended to include a top-down analysis under a Nordic specific scenario, which will include all both EU and non-EU member countries in the Nordic region. Also, it should focus on interlinkages and spillovers, as well as liquidity-solvency interactions.

Table 1. Finland: FSAP Systemic Risk Analysis Key Recommendations

	Recommendation	Addressee	Timing[1]
1	Enhance liquidity buffers to cover a predetermined threshold of wholesale funding outflows over a five-day horizon.	FIN-FSA	NT
2	Closely monitor banks' banking book quality and introduce independent stress test exercises of smaller scale on specific areas of risk (e.g., credit risk only).	FIN-FSA, and BoF	MT
3	Lead an effort to conduct a top-down Nordic-wide stress test coordinated exercise, considering interlinkages and spillovers, liquidity-solvency interactions, and expanding the coverage to both banks and NBFIs.	FIN-FSA, and BoF	MT

[1] Timing: C = Continuous; I = Immediate (within one year); NT = Near Term (within 1-3 years); MT = Medium Term (within 3-5 years).

BACKGROUND

A. Financial Sector Landscape

1. The Finnish financial system is relatively large, highly concentrated and dominated by a few deposit-taking institutions. Total banking sector assets were EUR 870.4 billion at end–2021 (Table 2) and Nordea's redomicilation to Finland in 2018 has substantially increased them.[1] The banking system continues to be highly concentrated, with the three largest banks—Nordea Bank, OP Financial Group, and Municipality Finance (accounting for 93 percent of domestic banking assets)[2]—designated as SIs and supervised by the Single Supervisory Mechanism (SSM) within the European Central Bank (ECB). Subsidiaries and branches of foreign banking groups operating in Finland amount to 44 percent of GDP.

2. Pension insurance companies (PICs) and fund management are the most significant parts of the NBFI sector, followed by insurance. Each industry is highly concentrated. As set out in Table 2, the 'statutory earnings related' pension for private sector workers had EUR 161 billion, with the bulk in the PICs. Earnings-related plans for public sector worker plans and specialized regimes are also significant, with a total of EUR 94 billion in assets. Total insurance assets were EUR 89.6 billion—with EUR 73.0 billion in life and EUR 16.6 billion in nonlife insurance. The total fund management sector had EUR 180.0 billion in assets at end-2021.

3. The 2016 FSAP found that although Finland's banking system was well capitalized and profitable, previously identified vulnerabilities remained. Despite the low interest environment, banks had maintained profitability by increasing trading income and reducing costs. However, it noted that the banking system remained reliant on external wholesale funding, with risks of systemic liquidity shortfalls. Household indebtedness continued to be a source of vulnerabilities to income and interest rate shocks. The FSAP highlighted the need to augment supervisory resources to address the challenges of the new regulatory environment introduced by the European Banking Union and strengthen enforcement; broaden the toolkit of macroprudential instruments; and expand regional coordination agreements.

[1] Through a cross-border reverse merger, the parent of the Nordea Group was redomiciled from Sweden to Finland, bringing it within the scope of the EU banking union. See IMF, Finland: Selected Issues, 2019.

[2] Nordea banking group is the largest bank in Finland by total assets (EUR 552 billion). OP is the largest bank in the country by market share (around 35 percent). Municipality Finance is a non-deposit taking credit institution jointly owned by the municipalities (total assets EUR 44 billion end-2020). In January 2022, the Finnish branch of Danske Bank was also designated an SI.

Table 2. Finland: Financial System Assets: 2016 and 2021

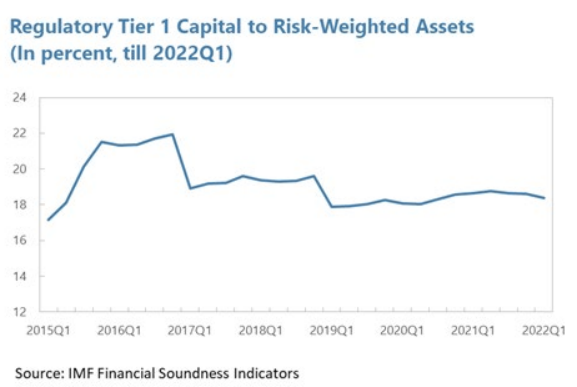
	2016			2021		
Sector	Assets	Number of Institutions	Assets (Percent of GDP)	Assets	Number of Institutions	Assets (Percent of GDP)
Banking sector (consolidated)	537,397	46	247.1	870,440	42	346.2
Domestic banking groups	185,366	10	85.2	759,029	11	301.9
of which: Three largest banking groups	157,360	3	72.3	707,190	3	281.3
Subsidiaries and branches of foreign banking groups operating in Finland	352,031	36	161.8	111,411	31	44.3
Insurance and Pension sector	194,252	68	89.3	250,847	59	99.8
Life	58,884	11	27.1	72,953	9	29.0
Non-life	16,778	36	7.7	16,643	34	6.6
Employee pension insurance	118,590	21	54.5	161,251	16	64.1
Investment funds	119,963	783	55.2	179,883	982	71.5
Stock market capitalization	203,265	145	93.4	345,689	184	137.5
Corporate debt						
Outstanding loans and debt securities	229,054		105.3	263,744		104.9
of which: issued in Finland	155,344		71.4	176,777		70.3

Source: FIN-FSA, Bank of Finland, Statistics Finland.

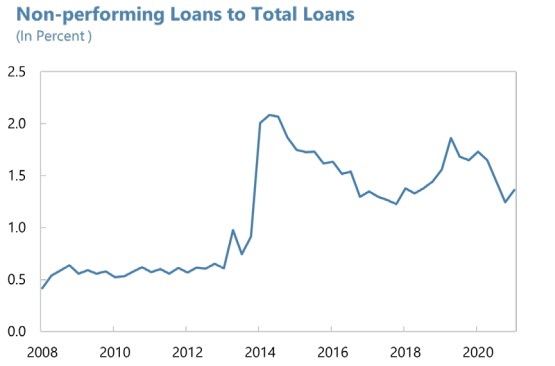
Note: Investment funds includes mutual funds, private equity, money market funds and hedge funds.

4. Although the capital adequacy of the banking sector in Finland remains well above the EU average, banks' funding models are sources of vulnerability. The regulatory capital position of Finnish banks is strong at 21.2 percent (Figure 1), while the leverage ratio and the liquidity coverage ratio are 6.2 and 171 percent, respectively. Despite the pandemic, Finnish banks have gross interest margins of 47.6 percent, and remain profitable with return on assets and return on equity at 0.6 percent and 8.2 percent, respectively (Figure 1). However, Finnish banks are mainly funded through wholesale funding (43 percent of total liabilities), making an increase in its cost a major concern. Banks also retain significant derivatives exposure.

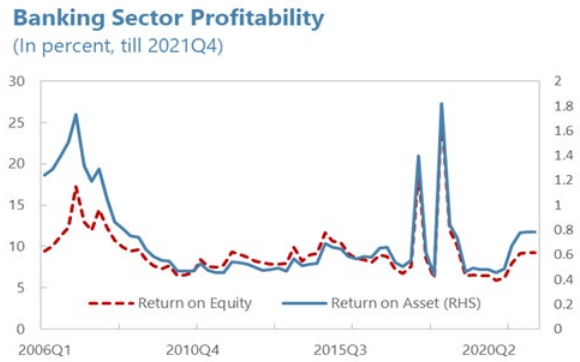
Figure 1. Finland: Banking Sector



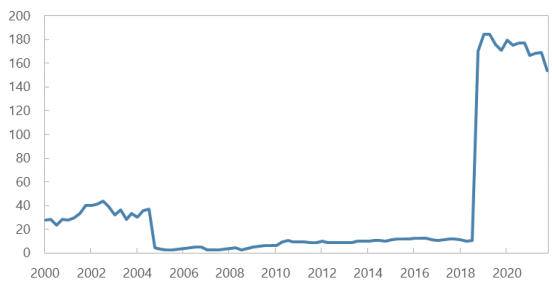
Source: IMF Financial Soundness Indicators



Source: Fin-FSA and Bank of Finland



Source: IMF Financial Soundness Indicators



Source: Bank for International Settlements

B. Macrofinancial Challenges

5. The authorities have had to manage the impact of the war in Ukraine. The authorities continue to monitor closely the impact of geopolitical risks on the Finnish financial system. The current challenges in the European energy market have created additional liquidity needs for energy companies, including to meet margin calls. They have been provided with public liquidity guarantees and bridge financing to avoid risks spilling into the financial sector.

6. The Finnish population has been rapidly ageing. Prospects for growth in the medium term are not strong, given population ageing and low productivity trends. Combined with intermunicipal migration, there is the potential for declining bank profitability, and risks from the residential real estate market with a bifurcation in price increases between Helsinki and the capital region, and other parts of the country, which could affect smaller cooperative banks and amalgamations given their potential concentration in declining regions.

7. Finland has weathered the COVID-19 pandemic well, with a mild recession relative to its European counterparts. However, the impact of COVID-19 on the commercial real estate (CRE) sector remains uncertain at this stage as lifestyles and working patterns continue to evolve.

8. Since the last FSAP, there have been major structural changes in the Finnish financial sector. Nordea's re-domiciliation in 2018 to Finland has increased the size of banking sector assets from 250 to 350 percent of GDP. Nordea's move deepens Finland's exposure to other Nordic

countries, particularly to Sweden. As a result, the FIN-FSA and FFSA have increased their staffing resources.

9. Cyber risks to the financial sector are elevated, while climate risks are limited. Ongoing threats from cyber criminals and state actors pose risks to the Finnish financial system, particularly in the context of the war in Ukraine. The Finnish Government passed legislation in June 2022 further expanding the crisis management responsibilities of the FFSA and BoF to establish a backup system to maintain continuity of customers' daily banking payments. Both transition and physical climate risks are low, with Finland among the lowest risk countries in climate change vulnerability indices.

C. Systemic Risks and Vulnerabilities

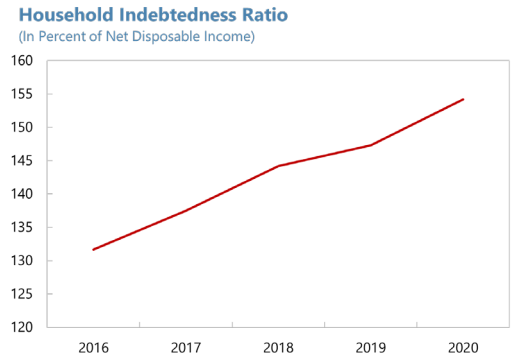
10. High indebtedness makes households vulnerable to interest rate shocks despite low debt-service-to-income (DSTI) ratios (Figure 2). As of August 2021, at least 93 percent of total loans to euro area households by Finnish banks were variable rate, making households vulnerable to increases in interest rates. However, rate collars purchased by many households generally mitigate the impact of higher interest rates in the near term, as does the practice by most banks to stress DSTIs at origination.[3] An increasing share of household debt is in the form of housing company loans (see Article IV 2019). More than half of bank lending is to households as mortgages to households or to housing companies, and unsecured consumer lending.[4]

[3] Banks are recommended to stress test the DSTI of mortgage applications using an interest rate of 6 percent and banks seem to follow this recommendation.

[4] Loans to housing corporations are 40 percent of total non-financial corporate (NFC) debt but to some extent they represent household liabilities.

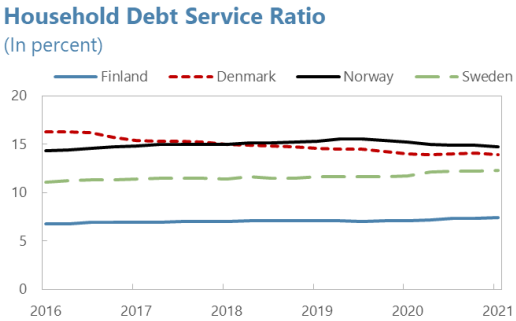
Figure 2. Finland: Household and Corporate Indebtedness

Household debt continued to go up during COVID…



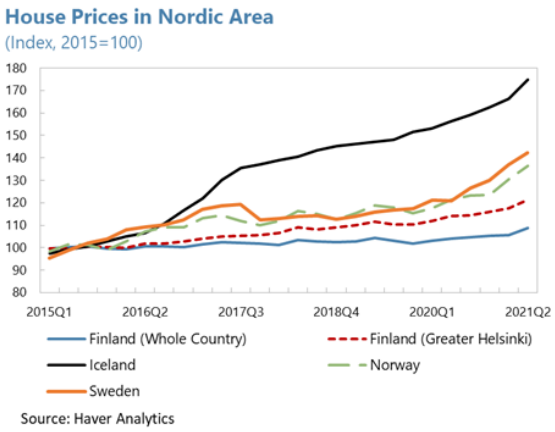
Source: OECD

…but debt service is low, given the low policy rate, high share of floating rate loans and relative house prices compared to other Nordics.



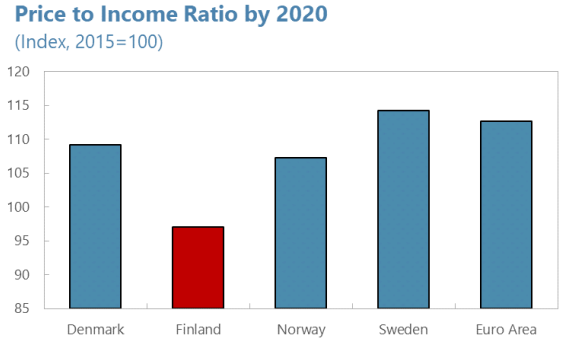
Source: Bank of International Settlements

House prices are rising in Greater Helsinki area…



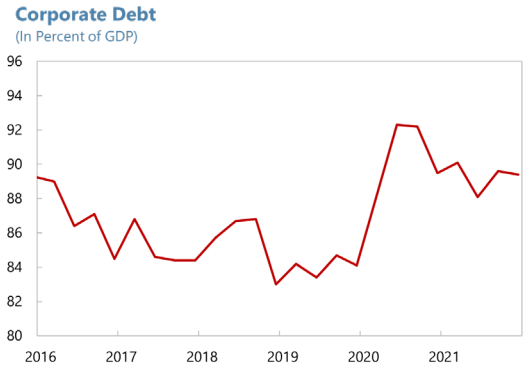
Source: Haver Analytics

…but houses are more affordable compared to 2015 across Finland



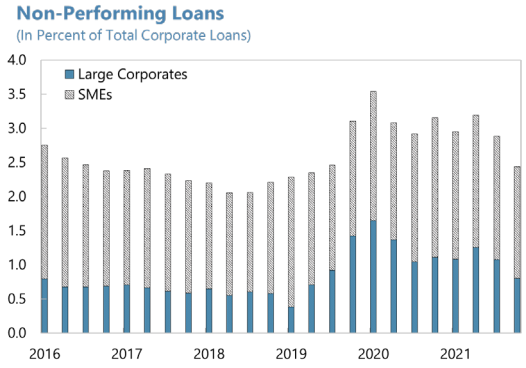
Source: OECD

While corporate debt has been rising…



Source: Bank of Finland

…Non-Performing Loans (NPLs) have not yet increased after peaking at the start of the pandemic



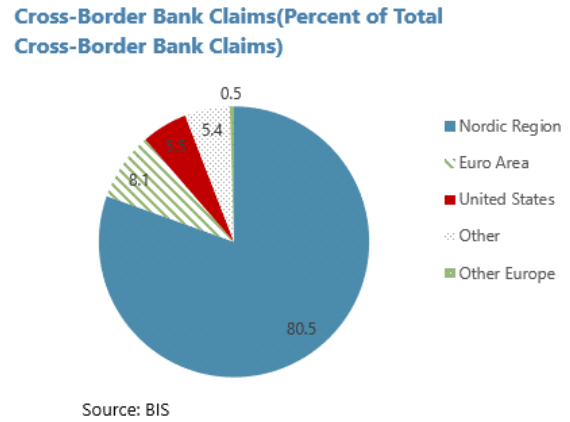
Sources: Bank of Finland, Fin-FSA

11. The Finnish banking sector is highly interconnected with the financial systems of the wider Nordic region. This brings financial diversification, but considerable contagion risk. The largest financial institution in the country, Nordea Bank has large cross-border exposures. Finnish banks' net foreign assets have gradually increased since the GFC and are 26.5 percent of GDP. BIS

data show the largest cross border exposures are to the Nordics and euro area. The banking sector is also exposed to indirect linkages from trade, with largest trade exposures to Germany, Sweden, the United States (U.S.), and the Russian Federation (Figure 3).

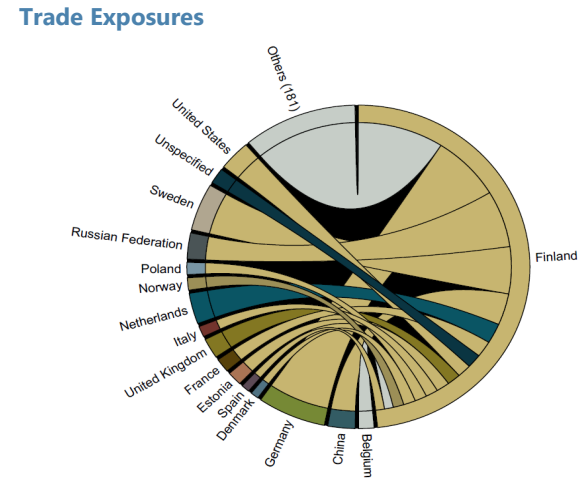
Figure 3. Finland: Cross-Border Exposures and Sources of Funding

The largest cross-border claims are in the Nordic region and …



Source: BIS

… major trade partners are the euro area, Sweden, and Russia.



Source: World Bank's WITS database.

12. The banking sector in Finland is heavily reliant on wholesale funding. Latest data on funding of the SIs and larger LSIs in Finland highlight that 32 percent of bank funding comes from retail deposits, with banks heavily reliant on wholesale funding (Figure 4). Banks are exposed to the risk of tightening global financial conditions, given the current stance of monetary policy and changes in global investor risk appetite. Increases in the cost of funding for banks, with potential limited ability to raise additional deposit funding by increasing deposit rates (due to the size of the financial system relative to size of the country), may lead to reductions in balance sheets and reductions in credit to the real economy in circumstances in which liquidity is not available in the wholesale funding markets.

Figure 4. Finland: Funding Sources for Finnish Banks

Source: IMF staff calculations using ECB data from June 2022

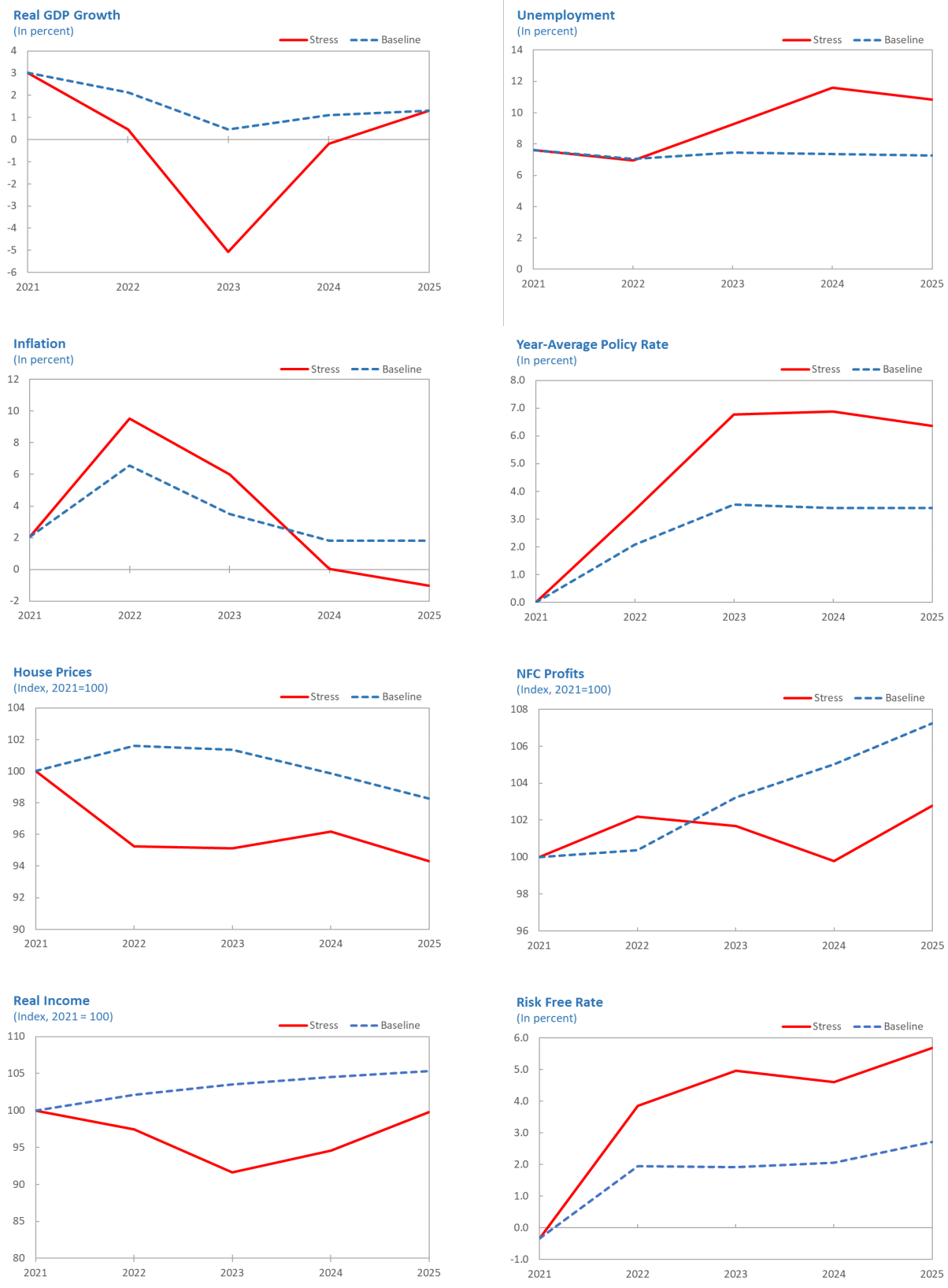
13. The FSAP identified the following key macrofinancial risks that could pose challenges for the banking sector if they materialized. The systemic risk analysis is undertaken on the joint realization of these risks (see the Risk Assessment Matrix (RAM) in Appendix II).

- *Intensifying spillovers from Russia's war in Ukraine.* Further sanctions resulting from the war and related uncertainties exacerbate trade and financial disruptions and commodity price volatility, with Europe, LICs, and commodity-importing EMs among the worst hit.
- *Commodity price shocks.* A combination of continuing supply disruptions (e.g., due to conflicts and export restrictions) and negative demand shocks causes recurrent commodity price volatility and social and economic instability.
- *De-anchoring of inflation expectations and stagflation.* Supply shocks to food and energy prices sharply increase headline inflation and pass through to core inflation, de-anchoring inflation expectations and triggering a wage-price spiral in tight labor markets. Central banks tighten monetary policy more than envisaged leading to weaker global demand, currency depreciations in EMDEs, and sovereign defaults. Together, this could lead to the onset of stagflation.
- *Local Covid-19 outbreaks.* Outbreaks in slow-to-vaccinate countries or emergence of more contagious vaccine-resistant variants force new lockdowns or inhibit commerce. This results in extended supply chain disruptions, slower growth, capital outflows, and debt distress in some EMDEs.

D. Scenarios

14. The stress tests are based on an adverse and a baseline (expected) macroeconomic scenario. The scenario spans four years (2022–25). The baseline scenario is aligned with the October 2022 World Economic Outlook projections. The adverse scenario reflects the main risks in the RAM, with higher inflation in the U.S. and advanced European economies, amid persistent geopolitical tensions and continued pandemic-related shortages. Sustained demand and increases in food and energy prices lead to euro area (and U.S.) policy rates being increased to bring inflation back to target, resulting in a recession. Financial conditions tighten, confidence retracts, and risk premiums spike. See Figure 5 for projected baseline and adverse scenario paths for the main macroeconomic variables used in the stress test.

Figure 5. Finland: Macroeconomic Scenario



Source: IMF Global Mcrofinancial Model and WEO

SOLVENCY STRESS TEST

A. Overview

15. The FSAP solvency stress test is a top-down exercise that covers four SIs and three LSIs that cover 93 percent of the banking sector assets.[5] The exercise is based on the IMF's internally developed solvency stress-testing framework. The stress test includes a comprehensive set of risks, including, market risk (equity, foreign exchange (FX), commodities, and interest rate risk), and income projections. By contrast, the derivatives book is not considered due to lack of access to granular data, so banks' variation margins cannot be appropriately addressed, and consequently their derivatives portfolio cannot be stressed meaningfully. The stress test was conducted using supervisory data for Q2 2022 provided by the SSM. Satellite models were estimated using aggregate data provided by the Bank of Finland (BoF) and the FIN-FSA.

B. Balance Sheet Projections

16. A quasi-static approach is used for the growth of banking and trading books over the scenario horizon. Asset allocation and the composition of funding remain the same, while balance sheets, which are based on total net assets, grow in line with the nominal GDP path specified in the scenario. To prevent banks from deleveraging, a floor on the rate of change in the balance sheet is set at zero percent. Balance sheet growth is estimated at a bank specific level, using the weighted average GDP growth of all countries where the bank has significant exposure. Other factors affecting balance sheet growth are the revaluation of assets in accordance with foreign exchange movements, and the conversion off a proportion of off-balance sheet items (i.e., credit lines and guaranties) to the balance sheet.

C. Credit Risk

17. Credit risk in the solvency stress test exercise is associated with domestic and cross-border household lending, corporate lending, and corporate bonds in the banking book (measured at amortized cost (AC)), and corporate bonds in the trading book, measured at fair value through other comprehensive income (FVOCI).

18. Credit risk associated with wholesale debt instruments is differentiated between AC, fair value through profit and loss (FVPNL), and FVOCI holdings. The credit risk associated with FVPNL securities is embedded in the market risk methodology, where the change in a security's price reflects changes due to risk-free rate movement or changes in credit risk premia. For AC securities, credit impairments are estimated as a banking book asset. Finally, debt securities at FVOCI are estimated through both the market risk methodology and through banking book credit impairment estimation.

[5] Danske Bank branch in Finland, a subsidiary of Danske Bank A/S (Copenhagen, Denmark) became an SI in January 2022.

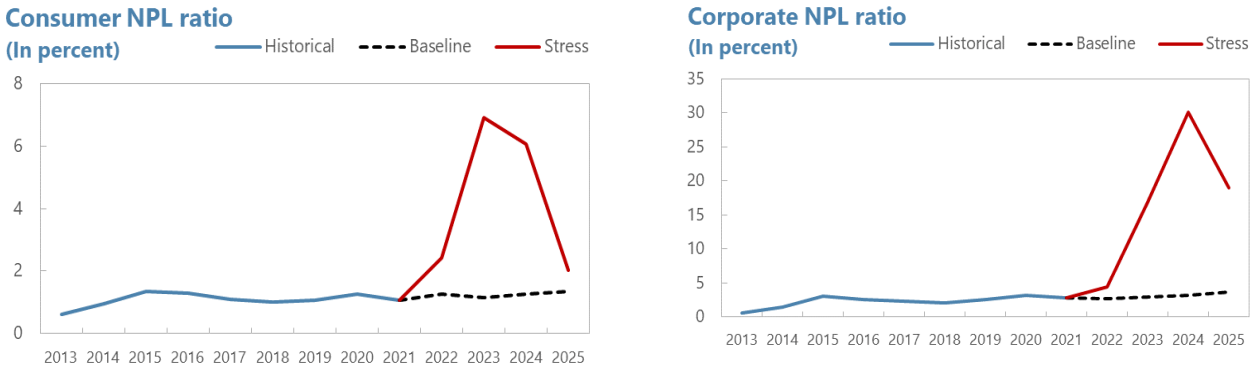
Probabilities of Default Estimation

19. All financial institutions in the solvency stress test have adopted the IFRS9 and credit impairments are calibrated in accordance with this accounting framework. Due to the lack of a long historical time-series of credit risk transition matrices (TM), scenario TM projections are estimated through Beta linking (Gross et al., 2020), where an aggregate probability of default is projected and adapted to stage 1 and stage 2 exposures according to the most recent observed transition matrices.

20. NPL ratios have been projected using an econometric model (Appendix III). Historical NPL ratios for consumer loans are available at an aggregate level only (without a separation between mortgage lending and other consumer lending); and so a distinction between secured and unsecured retail credit provision is derived through LGD modelling. Aggregate historical household and domestic corporate NPL ratios are cointegrated and are therefore projected through a vector error correction (VEC) model with exogenous macrofinancial variables (Figure 6). The macrofinancial variables that provided the best fit are unemployment, investment to GDP, and property prices. The interest rate environment (policy rate or EURIBOR) is not directly included in the model because it does not provide a good fit, but they are incorporated indirectly through investment to GDP.

Figure 6. Finland: Annual NPL Projections

Actual satellite models and projections are estimated in quarterly frequency. Charts are presented at an annual frequency, as they have been implemented in the stress test exercise.



Source: IMF staff calculations

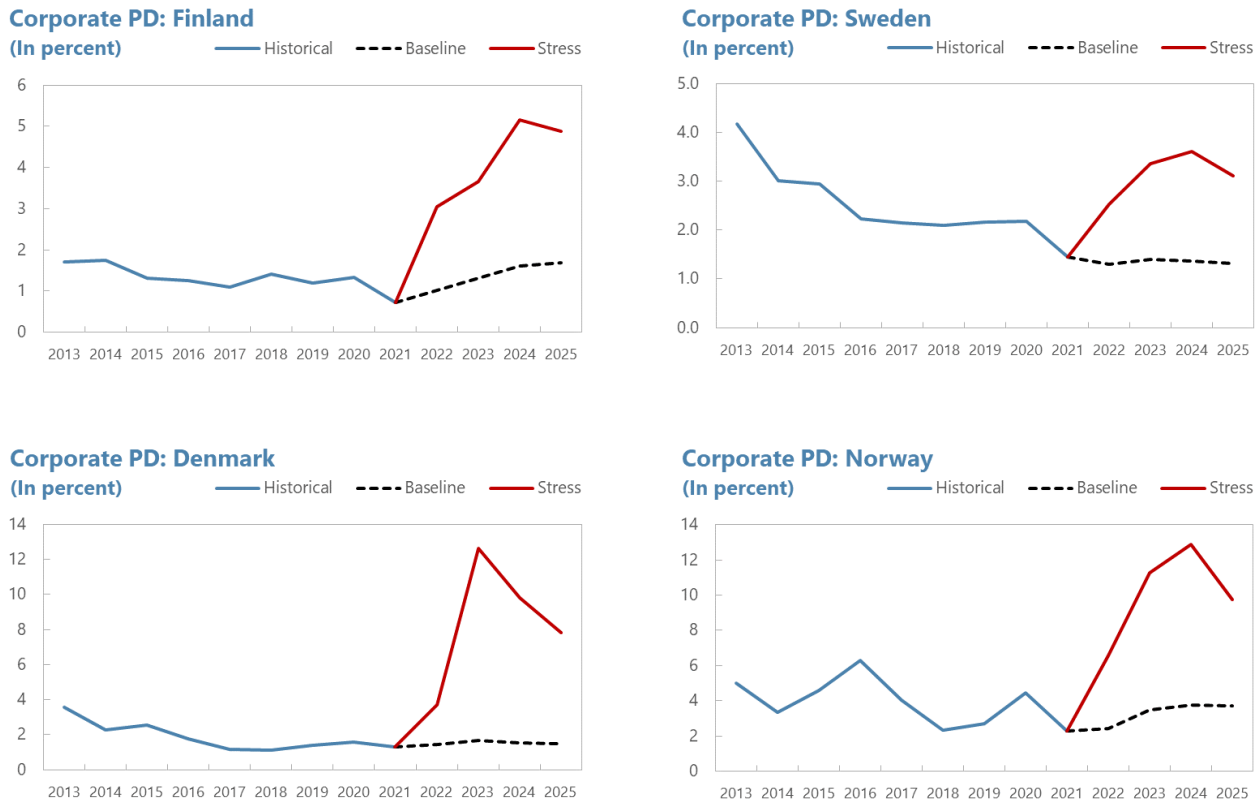
21. Domestic consumer lending probabilities of default (PD) are derived through the respective NPL ratio projection (Serwa, 2016). The cross-border household NPL ratio is assumed to follow the same growth path as the domestic NPL ratio. For SME lending, PDs are derived through the corporate NPL ratio in the same way.

22. For large domestic corporate lending, two independent PD paths are projected (Figure 7). One PD path comes from the NPL ratio projection (c.f. consumer credit) and one from a single-equation time-series model using the respective average corporate expected-default-frequency (EDF) data from Moody's and country specific macrofinancial explanatory variables. The two PDs are combined into one through linear programming (Reeves and Lawrence, 1991, Lam et al., 2001,

Panagiotopoulos, 2012).[6] Finally, cross-border corporate lending PDs are estimated through single-equation time-series models using country specific average corporate Moody's EDFs only.

Figure 7. Finland: Annual Corporate PD Projections

Actual satellite models and projections are estimated in quarterly frequency. Charts are presented at an annual frequency, as they have been implemented in the stress test exercise.



Source: IMF staff calculations

23. All NPL ratios and PD paths are estimated on aggregate level, and they are adapted to bank specific PDs through formula (1)

$$PD_{it} = N\left(G(PD_{i0}) + G(aPD_t) - G(aPD_0)\right) \quad \textbf{(1)}$$

where, PD_{it} is the bank specific probability of default and aPD_t is the aggregate probability of default at time t, G is inverse of cumulative distribution function of standard normal distribution and N is cumulative distribution function of standard normal distribution.

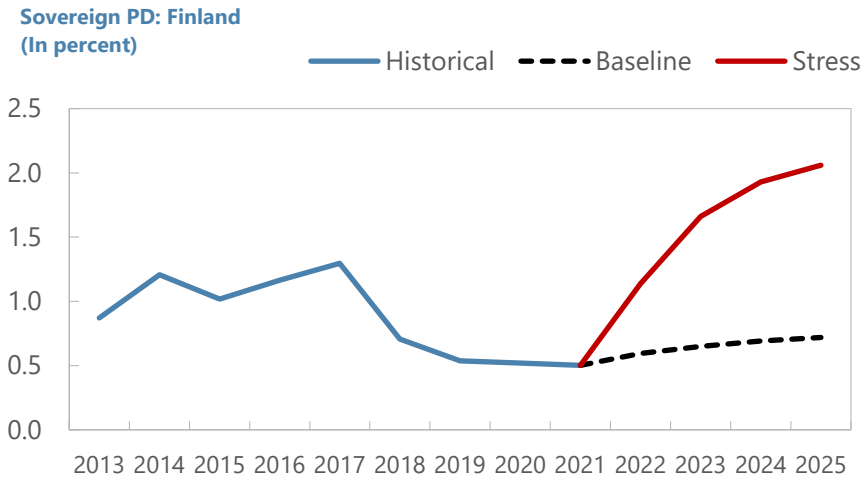
24. Municipality Finance PLC (Kuntarahoitus Oyj–MuniFin), one of the SI credit institutions, is owned by the Finnish municipal sector. Its business model is to provide government guaranteed mortgage lending to housing companies. Since the banking book of MuniFin is government guaranteed, the banking book's PD corresponds to Finland's sovereign PD

[6] Details can be found in Appendix IV.

(Figure 8), implied by Finland's sovereign spreads from the stress and baseline scenarios.

Figure 8. Finland: Sovereign PD

Actual satellite models and projections are estimated in quarterly frequency. Charts are presented in annual frequency, as they have been implemented in the stress test exercise.



Source: IMF staff calculations

Loss Given Default Estimation

25. Loss given default (LGD) rates for collateralized lending are calibrated through structural modelling using reported information on the value of collateral (loan to value, (LTV)), starting point reported LGDs, and property price paths. LGD for unsecured lending is calibrated through the Frye-Jacobs method (Frye and Jacobs, 2012). For MuniFin, a ceiling to the LGD is set at 25 percent, as this is the LGD level used in the calibration of sovereign credit-default-swap (CDS) spreads for developed countries.

Risk Weighted Assets Estimation

26. In the calibration of risk weighted assets (RWAs), standardized (STA) and internal ratings-based (IRB) portfolios have been differentiated. RWAs change due to balance sheet growth, new provisions for credit losses, exchange rate movements, and the triggered portion of off-balance sheet items. For IRB portfolios, the Asymptotic Single Risk Factor (ASRF) model for unexpected losses is implemented for different types of exposures (according to Basel III). Regulatory through-the-cycle (TTC) Probabilities of Default (PD) are calibrated through the scenario point-in-time (PiT) projections, using a smoothing parameter recommended by the Finnish authorities, and regulatory downturn (DT) LGD is considered as the maximum between the reported DT LGD at period 0 and the estimated PiT LGD.

D. Market Risk

27. Solvency stress tests assess the resilience of banks when facing different sources of market risk, specifically, interest rates, exchange rates, FX, and equity prices. Market risk losses

have an impact on both capital resources, either via profit and loss or via other comprehensive income, and capital requirements. The impact on capital resources will include positions in the trading book as well as other fair valued items in the banking book. The impact on RWAs for market risk evolve with balance sheet assumptions.

28. Market valuation losses correspond to holdings of debt securities (sovereigns, financial institutions, and large corporates) are estimated using a modified duration approach. The current average Macaulay duration of the debt portfolio has been provided by the Finnish authorities. Modified duration is derived from Macaulay duration.

$$MD_t = \frac{MacD_t}{1 + y_t} \quad \textbf{(2)}$$

where MD_t is the average modified duration at time *t*, *MacD* is the average Macaulay duration and y is the average annual yield to maturity. The analysis focuses on trading book debt securities measured at fair value, with the change in fair value recognized either in FVPL or in FVOCI. Losses of assets classified at AC are estimated through the credit risk channel.

29. Debt securities are subject to three shocks: yield shocks, FX position, and risk-free rate. Modified duration for every year of the scenario is estimated through formula (3)

$$MD_t = \frac{MD_{t-1}}{1 + \Delta y_t + \Delta risk\_free_{t-1}} \quad \textbf{(3)}$$

where, Δy is the change in the yield spread caused by the shift in the yield curve of the underline debt security, measured at a point in time that matched the modified duration, and Δrisk_free is the risk-free rate shock (Germany bond yields).

30. The change in the value of a security is calculated through formulae (4), (5), and (6)

$$percent\Delta FV_t^{credit\ spread} = -MD_t \times \Delta y_t \quad \textbf{(4)}$$

$$percent\Delta FV_t^{risk\ free} = -MD_t \times \Delta risk\_free_t \quad \textbf{(5)}$$

$$FV_t = FV_{t-1}\left(1 + percent\Delta FV_t^{credit\ spread} + percent\Delta FV_t^{risk\ free}\right) \quad \textbf{(6)}$$

where, percentΔFVcredit spread and percentΔFVrisk free are the percentage changes in FV due to credit spread and risk-free shocks respectively.

31. For sovereign debt holdings, sovereign yield curves are constructed by linear interpolation of short- and long-term interest rates as specified in the macroeconomic scenarios. Losses are calculated as the product of the size of each bond portfolio, average duration, and the changes in the yields and the respective FX change for debt held in foreign currencies. For non-sovereign debt securities, yields move in line with sovereign yield with a credit spread at the three-year horizon. Debt holding valuations are estimated assuming 50 percent hedging for interest rate risk and FX.

32. Market valuation losses for commodity, FX, and equity securities are estimated as the starting position of the securities multiplied by the change in the respective commodity prices, FX, and equity prices paths of the scenario. Specifically, the market impact from full revaluation of equity holdings was subject to a floor constraint in formula (7).[7]

$$\Delta Eq = -0.3\, percent(Eq^{Long} + Eq^{Short}) \quad \textbf{(7)}$$

E. Net Interest Income

33. Net interest income (NII) stress-tests measure the vulnerability of banking income to interest rate changes. Interest rate risk is estimated on interest-bearing assets and liabilities. The BoF provided the FSAP with historical time-series of banking sector-wide average effective interest rates (stocks) for different categories of interest-bearing assets and interest paying liabilities.[8] These interest rates are projected for the stress and baseline scenarios through time-series regression models, where the dependent variable is the respective effective interest rate of the total stock of interest bearing assets/liabilities (both current and new business), and independent variables are elements of the interest rate environment (policy rate, interbank rate, and risk-free rate). Interest bearing assets are classified as i) consumer lending (secured and unsecured), ii) corporate lending, iii) debt securities, and iv) interbank lending. Interest bearing liabilities are classified into i) term deposits, ii) overnight deposits, iii) other deposits, iv) interbank borrowing, v) collateralized wholesale funding, and vi) uncollateralized wholesale funding.[9]

34. The change in banking sector-wide interest rate projections has been implemented for the respective bank-specific lending and borrowing rates, which are reported in the Financial Reporting (FINREP) regulatory data submissions. Projected bank-specific interest rates are multiplied with the projected stock of respective assets or liabilities after judgmental adjustments (e.g., excluding NPLs from interest-bearing assets) to estimate bank-specific interest-income and interest-expense levels.

$$y_{it} = Y_{i0}(y_{i0} + \Delta r_{it}) \quad \textbf{(8)}$$

Where, y_{it} is the projected interest income/expense of the interest-bearing asset/liability Y_i at time t, and Δr_{it} is the aggregate projected change of the average interest rate of the specific type of interest-bearing assets/liabilities from time 0 to time t. The results for average asset and liability rates are shown in Figures 9 and 10, respectively.

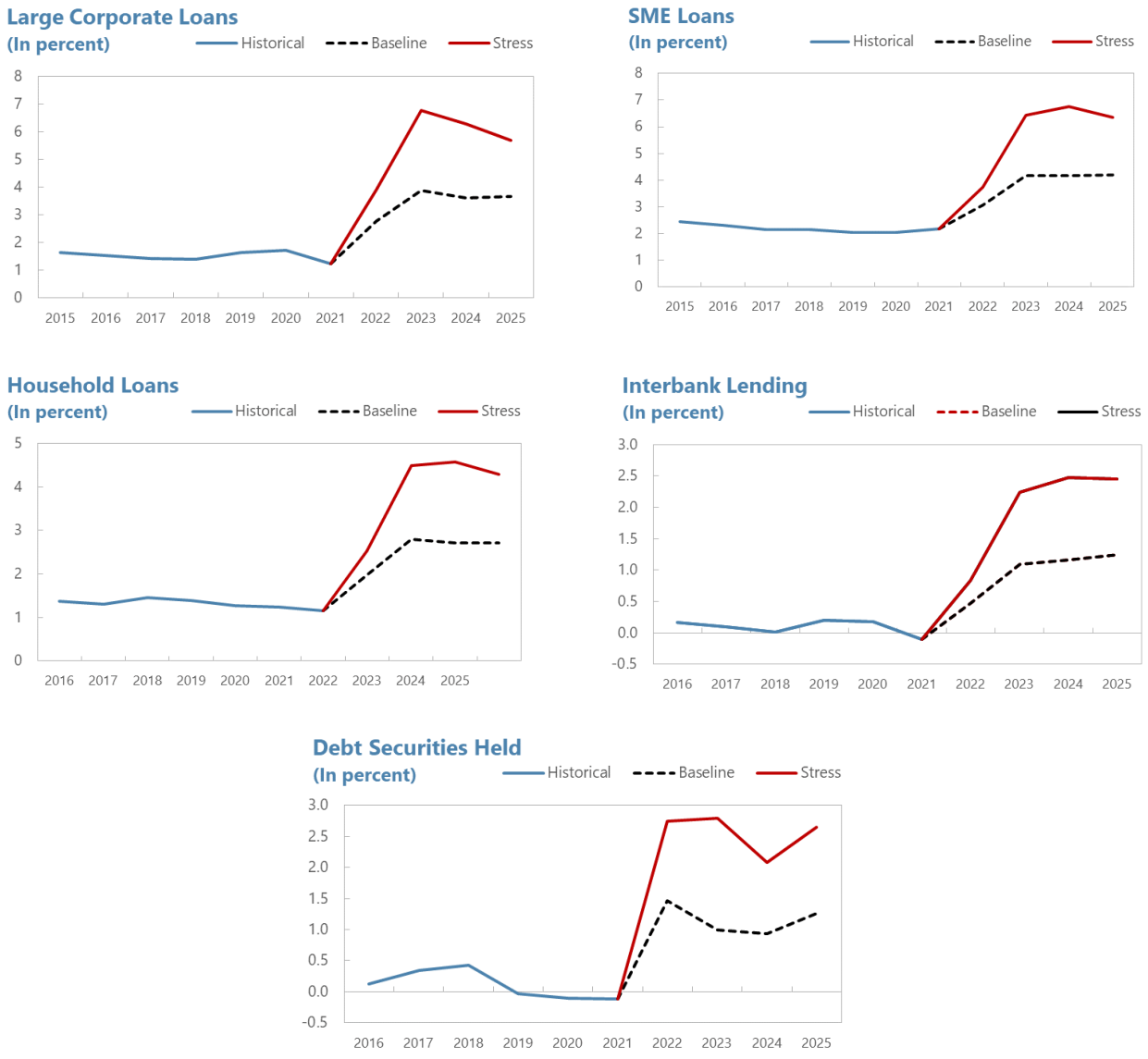
[7] A similar approach has been used in the EBA 2018 stress test.

[8] Interest rates on new business (flows) were not available; hence the FSAP implemented an alternative to the usual "repricing ladder" methodology, which is implemented in most FSAPs.

[9] Pass-through rates for interest bearing assets/liabilities linked with the policy rate are i) retail lending (both secured and unsecured): 0.5, ii) corporate lending: 0.7, iii) interbank lending: 0.5, iv) term deposits: 0.4, v) overnight deposits: 0.3, and vi) other deposits: 0.3. Pass-through rates for interest bearing assets/liabilities linked with the risk-free rate are i) debt securities: 0.8, ii) unsecured wholesale funding: 0.6, and iii) secured wholesale funding: 0.5. More details can be found in Appendix VI.

Figure 9. Finland: Annual Asset Rate Projections

Satellite models and projections are estimated on a quarterly basis. Charts are presented on an annual basis, as implemented in the stress test exercise.



Source: IMF staff calculations

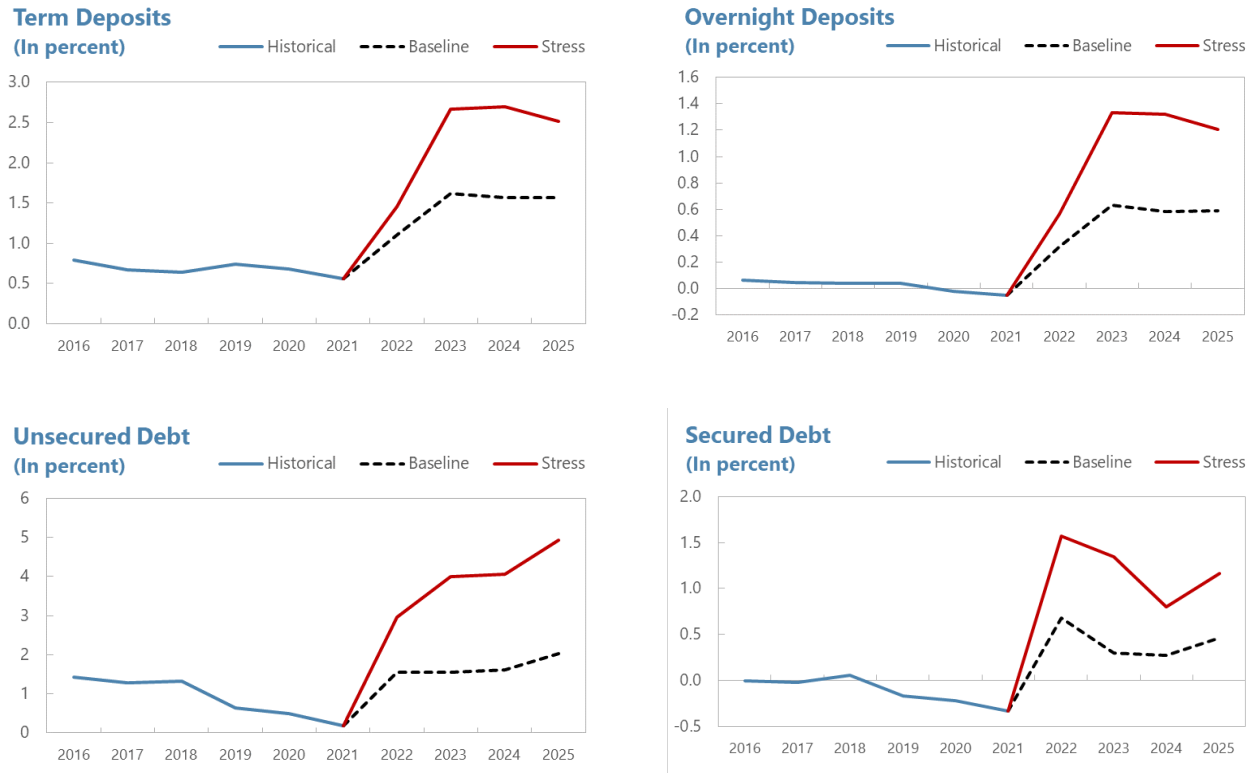
F. Non-Interest Income and Other Projections

35. Non-interest income (non-II) is projected based on a Monte Carlo simulation. This is because non-II includes many components that are not dependent on macro-financial variables. The parameters of the Monte-Carlo simulation are based on the observed historical trend and volatility of bank specific non-II data. 10,000 alternative non-II paths are projected. The average of the paths is used as a projection for the baseline, and the path in the 10th percentile is used for the adverse scenario to provide a more conservative estimate for the stress. Finally, both the baseline and stressed non-II projections have been adapted to nominal GDP growth, in line with the balance-sheet growth rule.

36. Other expenses in Profit and Loss and the rest of Other Comprehensive Income (OCI) that is not derived from the market risk analysis—rest Other Comprehensive Income (rOCI)—are projected according to nominal GDP growth. This is done under the assumption that other expenses to total assets and rOCI to total asset ratios remain constant in the exercise. Other expenses are 0.8 percent of total assets, and rOCI 0.02 of total assets.

Figure 10. Finland: Annual Liabilities Rate Projections

Actual satellite models and projections are estimated on a quarterly basis. Charts are presented on an annual basis, as implemented in the stress test exercise.



Source: IMF staff calculations

37. Income tax and dividends are calculated as a fixed rate when profit before tax (PBT) is positive (without counting OCI). The tax rate is set at 20 percent. The rate of dividends is the average observed dividend rate of every bank over the last five years.

G. Results

38. Banks appear to be resilient to severe macrofinancial shocks, with all meeting the hurdle rates over the stress testing horizon (Figure 11). In the baseline, the aggregate CET1 capital ratio is on an upward trajectory due to banks' revenue-generating capacity from the gradual increase in base rate, as well as low credit impairments. Under the baseline assumptions, the

system's aggregate CET1 capital ratio increases from 19.4 to 27.7 percent between 2021–25.[10] In the adverse scenario, however, the aggregate CET1 capital ratio declines by 7.4 percentage points to 12 percent at end-2025. Banks record weakened profits in the two first years of the scenario on average, but they record losses in the last year of the scenario. The decline in the capital ratio is mainly a result of net income losses and the deterioration of credit exposure quality, which drives an increase in risk-weighted assets (RWA), contributing to a charge of 8.2 percentage points. All banks meet the minimum capital requirements, but not all meet their CCoB/O-SIIB.

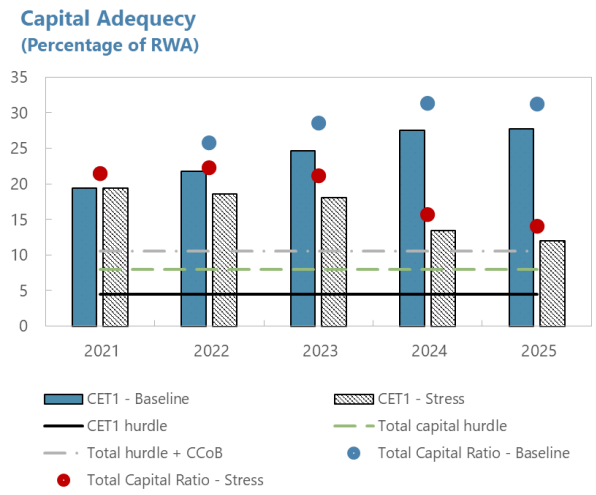
39. Credit impairments are a key factor underpinning profitability depreciation in the adverse scenario (Figure 12). Four-year cumulative credit impairments are 59.1 percent of starting CET1 capital by end-2025. Under the baseline scenario, cumulative four-year impairments are 3.8 percent of starting capital. Most credit risk impairments are recorded during the two last years of the scenario.

40. The sharp increase in the policy rate in the adverse scenario allows banks to compensate with high net interest margins (NIM). The average NIM in the adverse scenario rises to 2.2 percent by end-2023 when the policy rate in the scenario increases to 6.8 percent. In the baseline, NIM is 1.6 percent at end-2023, where the average policy rate during the year is 3.5 percent. NIM increase is largely uniform across banks. The average annual risk-free rate increases from -0.3 to 5.7 percent over 2021–25 in the stress scenario. The average NIM in the adverse scenario drops to 1.5 percent at end-2025 due to the decrease in the base rate while the risk-free rate remains high.

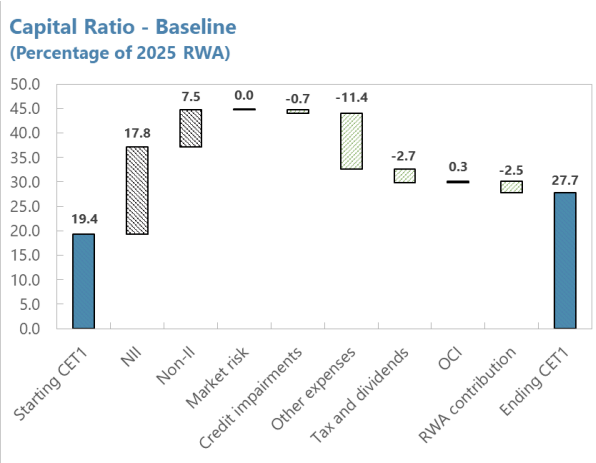
41. Market risk losses are high during the first year of the adverse scenario, but they fall during the other years of the scenario. While they contribute negatively to profitability and capital, they are not the main drivers of the results of the bank solvency analysis. Four-year cumulative losses are 8.6 percent of starting CET1 under stress, versus losses of 0.1 percent in the baseline. Stressed non-interest income is lower than in baseline, but it remains positive on average.

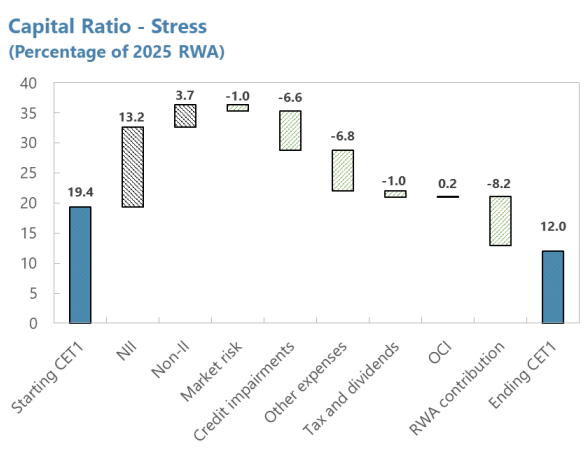
[10] This is partly because the dividend ratio in banks that record profits is assumed constant (i.e., the bank-specific historical average dividend ratio). However, in cases were banks record higher profits, a higher dividend ratio could have been considered, which would have resulted more moderate increase in regulatory capital over the course of the baseline scenario.

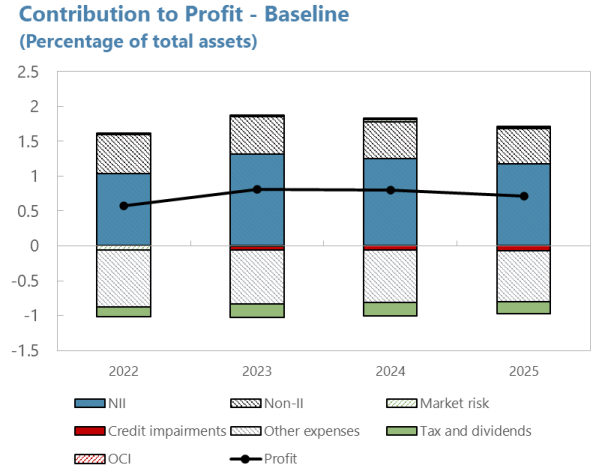
Figure 11. Finland: Solvency Stress Test Results

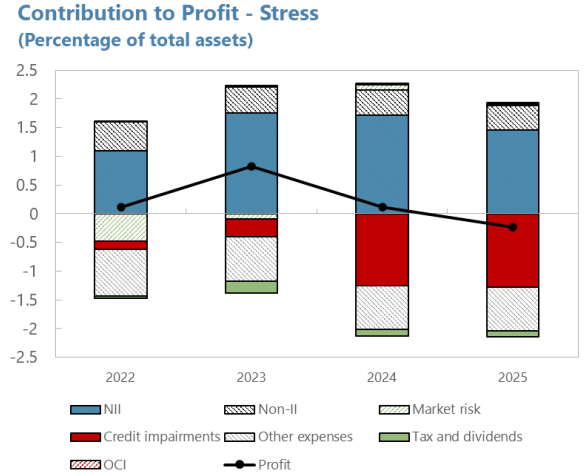


- ***Capital adequacy:*** *All banks have been highly capitalized in the start of the stress test. CET1 sufficiently covers the minimum capital requirements, and it continues being sufficient during both scenarios. In the adverse scenario, capital decreases until 2024 and starts recovering in 2025.*
- ***Capital flow:*** *During the stress scenario, the most important factor that contributes to the overall decrease of the capital is credit impairments and RWAs.*
- ***Contribution to profit:*** *The main factor that weakens profitability during the stress is in the increase in credit impairments. This is counterbalanced by the increase in the NII.*









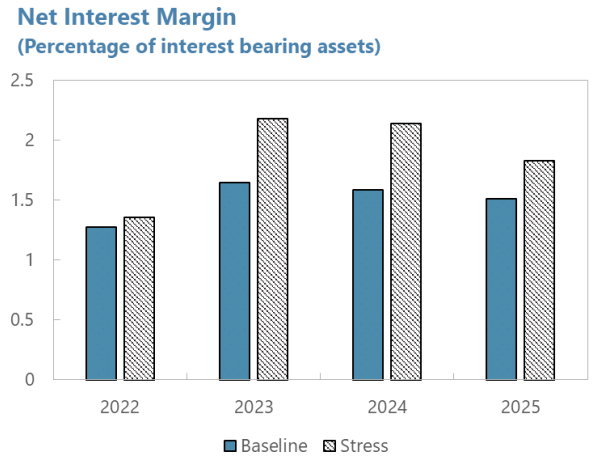
Source: IMF staff calculations

42. While there is broad consistency in impacts across SIs and LSIs, the results suggest a level of heterogeneity in the drivers of capital depletion. SIs record greater impairments in the

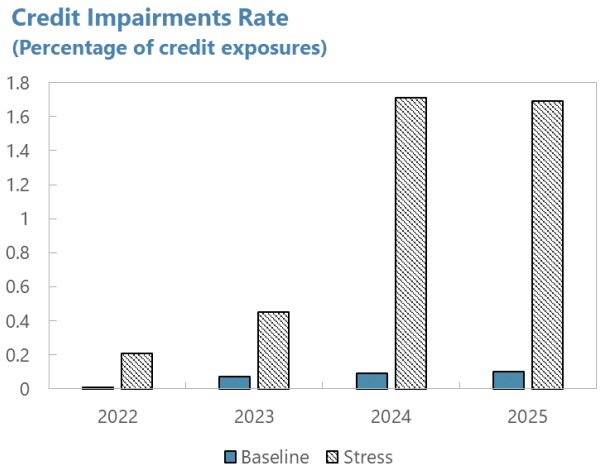
trading book and higher volatility of returns in the market book (either greater losses or greater gains). This is an indication that larger banks have a higher risk appetite, while smaller banks are more risk averse and have smaller trading books. Furthermore, some heterogeneity arises from distinct business models of some banks.

Figure 12. Finland: Risk Projections

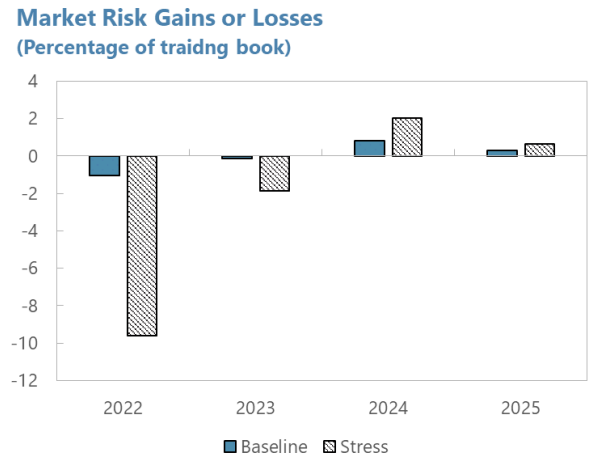
The sharp increase in the policy rate in the adverse scenario allows banks to compensate with high NIM. NII to interest bearing assets peaks in 2023 at 2.2 percent in the stress scenario.



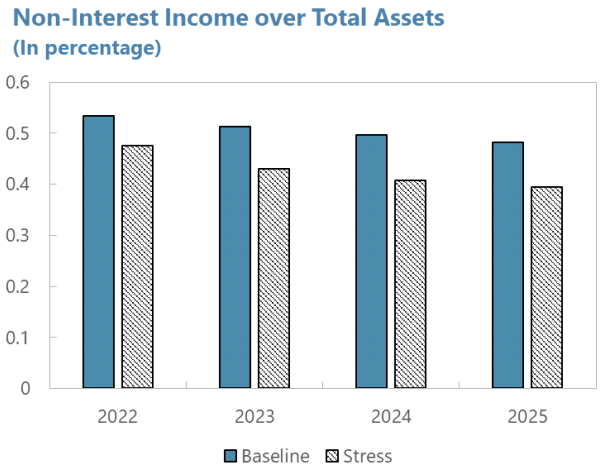
Credit impairments are a key factor underpinning the profitability depreciation in the adverse scenario. Impairments to credit exposures peaks in 2024 at 1.7 percent.



Market risk losses are low. Losses over total trading book peak in 2022 at 9.6 percent, but they slightly recover in the last two years of the scenario.



Aggregate Non-II follows a slight decreasing trend. Although, its impact on the final results is low.



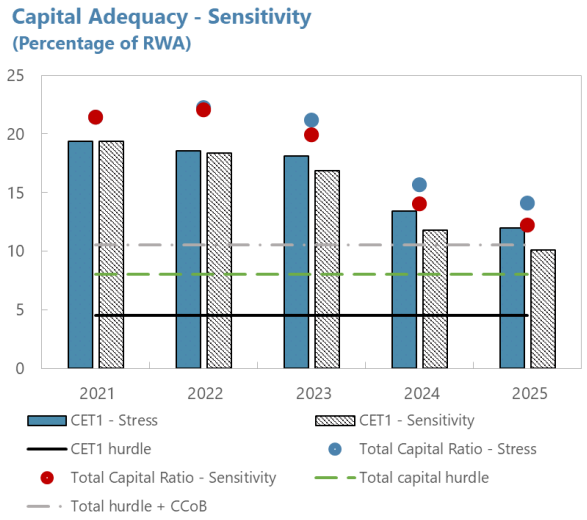
Source: IMF staff calculations

H. Sensitivity Analysis

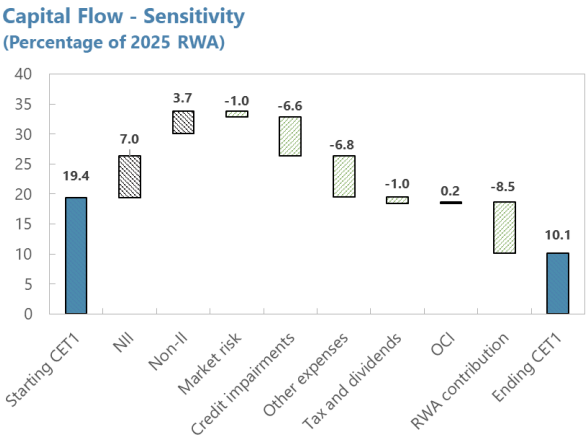
43. The solvency analysis shows that one of the counterbalancing factors of the adverse scenario is the high NIM the banks record due to the increase in the policy rate. A sensitivity analysis on the stress testing results explains the solvency stress test results and illustrates the effect of high NIM on banks' ability to absorb macrofinancial shocks. In the analysis, the policy rate and the interbank rate in the adverse scenario follow the same paths of the baseline scenario. This

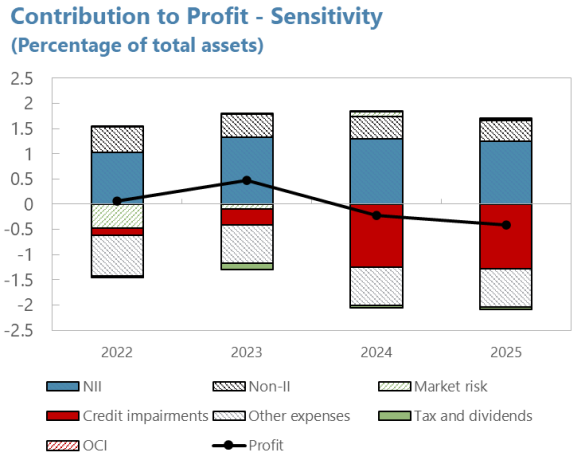
scenario is illustrative and not necessarily plausible because the increase in the interest rates is one of the stress factors of the adverse scenario (i.e., higher indebtedness and limited access to funding).

Figure 13. Finland: Sensitivity Analysis Results



- ***Capital adequacy:*** *Banks record lower capital ratios in comparison with the stress test, and some of them cannot meet the minimum capital requirements.*
- ***Contribution to profit:*** *Profitability is affected by the lower NIM, but most banks continue to record profits.*





Source: IMF staff calculations

44. The results of the sensitivity analysis show that banks' profitability decreases further and capital declines. Nearly all banks record losses in at least one year of the scenario. Average CET1 now falls to 10.1 percent in 2025, while total capital adequacy ratios are 12.2 percent (Figure 13). The CET1 ratio remains sufficient on average, but some banks are unable to meet their minimum capital requirements in 2025. Overall, the sensitivity analysis shows that banks would have faced significant distress if interest rates had remained low in the adverse macroeconomic scenario.

LIQUIDITY STRESS TEST

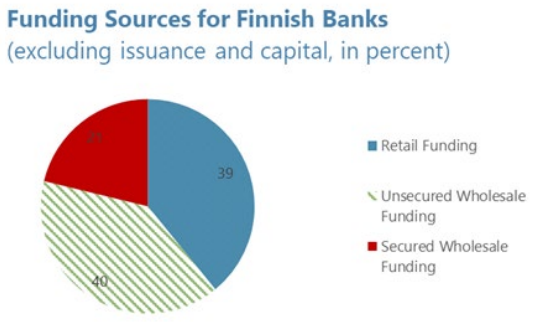
A. Overview

45. Three different liquidity exercises are conducted to assess the banking sector's resilience to funding and market liquidity shocks. There are two liquidity stress test exercises: an LCR stress test and a cash-flow-based analysis, and a qualitative analysis underlining the banking funding position (net stable funding ratio (NSFR)). Three major banks and three LSIs are included in the liquidity stress test exercises, which are implemented in EUR. The LCR exercise measures banks' ability to cover their 30-day need liquidity need (weighted net outflow) with their high-quality liquid assets, while the cash-flow analysis considers different maturities of cash inflows and cash outflows. Specifically, it simulates cash outflows over maturity buckets from 1 day to 360 days, as opposed to the single 30-day window assumed by the LCR. The more qualitative NSFR considers the longer-term available funding of the banks relative to their funding needs.

46. The liquidity stress test exercises use different thresholds and are conducted using extensive and up-to-date consolidated regulatory data. As of end-2018, LCR stress tests are considered passed if the ratio of liquid assets and net outflows under the stress scenario is higher than 100 percent. Similarly, the NSFR has a threshold of 100 percent for the ratio between available and required funding. Meanwhile, the cash-flow stress test is considered passed if the cumulative net funding gap is higher or equal than zero for each maturity bucket. All these tests use regulatory data, namely Common Reporting Framework (COREP) and FINREP, that provide detailed data on individual bank balance sheets, liquid assets, inflows and outflow, funding sources, and maturities. The stress test uses end-June 2022 data for the three SI banks, while for LSIs data for end-March or end-May 2022 data is used depending on the liquidity test exercise.

47. For Finnish banks, wholesale funding is the primary funding source, which creates a real risk of a liquidity shortfall. The Finnish banking system is highly reliant on wholesale funding (secured and unsecured), which accounts for 61 percent of stable funding (40 percent unsecured and 21 percent secured funding), followed by retail financing at 39 percent (Figure 14). Under a stress scenario, this dependence on wholesale funding would significantly increase liquidity outflows and put pressure on the LCR and cash flow. In addition, a predominance of wholesale financing makes the banking system more vulnerable to a tightening in global financial conditions (e.g., due to an increase in the risk-free rate).

Figure 14. Finland: Funding Structure



Source: IMF staff calculations

B. Liquidity Coverage Analysis

48. The LCR test has one baseline and then various stress scenarios for liquid assets, inflows, and outflows. The scope of this exercise is to measure the liquidity position of the banks under extreme conditions and to identify the key sources of vulnerability (eligible liquid assets, inflows, or outflows). In contrast with the solvency stress tests, the liquidity stress test is not linked to the macro-financial scenarios but to independent liquidity shocks. The baseline test corresponds to the Basel III scenario that stresses eligible liquid assets, drops in inflows, and rises in outflows. Further, we use haircuts, run-off, and roll-off rates to form our stress scenario. The factors, rates, and haircuts are presented in Table below. Thus, our primary stress scenarios are:[11]

1. *Liquid assets stress:* Basel III scenario plus higher stress on eligible liquid assets

2. *Inflows stress:* Basel III scenario plus greater drop in inflows

3. *Outflows stress:* Basel III scenario plus a greater rise in outflows

4. *Inflows-outflows stress:* Basel III scenario plus more significant drop in inflows and a greater rise in outflows (scenarios 2 and 3 combined).

5. *Extreme LCR stress:* Higher stress on eligible liquid assets asset, drop in inflows and rise in outflows (scenarios 1, 2, and 3 combined).

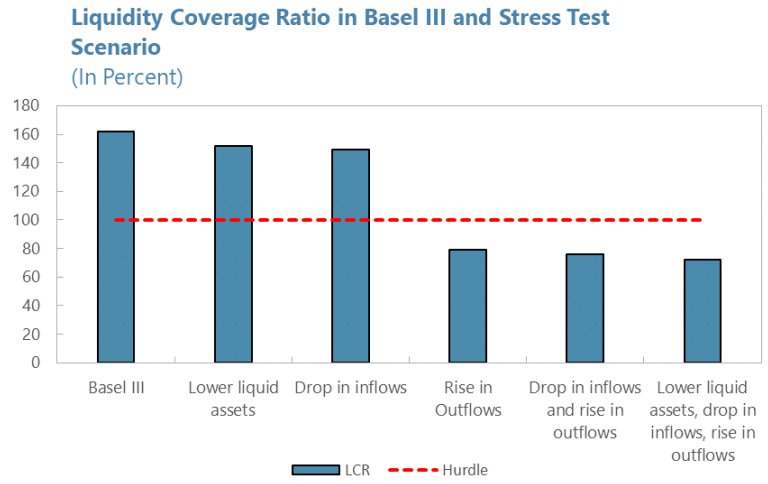
Table 3. Finland: LCR Stressed Factors

LCR Stressed factors, rates, and haircuts	Scenario				
	1	2	3	4	5
Haircuts on liquidity buffers					
Roll-off rates on Inflows					
Run-off rates on Outflows					

49. All banks passed the Basel III-based LCR test and sustained the mild scenario of stress on liquid assets and inflows. Figure 15 presents the LCR for the Basel III baseline scenario and the five stress scenarios for the aggregate banking system. In the Basel III scenario, all banks passed the test, with an average level of 162 percent, well above the 100 percent threshold. All banks can also sustain a higher haircut in liquid assets and a greater drop in inflows (resp. scenarios 1 and 2). There are no apparent vulnerabilities on the inflow and liquid assets side.

[11] The exact specifications of the scenarios can be found in the Appendix VI

Figure 15. Finland: LCR Analysis Results



Source: IMF staff calculations

50. However, almost all banks failed tests with scenarios that involved higher outflows. As previously stated, the Finnish banking system is highly vulnerable to outflows because of the nature of its funding sources and its susceptibility to large deposit withdrawals. Concerning outflows, higher run-off rates were applied to demand deposits of retail and unsecured wholesale funding. Thus, for scenarios that involve a higher rate of outflows (scenarios 3, 4, 5), almost all banks fail the tests and exhibit an LCR below 100 percent, with aggregate LCR of 79 percent, 76 percent, and 72 percent, respectively.

C. Cash-Flow Analysis

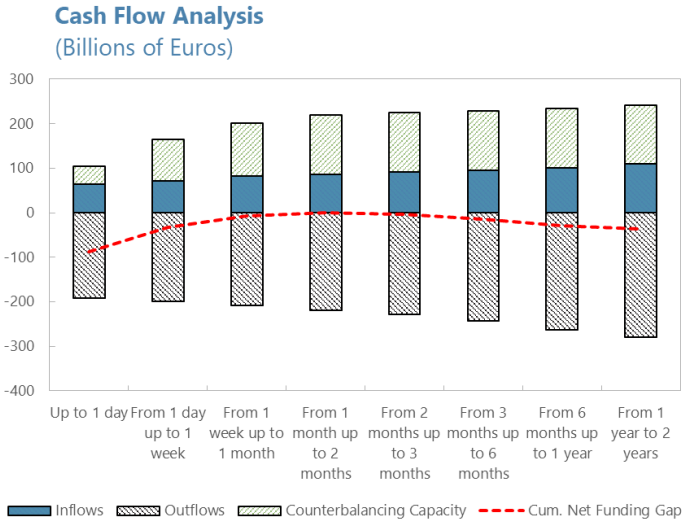
51. The cash flow stress test analyzes the liquidity risk exposure and risk bearing capacity of the banks. Cash flow stress tests are conducted using supervisory data on contractual cash flows for different maturity buckets. This approach employs multiple shocks that allow the estimation of the order of magnitude of potential liquidity needs of individual banks and the banking system. It also reveals the level of liquidity risk tolerance, identifying the cases under which circumstances banks would need additional liquidity support because of the mismatch of cash flows, and the absence of available counterbalancing capacity under stress. In addition, it highlights the potential reliance of the banking system on different sources of funding.

52. The cash flow stress test focuses on two key indicators, banks' net-funding gap, and their counterbalancing capacity. The net-funding gap is defined as the difference between inflows and outflows in each time bucket, and the sum of these differences across buckets (i.e., the cumulated net-funding gap). The counterbalancing capacity is defined as the sum of cash inflows that banks can generate under stress at reasonable prices in the respective bucket. The cumulative counterbalancing capacity is the sum of the counterbalancing capacities across time buckets. The analysis builds on data collected within the COREP templates.

53. The cash flow stress scenario involves shocks covering several horizons (e.g., 5 days, 4 weeks, 3 months) with varying assumptions regarding liquidity buffers, inflows, and outflows. It draws on the assumptions built into the solvency stress test to ensure consistency among both tests. For example, stressed market values of securities or markets' reaction toward banks' ability to raise funding after drop in capital ratios. The tests also incorporated assumptions about gradual tightening of monetary conditions, such as changes in eligible collateral used to obtain liquidity from the central bank, and changes in interest rates.

54. Results suggest that the banking system would have insufficient buffers to sustain outflows at all maturity buckets (Figure 16). The data show negative cumulative net funding gaps despite the counterbalancing capacity of asset fire sales across all maturity buckets. This is due to the importance of wholesale funding (secured and unsecured) and the liabilities resulting from non-operational deposits from financial and non-financial counterparties. The large scale of wholesale funding and its short-term maturity makes the banking system vulnerable to large withdrawals.

Figure 16. Finland: Cashflow Analysis Results



Source: IMF staff calculations

D. Net Stable Funding Analysis

55. The NSFR test suggests that the banking system has enough resources to fund its operations over a year. At the aggregate level, available stable funding reaches 479 billion USD, well above the required stable funding of 404 billion USD, leading to an aggregate NSFR ratio of 118 percent, well above the 100 percent target rate. At the individual bank level, most ratios exceed 120 percent. Again, the large scale of wholesale funding allows the NSFR to go well above 100 percent despite creating vulnerabilities.

E. Results and Recommendations

56. The adverse scenario liquidity analysis reveals significant vulnerabilities due not only to the size of wholesale funding, but especially its overall short-term nature. Three stress tests are conducted (NSFR, Cash-Flow and LCR) to assess the resilience of the Finnish banking system to liquidity risk. Although the ratio between available and required stable funding exceeds 100 percent, the qualitative NSFR test highlights the heavy reliance of banks on wholesale funding (secured and unsecured) that requires market access. In mid-2022, unsecured wholesale funding accounted for about 40 percent of total available funding. In addition, about 70 percent of unsecured wholesale funding consists of sight deposits from corporate and financial institutions that are very vulnerable to large outflows. Thus, while banks rely heavily on wholesale funding, its short-term nature amplifies cash-outflows at early maturity buckets, generating a large negative cumulative net funding gap despite counterbalancing capacity from liquid asset fire sales in the cash-flow analysis. In addition, the LCR—a measure of the capacity for the banks to cover the short-term net outflows with High-Quality Liquid Assets (HQLA)—falls well below the 100 percent threshold when applying a scenario with rise in outflows. Indeed, LCR drops from 162 percent in the Basel III scenario to 79 percent when the scenario solely includes an increase in outflow run-off rates, such as retail deposits and wholesale funding factors.

57. The analyses suggest the need for tighter liquidity regulation. Ideally, banks should adjust their funding structure but, because of the size of the financial system relative to the size of the economy, it is difficult to decrease the proportion of wholesale funding from the total funding availability in the near term. The authorities should direct Finnish banks to adjust their wholesale funding over time, aiming to increase the proportion of longer-term and demand deposits, to the extent that is feasible. Furthermore, the authorities are recommended to run more frequent liquidity stress test exercises and should require banks to hold a more sufficient stock of HQLA to withstand the stress test results.

ACCESS TO FUNDING ANALYSIS

A. Overview

58. A second-round effect stress test was undertaken to measure the impact of the solvency stress test results on bank access to wholesale funding. As previously mentioned, the Finnish financial system is large, and its most of its funding is from wholesale sources. The analysis estimated how the banking financial position, in combination with the macro-financial environment, affect banking bond yields.[12] This analysis aims providing intuitive on the interaction between solvency and liquidity, measuring how deterioration in banking solvency will affect the access to market funding.

[12] Banks that do not issue bonds have been excluded from the analysis. The analysis focusses on marginal funding cost only (i.e., the cost of a bank issuing new debt). These yields do not affect banks' NIM as they do not affect interest payable on existing debt.

B. Model

59. A panel model is calibrated,[13] where the dependent variable is bank specific 5-year bond yields and independent variables are indices for banks' financial positions and the risk-free rate. Banking position fundamentals consist of four dimensions: i) solvency, ii) profitability, iii) asset quality, and iv) liquidity. Several dimension specific indices are tested that proxy these four dimensions. None of the potential solvency measures have been proved significant, most likely because Finnish banks are well-capitalized, and the volatility of their solvency is low. The remaining variables that have been implemented are:

- *Profitability:* Return on assets (total profits over total assets)
- *Asset quality:* Provisions over credit exposures
- *Liquidity:* Liquid assets to total assets
- *Risk-free rate:* German sovereign bond yields

Banking fundamental projections from the solvency stress test exercise have been implemented in the model (the liquid assets ratio has been assumed fixed) and in addition to the respective risk-free paths, bond yield projections have been generated for both baseline and stress scenarios.

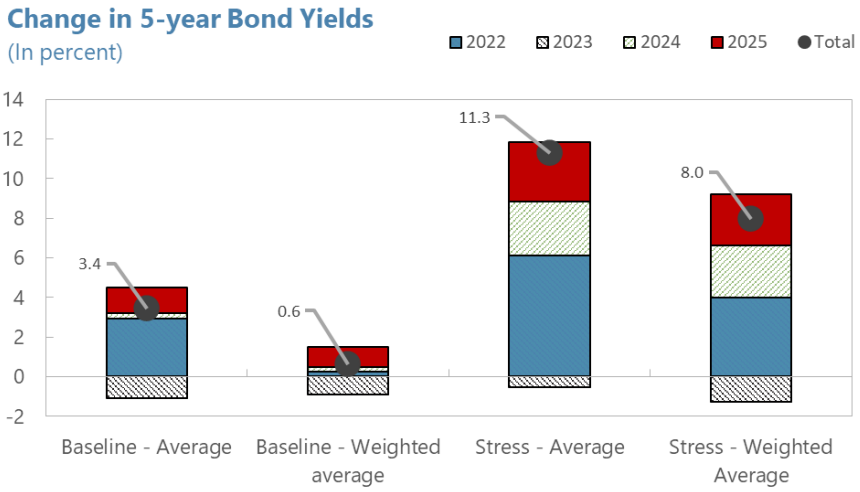
C. Results and Recommendations

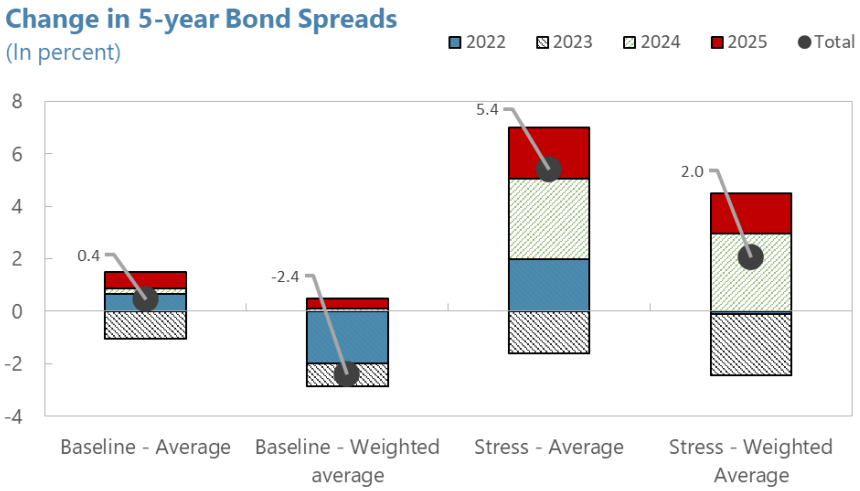
60. The high increase in the risk-free rate, in combination with the solvency stress test results, has a significant impact on bank yields. The observed weighted average of 5-year bond yields at end-2021 was 0.5 percent (0.6 simple average) and has risen to 2.8 percent in Q2 2022 (2.5 present simple average). Over the course of the stress scenario, there is an 11.3 percentage point cumulative increase in the five-year bond yield on average, or an 8 percentage points increase in the weighted average according to the total five-year yield value in December 2021 (3.4 and 0.6 percentage points in the baseline scenario, Figure 17). 5.4 (average) and 2 (weighted average) percentage points of the increase is due to credit spreads. The greatest increase in spreads is observed in the last two years of the stress scenario, when there is the largest increase in credit impairments and capital depreciation. The greatest increase in the total yield is in the first year of the stress scenario, when the risk-free rate increases the most. Bank-specific yield changes depend on their stress test performance.

[13] Details of the model are presented in Appendix VII

Figure 17. Finland: Bond Yields and Spreads

The charts show the simple and weighted average estimated change in 5-year bond yields and spreads of every bank in the exercise that issues bonds. Weighted average four-year change is the overall change in the banking 5-year bond yields and spreads weighted by the total value of bonds issued from each bank in December 2021.





Source: IMF staff calculations

61. The results of the analysis show that Finnish banks, despite being very well capitalized, may face constraints to wholesale funding access during a stress period, when banking solvency decreases, and risk-free rates increase. The potential liquidity distress due to wholesale funding outflows, which is shown in the liquidity stress test results, may amplify this problem and make wholesale funding the main issue of concern for Finnish banks. Over the last decade, banks have enjoyed easy access to wholesale funding due to the low interest rate environment. However, this business model may be less viable in the future, with higher market interest rates. Although Finnish banks are very well capitalized and have a large capacity for loss absorption under stress, potential losses, and the deterioration in the quality of their portfolios, in

combination with an increase in interest rates, may reduce access to funding. This could cause liquidity issues.

62. Projected yields should not be interpreted as projected rates for interest expenses. They are rather indicative of the easiness of access to market funding. It is expected that when yields increase to a high level, banks will stop issuing new debt securities and will start looking to alternative sources of funding until yields return to normal levels.

63. The analyses suggest the need to: (i) closely monitor banks' banking book quality, in particular for banks with a higher credit risk appetite; (ii) introduce independent stress test exercises on a smaller scale throughout the year. These stress tests should focus on specific areas of risk (e.g., credit risk or interest rate risk only) instead of a complete solvency stress test. They should allow for multiple scenarios and sensitivity analyses to illustrate the potential worsening of banking balance sheet positions, which may not be observable due to banks' high level of capitalization.

D. Domestic Interbank Contagion and Interconnectedness Analysis

64. The domestic interbank analysis is based on a matrix of bilateral domestic interbank gross credit exposures of the six large banks.[14] The analysis is based on large exposures data in COREP. The template includes bank specific exposures to other financial institutions. The data reporting date is end-March 2022, which is the most recent period that reports for all six banks are available. The stress test assumes the hypothetical default of each bank, one at a time. The default occurs on all interbank obligations of the bank, and the test assesses the impact on other banks. If the default of any given bank on its interbank obligations implies the default of another bank in the system, a subsequent round is calculated and so on. Regarding funding shocks, in addition to the direct loss of capital, a bank needs to replace a fraction of the funding lost due to the default. It does so by selling other assets at deep discounts in the market, and these fire sales cause further losses of capital. The criterion of banking default is failure to meet minimum capital requirements (either 4.5 percent CET1 ratio or 8 percent total capital ratio). The analysis produces two outputs: i) an index of vulnerability—the probability of default of a counterparty due to contagion of systemic event, and ii) an index of contagion—the probability of a contagious systemic event if the counterparty defaults.

65. Two spillover scenarios are tested: i) a simple credit shock scenario, and ii) a credit and funding shock scenario. The model requires a set of predetermined parameters:

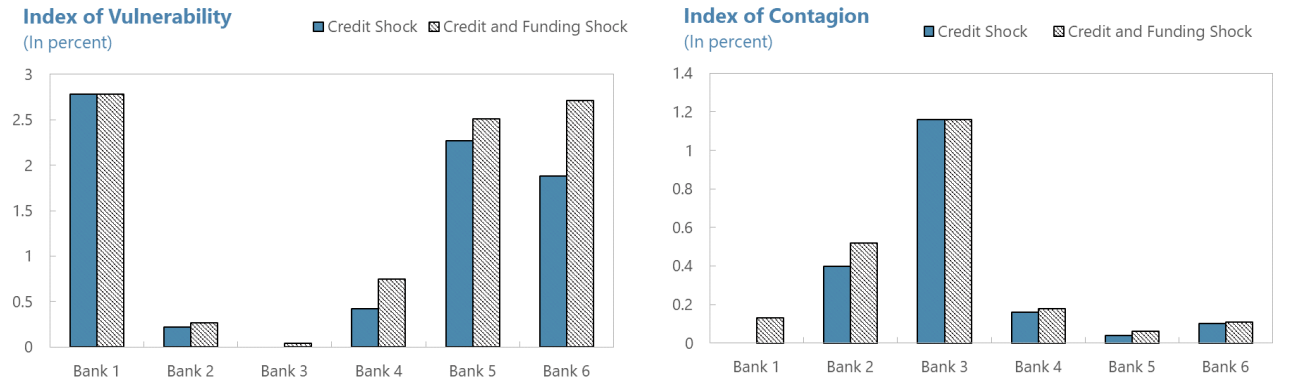
- *Lambda* (credit shock): The portion of LGD. In this analysis is set to 65 percent.
- *Delta* (funding shock): The loss factor due to funding shortfall. In the analysis is set to 50 percent.

[14] The analysis only includes banks domiciled in Finland and no foreign branches because these do not hold any capital and information is lacking.

- *Rho* (funding shock): The fraction of lost funding that is not replaceable. In the analysis is set to 35 percent.

66. The analysis reveals that contagion risks stemming from domestic interbank exposures are very limited. In Finland, domestic interbank positions are small, especially compared to banks' capitalization. For the six banks in the system, the sum of their gross domestic exposures to the other three banks is smaller than their regulatory capital. The results in both scenarios are very similar. Therefore, no single failure of a domestic bank would trigger the failure of another bank in either of the scenarios, and thus no "cascade effect" would take place in this four-bank market. Moreover, as at end-March 2022, none of the banks is found to be undercapitalized at the regulatory minimum after a shock on one or several of its domestic interbank exposures. All banks have low vulnerability to spillovers in the model; however, some banks have an index of vulnerability, (the percentage of loss at a single institution due to the default of all other institutions) significantly higher than the others (Figure 18). The index of contagion, which corresponds to the average percentage of loss of other banks due to the failure of a given bank is low overall.

Figure 18. Finland: Domestic Interbank Contagion Analysis Results



Source: IMF staff calculations

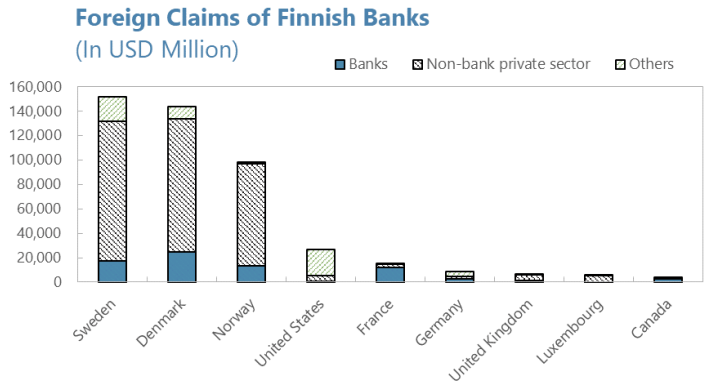
E. Cross-Border Contagion and Interconnectedness Analysis

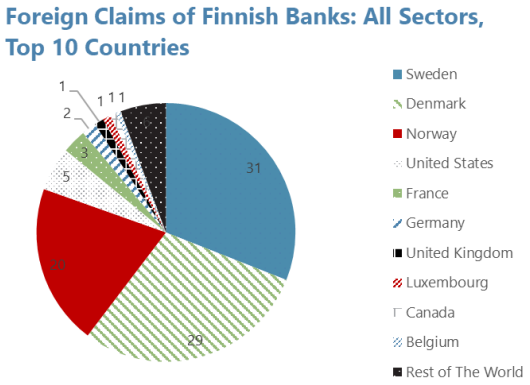
67. Cross-border analysis reveals strong linkages between the Finnish banking system and other Nordic countries. Cross-border exposures to Denmark, Norway, and Sweden represent 80 percent of total cross border exposures (Figure 20). This typically involves intragroup exposure within Nordic banking groups. There are also significant exposures outside the Nordic region, particularly with France, the UK, Germany, and the U.S.

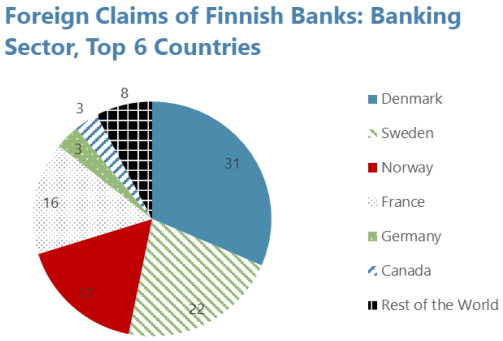
68. CBS data from the BIS is used to analyze the nature of foreign exposures of Finnish banks. The CBS is informative on the type of exposures by sector, the extent of pure cross-border claims versus local claims, and the funding patterns for the local operations for banks. As with the domestic cross-border analysis, the stress test assumes the hypothetical default of each national counterparty, one at a time. The default occurs on all claims in the specific country and the test assesses the impact on the Finnish banking sector.

69. Two spillover scenarios are conducted using the BIS-CBS for March 2022. The first scenario applies to reporting banks' exposure to foreign banks only, considering both credit and funding shocks (Scenario A). The second considers the impact of a credit shock to the total exposure of the banking sector, including claims to banks, governments, and the nonfinancial sector (Scenario B). The assumptions and the parameters used in the test are same as in the interbank network analysis (lambda is set to 65 percent, delta is 50 percent, and rho is 35 percent). The Finnish banking sector is considered in default when the cumulative CET1 ratio drops below 4.5 percent.

Figure 19. Finland: Claims of Finnish Banks





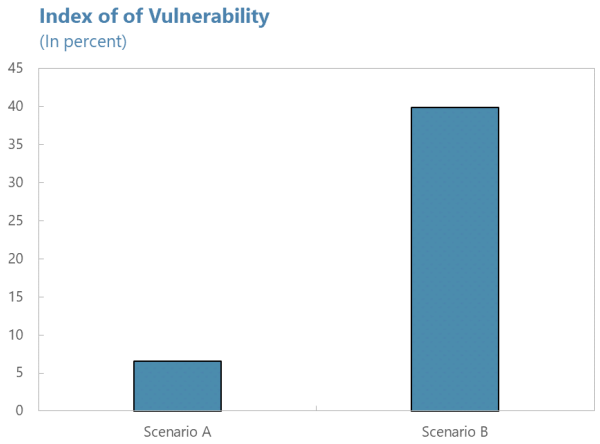


Source: BIS Consolidated Banking Statistics Q1 2022

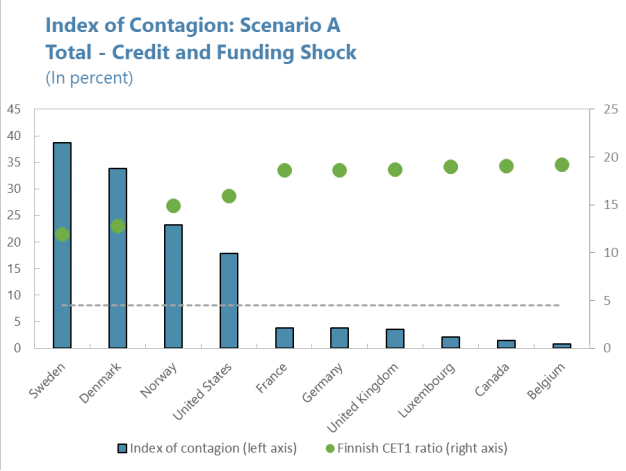
70. The analysis suggests that the Finnish banking sector is closely linked to the Nordic banking systems through interbank exposures (Figure 20). Finland is most vulnerable to Sweden. A potential distress in the Swedish banking sector will have a 38.6 percent impact on banking capital in Finland. The second country to which Finland is vulnerable is Denmark (33.8 percent), followed by Norway (23.2 percent), and France (17.8 percent). The overall index of vulnerability for Finland in Scenario A is 6.6 percent.

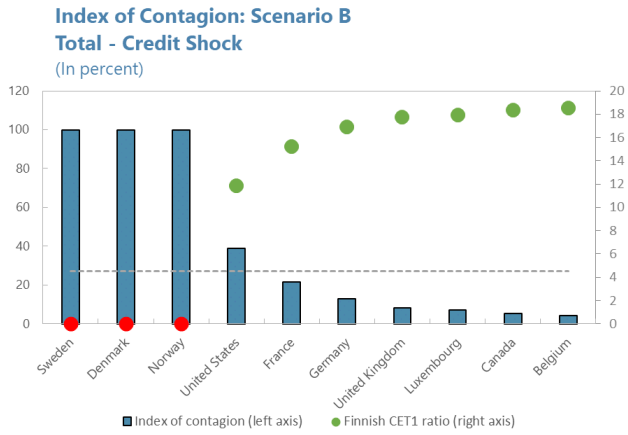
71. The impact of scenario B is far greater. A systemic default in any Scandinavian country will cause a 100 percent impact on Finnish banks' capital. The fourth country is the U.S. (38.9 percent), followed by France (21.4 percent). The overall index of vulnerability in scenario B is significantly higher at 39.8 percent.

Figure 20. Finland: Cross-Border Contagion Analysis Results



- ***Index of vulnerability:*** *The overall vulnerability of the Finnish banking sector against a systemic cross-border shock in another foreign banking sector (Scenario A) is low (6.6 percent). Although, the vulnerability against and overall systemic stress (Scenario B) is significantly greater (39.8 percent)*
- ***Index of contagion:*** *The two charts show the ten countries Finland is most vulnerable in each cross-border contagion scenario. Sweden, Denmark, and Norway are the most contagious countries in both scenarios. Although, the magnitude of the impact in Scenario B is significantly greater than Scenario A.*





Source: IMF staff calculations

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Appendix I. Risk Assessment Matrix

Risk	Overall Level of Concern	
	Relative Likelihood	Expected Impact if Materialized
Intensifying spillovers from Russia's war in Ukraine. Further sanctions resulting from the war and related uncertainties exacerbate trade and financial disruptions and commodity price volatility, with Europe, LICs, and commodity-importing EMs among the worst hit.	**High**	**High** A negative shock would hit imports and exports, which further hit vulnerable sectors in the Finnish economy, weakening investment and growth, an increasing NPLs. Funding costs rise for corporate borrowers, reducing credit availability.
Commodity price shocks. A combination of continuing supply disruptions (e.g., due to conflicts and export restrictions) and negative demand shocks causes recurrent commodity price volatility and social and economic instability.	**High**	**High** A negative shock would hit imports and exports, which further hit vulnerable sectors in the Finnish economy, weakening investment and growth, an increasing NPLs. Funding costs rise for corporate borrowers, reducing credit availability
Deepening geo-economic fragmentation and geopolitical tensions. Broadening of conflicts and reduced international cooperation accelerate deglobalization, resulting in a reconfiguration of trade, supply disruptions, technological and payments systems fragmentation, rising input costs, financial instability, a fracturing of international monetary and financial system, and lower potential growth.	**High**	**High** Lower economic growth, higher input costs, supply disruptions and changed trade patterns will result in lower real incomes, lower firm profitability resulting in increased NPLs.
De-anchoring of inflation expectations and stagflation. Supply shocks to food and energy prices sharply increase headline inflation and pass through to core inflation, de-anchoring inflation expectations and triggering a wage-price spiral in tight labor markets. Central banks tighten monetary policy more than envisaged leading to weaker global demand, currency depreciations in EMDEs, and sovereign defaults. Together, this could lead to the onset of stagflation.	**Medium**	**High** Significant market losses in bank portfolios as asset values fall. Potential significant liquidity impact on banking sector, given high reliance on wholesale funding. Higher funding costs impact corporate borrowers, reducing credit availability, including for households. Higher retail interest rates worsen household indebtedness.
Local Covid-19 outbreaks. Outbreaks in slow-to-vaccinate countries or emergence of more contagious vaccine-resistant variants force new lockdowns or inhibit commerce. This results in extended supply chain	**Medium**	**High** Financial conditions tighten. Contraction of consumption and investment impairs financial sector health. Changing work

Risk	Overall Level of Concern	
	Relative Likelihood	Expected Impact if Materialized
disruptions, slower growth, capital outflows, and debt distress in some EMDEs.		patterns undermine CRE and prime residential house prices. Increased NPLs undermine bank balance sheets.
Cyberthreats. Cyberattacks on critical physical or digital infrastructure (including digital currency platforms) trigger financial instability and disrupt economic activities.	**Medium**	**Medium** Cyberattack on critical banking infrastructure necessitates use of backup payment system and decreases public confidence in the banking system.

Appendix II. Stress Test Matrix

Banking Sector: Solvency Stress Test		
Top-Down by IMF		
1. Institutional Perimeter	Exercise	• Top-Down by FSAP team.
	Institutions Included	• Seven banks subcategorized as SIs (four banks) and LSIs (three banks). • Among the SIs, the largest is internationally oriented, and 80 percent of its total exposures are cross-border, one does government guaranteed residential mortgages only, one focuses on retail banking, and one is a subsidiary of a foreign bank. The latter has become an SI recently and the analysis will be reduced due to limited data availability. • One SI is branch of a foreign bank and it does not hold capital; thus, it is excluded from the solvency analysis, although, it is included in the total profitability. • All LSIs are domestically focused. One of them focuses on asset management and two on retail banking.
	Market Share	• Total coverage is about 93 percent of the banking sector, with 85 percent for SIs and 8 percent for LSIs.
	Data and Baseline Date	• Multiple data vintages: December 2021 (year end, starting point for PnL), March 2022 and July 2022 (starting point for balance sheet and capital). • Supervisory data: Bank balance sheet and supervisory statistics (including FINREP and COREP), information on interest rate risk in the banking book (IRRBB), liquidity risk and market risk sensitivities (including STE templates) provided by the authorities and the ECB. Expected Default Frequency sourced from Moody's. Further supervisory information was provided, including the probability of defaults by credit portfolios, and a bank-specific stage transition matrix by portfolio from FINREP. • Market and publicly available data, such as information from ECB statistical data warehouse on funding and lending rates by type of asset and funding portfolios. • Scope of consolidation: banking activities of the consolidated banking group for banks having their headquarters in Finland. Foreign subsidiaries are assessed on the unconsolidated level covering domestic activities only. • Coverage of sovereign and non-sovereign securities exposures: debt securities measured through fair value (FVPL and FVOCI) and amortized cost (AC) account. • Coverage of lending exposure: credit institutions, nonbank financial institutions, household, and corporate (Finland, Sweden, Norway, Denmark).
2. Channels of Risk Propagation	Methodology	• FSAP team satellite models and methodologies. • Balance-sheet regulatory approach. • Market risk is treated as an add-on component, with a separate calibration. The market risk stress scenario has an impact on both capital resources (either via profit and loss or via Other

		Comprehensive Income (OCI)) and capital requirements (RWA). The impact on capital resources comprises of positions in the trading book as well as other fair valued items in the banking book. The impact on RWA for market risk evolve with balance sheet assumptions. • Traded risk impact from the revaluation of trading assets (FVPL) and securities classified as fair value thorough other comprehensive income (FVOCI) securities by counterparty: central government (by country issuers), credit institutions, other financial institutions, and nonfinancial corporates. Credit spreads on sovereign, credit institutions and corporate securities interpolated using bank-specific residual maturity at the book and issuer level (i.e., sovereign issuers by country and individual corporate issuers by ISIN codes). Credit spreads on other securities estimated on a hypothetical portfolio using a duration proxy. Valuation effects assessed using a modified duration approach. Hedges are considered as ineffective under stress.
		• The losses for securities portfolios are based on duration approach. Losses on equities (both long and short position) were based on stock market price movement specified by the scenario. • For internally modelled exposures (IRB), projection of PiT and TTC PDs, LGD, EAD and RWA. For STA exposures, projection of new flows of defaulted exposures, coverage ratio for defaulted loans, and risk weight downgrade for performing exposures. Credit risk projections for IRB and STA exposures cover credit institutions, nonbank financial corporates, and households. Corporate PDs for largest exposures are proxied by Moody's EDFs. The resulting impact is translated into credit loss impairment charges and shifts to RWAs due to capital charges for defaulted assets. • Provisioning for IRB and STA was modeled using IFRS9 transition matrix approach. Transition matrices, PiT PDs, PiT LGDs for loan and securities classified under financial asset measured through amortized cost (AC), and other comprehensive income (FVOCI) were modeled using COREP data. • Funding costs projected at the portfolio level using funding structure by product (retail and wholesale deposits, secured and unsecured debt securities, repo, etc.) and maturity bucket (overnight vs. term). Funding projections capture systematic risk (linked to the scenario) and idiosyncratic risk (for spreads on debt instruments issued over benchmark). Funding cost projections utilized bank level data on 12 Irish banks from COREP templates. Lending rates were projected at the system level and attached to bank-specific interest rates and outstanding amount at cut-off date (interest rate on corporate and household loans and debt securities).
	Stress Test Horizon	• 2022 Q1–2025 Q4 (4 years)
3. Tail Shocks	Scenario	• Two Scenarios:

		• A baseline scenario based on the April 2022 WEO macroeconomic projections. • An adverse scenario that captures the key risks in the RAM. This scenario relies on GFM, a structural macroeconometric model of the world economy, disaggregated into forty national economies, documented in Vitek (2018). Scenarios for foreign countries where Finland has significant exposure is extracted from GFM and is internally consistent with country scenarios of other ongoing FSAPs.
4. Risks and Buffers	Risk Covered	• Risks covered include credit (on loans and debt securities), market (valuation impact of debt instruments through repricing and credit spread risk as well as the P&L impact of net open positions in market risk factors such as foreign exchange risks) and interest rate risk (IRRBB) on the banking book. • Concentration risk by sensitivity analysis. • Solvency and liquidity risk interactions, mainly through asset haircuts.
	Behavioral Adjustment	• For the growth of the banks' balance sheet over the stress-test horizon, a quasi-static approach is used. Asset allocation and the composition of funding remain the same, whereas the balance sheet grows in line with the nominal GDP paths of major geographical exposures and subject to reduced credit demand in material jurisdictions and FX shock from revaluation effects on foreign currency loans specified in the stress test scenario. However, to prevent the banks from deleveraging, the rate of change of balance sheets is set at a floor of zero percent. This constraint is binding in the adverse scenario. • In projecting RWAs, standardized and IRB portfolios are differentiated. For the standardized portfolios, RWAs changed due to the balance sheet growth, new inflows of non-performing loans, new provisions for credit losses, exchange rate movements, and the conversion of a portion of off-balance sheet items (undisbursed credit lines and guarantees) to on-balance sheet items. For the IRB portfolios, through-the-cycle-PDs, downturn LGDs and EAD for each asset class/industry are used to project risk weights. • Interest income from non-performing loans is not accrued. • We assume that banks do not issue new shares or make repurchases during the stress test horizon. Dividends are assumed to be paid out at 30 percent of current period net income after taxes (i.e., only if net income is positive) by banks that were in compliance with supervisory capital requirements.
5. Regulatory and Market-Based Standards and Parameters		• National regulatory framework Basel III regulatory minima on CET1 (4.5 percent) and include any requirements due to systemic buffers for three other systemically important institution (O-SII). In addition to the CET1, the team evaluated total banking capital adequacy ratio against the 8 percent level, their Tier 1 capital ratio against the 6 percent benchmark and the leverage ratio during the stress test horizon against the 3 percent Basel III minimum requirement. The same hurdle rate was used for baseline and adverse scenario. The hurdle rate for

		CET1, T1 and total capital adequacy do not include capital conservation and capital countercyclical buffers as well as pillar 2 requirement. Banks that end the stress test horizon with a capital level or a leverage ratio below the relevant hurdle rates, are considered to have failed the test.
6. Reporting Form for Results	Output Presentation	• The results of the stress tests are reported using a variety of charts and tables. These potentially include the evolution of capital ratios for the system as a whole and as groups of retail banks and large international banks. Outputs also include information on impact of different result drivers, including profit components, losses due to realization of different risk factors; capital shortfall as sum of individual shortfalls; in euros and in percent of nominal annual GDP; number of banks and corresponding percentage of assets below the regulatory minimum (or below the minimum leverage ratio).
Banking Sector: Liquidity Stress Test		
Top-Down by IMF		
1. Institutional Perimeter	Exercise	• Top-Down by FSAP team.
	Institutions Included	• Six banks subcategorized as SIs (three banks) and LSIs (three banks). One SI is not included due to lack of data.
	Market Share	• Total coverage is about 80 percent of the banking sector, with 73 percent for Sis and 7 percent for LSIs.
	Data and Baseline Date	• Latest data: April 2022. • Source: supervisory data (LCR, NSFR, and ALMM Maturity Ladder template). • Scope of consolidation: banking activities of the consolidated banking group for banks having their headquarters in Finland. Foreign subsidiaries are assessed on the unconsolidated level covering domestic activities only.
2. Channels of Risk Propagation	Methodology	• Basel III LCR and cash-flow based liquidity stress test using maturity buckets by banks, incorporating both contractual and behavioral (where available) with assumption about combined interaction of funding and market liquidity and different level of central bank support. • Liquidity test in EUR, USD, and Sterling.
3. Risks and Buffers	Risks	• Funding liquidity. • Market liquidity.
	Buffers	• The counterbalancing capacity, including liquidity obtained from markets and/or the central bank's facilities. Expected cash inflows are also included in the cash-flow based and LCR-based analysis.
4. Tail shocks	Size of the Shock	• The run-off rates are calibrated to reflect scenarios of system-wide deposit runs and dry-up of unsecured wholesale and retail funding, with additional run-off for non-resident deposits on top of the retail and wholesale run-off, which is calibrated following historical events, recent international experience in liquidity crises and IMF

		expert judgment. • Retail scenario key assumptions are: (i) 10 percent run-off rates for stable retail deposits and 20 percent for less stable retail deposits; (ii) 10-35 percent for operational deposits and 20-40 percent for non-operational deposits; and (iii) no changes in liquid asset weights. • Wholesale scenario key assumptions are: (i) 5 percent run-off rates for stable retail deposits and 10 percent for less stable retail deposits; (ii) 15-35 percent for operational deposits and 40-60 percent for non-operational deposits; and ((iii) no changes in liquid asset weights. • Combined run-off and price shock scenario key assumptions are: (i) 10 percent run-off rates for stable retail deposits and 20 percent for less stable retail; (ii) 15-35 percent for operational deposits and 40-60 percent for non-operational deposits; and ((iii) liquid assets weight reduction of 0-5 percent for level 1 assets, 3-20 for level 1 covered bonds, 5-15 percent for level 2A assets and 5-25 for level 2B assets. • The liquidity shocks will be simulated for 1–month for both LCR, and 5-days, 1-month, 3-months, and 1-year for the cash-flow based approach. • The haircuts of high-quality liquid assets (HQLA) are calibrated against ECB haircuts, past Euro Area FSAPs, and market shocks for investment securities and money market instruments in the solvency stress test.
5. Regulatory and Market-Based Standards and Parameters	Regulatory Standards	• Consistent with Basel III regulatory framework (LCR). • Liquidity shortfall by bank.
6. Reporting Format for Results	Output Presentation	• Liquidity ratio or shortfall by groups of banks and aggregated (system wide). • Number of banks that still can meet or fail their obligations.
Banking Sector: Interconnectedness Analysis		
Top-Down by IMF		
1. Institutional Perimeter	Exercise	• Top-Down by FSAP team.
	Institutions Included	• Cross-border contagion: country-pair bilateral exposure across Nordic/Baltic region, rest of Euro Area, US, and Russia.
	Data and Baseline Date	• BIS consolidated banking statistics.
2. Channels of Risk Propagation	Methodology	• Balance-sheet model: Network model by Espinosa-Vega and Solé (2010).

3. Tail shocks	Size of the Shock	• Pure contagion: financial distress in foreign countries. • Default threshold: banks would default if their CET1 capital ratios fall below 4.5 percent (regulatory minimum).
4. Reporting Format for Results	Output Presentation	• Capital shortfall systemwide, by bank and by group: contagion and vulnerability scores. • Amplification and cascade effects, direction, and size of spillovers within the network.
Banking Sector: Funding Cost		
Top-Down by IMF		
1. Institutional Perimeter	Exercise	• Top-Down by FSAP team.
	Institutions Included	• Two banks that do not issue bonds.
	Market Share	• Total coverage is about 85 percent of the banking sector.
	Data and Baseline Date	• Publicly available market data on banking bond yields (July 2022), historical bank-specific balance sheet and PnL data from Bloomberg, and solvency stress-testing projections.
2. Channels of Risk Propagation	Methodology	• Panel regression between cost of funding and bank specific performance indicators.
3. Risks and Buffers	Risks	• Credit spreads. • Interest rate.
	Firm Behavioral Response	• Firms are not allowed to raise capital.
4. Tail Shocks	Size of the Shock	• Drop in banking profitability and asset quality due to solvency stress test.
5. Regulatory and Market-Based Standards and Parameters	Regulatory Standards	• Market-based analysis, no capital thresholds are applied.
6. Reporting Format for Results	Output Presentation	• Relationship between banking performance and access to funding. • Projection of marginal wholesale funding cost under the alternative scenarios.

Appendix III. Probabilities of Default: Econometric Estimation

All PDs (and NPL ratios) used in the solvency stress test have been estimated through time series modelling.

1. PDs and NPL ratios can range between [0, 1], (for 0 percent to 100 percent); thus, all econometric models are implemented on the logistic transformation of dependent variables

$$LogitY = ln\left(\frac{Y}{1-Y}\right) \quad (1)$$

where, *Y* is the dependent variable and *LogitY* is its logit transformation. The econometric model has been used to simulate 10,000 alternative paths under both the baseline and the adverse scenarios and the respective average paths have been used as projections. For EDF projections under the stress scenario, the path in the 90th percentile has been selected to better capture the impact of the adverse macroeconomic environment.

NPL Ratios

2. Historical household and corporate NPL ratios have been cointegrated; thus, they are modeled together through a vector error correction model (VECM) with exogenous macrofinancial variables (Table 1).

Table 1. Finland: NPL VECM

Variable	Estimate	SE	tStat	pValue
Constant (Consumer)	-1.0455	0.2905	-3.5993	0.0003
Constant (Corporate)	0.0135	0.2707	0.0498	0.9603
Adjustment (Consumer, Consumer)	0.0562	0.0154	3.6587	0.0003
Adjustment (Corporate, Consumer)	0.0009	0.0143	0.0663	0.9472
Impact (Consumer, Consumer)	-0.4066	0.1111	-3.6587	0.0003
Impact (Corporate, Consumer)	-0.0069	0.1036	-0.0663	0.9472
Impact (Consumer, Corporate)	0.2034	0.0556	3.6587	0.0003
Impact (Corporate, Corporate)	0.0034	0.0518	0.0663	0.9472
d Unemployment t (Consumer)	0.1115	0.0708	1.5742	0.1154
d Unemployment t (Corporate)	0.1645	0.0660	2.4921	0.0127
d Investment to GDP t-1 (Consumer)	-21.3959	9.8672	-2.1684	0.0301
d Investment to GDP t-1 (Corporate)	-11.4092	9.1960	-1.2407	0.2147
d LN Property Prices t-1 (Consumer)	-3.0129	1.1182	-2.6944	0.0071
d LN Property Prices t-1 (Corporate)	-2.5660	1.0422	-2.4622	0.0138
dummy (Consumer)	0.5676	0.1083	5.2436	0.0000
dummy (Corporate)	0.8951	0.1009	8.8722	0.0000

3. The model has been estimated on quarterly observations from Q4 2005 to Q4 2001 (65 observations). The optimal order of the model is zero (according to the Bayesian Information Criterion – BIC). The exogenous variables of the model are the quarterly change in unemployment, quarterly change of real investment over real GDP ratio, quarterly log-difference of property prices, and a dummy variable to capture a structural break in the series in Q4 2013.

Finland Corporate Probability of Default

4. The historical Moody's average Finnish corporate EDF is estimated through a single time series model with exogenous variables. The model has been estimated on quarterly observations from Q3 2001 to Q4 2021 (78 observations). The optimal specification of the model is an ARIMA(1,0,0). The dependent variable is the logit transformation of the EDF, and exogenous variables are annual real GDP growth, annual real investment growth, and EURIBOR. The specification of the model is presented in Table 2.

Table 2. Finland: Corporate PD Model

Variable	Estimate	SE	tStat	pValue
Constant	-0.8277	0.2376	-3.4838	0.0009
ARt-1	0.8179	0.0548	14.9148	0.0000
GDP growth t-1	-4.7941	2.9975	-1.5994	0.1142
GDP growth t-2	-8.4974	4.5067	-1.8855	0.0635
GDP growth t-3	-7.0611	3.3351	-2.1172	0.0378
Investment growth t-1	-0.4878	0.3164	-1.5419	0.1276
Investment growth t-2	-0.6494	0.3146	-2.0642	0.0427
EURIBOR t-1	3.1773	1.2758	2.4904	0.0151

Denmark Corporate Probabilities of Default

5. The historical Moody's average Danish corporate EDF is estimated through a single time series model with exogenous variables. The model has been estimated on quarterly observations from Q3 2006 to Q4 2021 (57 observations). The optimal specification of the model is an ARIMA(0,1,0). The dependent variable is the logit transformation of the EDF, and exogenous variables are quarterly change of Denmark's interbank rates, quarterly log-difference of Denmark's real GDP, and quarterly change of Denmark's output gap. The specification of the model is presented in Table 3.

Table 3. Denmark: Corporate PD Model

Variable	Estimate	SE	tStat	pValue
d Interbank t	0.0658	0.0930	0.7068	0.4828
d Interbank t-1	0.1957	0.0878	2.2298	0.0301
d LN GDP t-3	-8.2813	4.3703	-1.8949	0.0637
d Output gap t	-0.2053	0.0414	-4.9536	0.0000

Norway Corporate Probabilities of Default

6. The historical Moody's average Norwegian corporate EDF is estimated through a single time series model with exogenous variables. The model has been estimated on quarterly

observations from Q3 2001 to Q4 2021 (78 observations). The optimal specification of the model is an ARIMA(0,1,0). The dependent variable is the logit transformation of the EDF, and exogenous variables are quarterly change of Norway's interbank rates, and quarterly change of Norway's output gap. The specification of the model is presented in the Table 4.

Table 4. Norway: Corporate PD Model

Variable	Estimate	SE	tStat	pValue
d Interbank t-1	0.2762	0.0543	5.0858	0.0000
d Output gap t-1	-0.2617	0.0615	-4.2578	0.0001

Sweden Corporate Probabilities of Default

7. The historical Moody's average Swedish corporate EDF is estimated through a single time series model with exogenous variables. The model has been estimated on quarterly observations from Q3 2001 to Q4 2021 (78 observations). The optimal specification of the model is an ARIMA(0,1,0). The dependent variable is the logit transformation of the EDF, and exogenous variables are quarterly change of Sweden's interbank rates, quarterly log-difference of Sweden's real GDP and quarterly change of Sweden's output gap. The specification of the model is presented in the Table 5.

Table 5. Sweden: Corporate PD Model

Variable	Estimate	SE	tStat	pValue
d Interbank t-1	0.1799	0.0468	3.8433	0.0003
d LN GDP t-3	-3.9048	2.1997	-1.7752	0.0800
d Output gap t	-0.0867	0.0222	-3.9064	0.0002

Finland Sovereign Probability of Default

8. MuniFin only does government guaranteed lending, so Finland's sovereign PD is used as PD for MuniFin's lending. The historical Moody's Finland's sovereign EDF is estimated through a single time series model with exogenous variables. The model has been estimated on quarterly observations from Q3 2001 to Q4 2021 (78 observations). The optimal specification of the model is an ARIMA(1,0,0). The dependent variable is the logit transformation of the EDF, and exogenous variables are annual real GDP growth and quarterly change in output gap. The specification of the model is presented in the Table 6.

Table 6. Finland: Sovereign PD Model

Variable	Estimate	SE	tStat	pValue
Constant	-0.4475	0.2366	-1.8116	0.0634
ARt-1	0.9076	0.4577	19.027	0.0000
GDP growth t-2	-3.68	2.4105	-1.5267	0.1322
d Output gap t	-0.0462	0.0309	-1.4965	0.1399

Appendix IV. Finland Corporate Probabilities of Default: Econometric Estimation

1. Aggregate domestic large corporates PD projections consisted of a combined projection of the aggregate corporate PD estimated through the NPL and Moody's average Finnish corporate EDF projection. The rationale of this approach is that different PD measurements involve different type of information; including all of them provides a more coherent estimation of a PD path. The weights of the combination have been estimated through linear programming.

$$PD_t^c = w_a PD_t^a + w_b PD_t^b \quad (1)$$

s.t. $$w_a + w_b = 1 \quad (2)$$

where, PD_t^c is the combined PD estimation for time *t*, PD_t^a is the PD derived through the *NPL*, PD_t^b is the corporate EDF, and w_a and w_b are the combination weights.

2. The combination weights are calibrated according to the individual in-sample forecasting accuracy of the two individual projections. The first step of the weight estimation process is the normalization (adjustment) of both observed and predicted individual PDs.

$$A_{i,i}^{ad} = \frac{A_{i,t}}{\frac{1}{T}\sum_{t=1}^{T} A_{i,t}} \quad (3)$$

$$A_t^{mean} = \frac{1}{I}\sum_{i=1}^{I} A_{i,t}^{ad} \quad (4)$$

$$F_{t,i}^{ad} = \frac{F_{i,t}}{\frac{1}{T}\sum_{t=1}^{T} A_{i,t}} \quad (5)$$

where, $A_{i,t}$ is the observed historical PD, $F_{i,t}$ is the predicted (fitted) historical PD for time *t* ($i \in \{a, b\}$). $A_{i,t}^{ad}$ and $F_{i,t}^{ad}$ are the adjusted observed and predicted PDs respectively, and A_t^{mean} is the average observed PD of the two individuals projections.

3. Then weights are calibrated through the following linear program

$$\min_w \sum_{t=1}^{T} (\varepsilon_t^1 + \varepsilon_t^2) \quad (6)$$

$$s.t. \begin{cases} \sum_{i=1}^{I} w_i F_{i,t}^{ad} - A_t^{mean} + \varepsilon_t^1 - \varepsilon_t^2 = 0 \;\forall\, t \in [1,T] & (7) \\ \sum_{i=1}^{I} w_i = 1 & (8) \\ w, \varepsilon^1, \varepsilon^2 \geq 0 & (9) \end{cases}$$

4. The estimated combination weights are 0.56 for the NPL base projection and 0.44 for EDF based projection.

Appendix V. Interest Rates: Econometric Estimation

1. The average interest rates of interest-bearing assets and liabilities have been projected through time-series regression models. The dependent variable is the respective average interest rate and independent variables are elements of the interest rate environment. Dependent variables are EURIBOR (lending and deposits), risk-free rate (debt securities), and other macrofinancial variables that may affect the interest banks charge or receive.

Loans

2. Average retail lending rates are estimated through a single time series regression model, with an autoregression component and (ARIMA(1,1,0)) and two exogenous variables, quarterly change of EURIBOR and unemployment. EURIBOR captures the interest rate environment, and unemployment the risk premia of the retail lending exposure (i.e., the ability of the borrower to repay the loan). The model is estimated on quarterly frequency series from Q2 2009 to Q4 2021 (46 observations).

Table 1. Finland: Retail Lending Rate Model

Variable	Estimate	SE	tStat	pValue
Art-1	0.2179	0.0865	2.5188	0.0158
d EURIBOR t	0.5073	0.0608	8.3463	0.0000
d Unemployment t-2	0.0010	0.0054	1.7970	0.0797

3. Corporate lending rates are divided to large corporates and SMEs. The analysis shows that the two series are cointegrated, so they are modeled together through a VECM. The optimal order of the model is zero (BIC). The exogenous variables of the model are the quarterly change in EURIBOR and quarterly log-difference of equity prices. Like retail lending, EURIBOR captures the interest rate environment and equity prices the risk premia of corporate lending exposures. The model is estimated on a quarterly frequency from Q2 2009 to Q4 2021 (46 observations).

Table 2. Finland: Corporate Lending Rate Model

Variable	Estimate	SE	tStatistic	pValue
Constant (Large)	-0.4920	0.1209	-4.0684	0.0000
Constant (SME)	0.0626	0.0382	1.6402	0.1010
Adjustment (Large, Large)	-0.1810	0.0393	-4.6065	0.0000
Adjustment (SME, Large)	0.0174	0.0124	1.4018	0.1610
Impact (Large, Large)	-0.7301	0.1585	-4.6065	0.0000
Impact (SME, Large)	0.0701	0.0500	1.4018	0.1610
Impact (Large, SME)	0.7595	0.1649	4.6065	0.0000
Impact (SME, SME)	-0.0729	0.0520	-1.4018	0.1610
d EURIBOR t (Large)	1.3901	0.3985	3.4887	0.0005
d EURIBOR t (SME)	0.6588	0.1258	5.2388	0.0000
d LN Equity Price t-3 (Large)	-4.1771	1.5602	-2.6772	0.0074
d LN Equity Price t-3 (SME)	-0.7054	0.4924	-1.4325	0.1520

4. The average interbank lending rate is cointegrated with EURIBOR, so it is estimated through a single equation Error Correction Model (ECM). The optimal specification does not include an autoregression component. The model is estimated on quarterly frequency series from Q2 2009 to Q4 2021 (46 observations).

Table 3. Finland: Interbank Lending Rate Model		
Variable	**Interbank Lending**	
d EURIBOR t	Estimate	0.4675
	SE	0.1056
	pValue	0.0000
Lambda	Estimate	-0.0340
	SE	0.0179
	pValue	0.0650
Error correction		
Constant		-0.1030
EURIBOR t-1		4.9769

Deposits

5. Three types of deposit rates are available: term deposits, overnight deposits, and other deposits. All three are estimated through single equation time series modes, with the quarterly change of EURIBOR as an exogenous variable and one autoregression component whenever it is required. All three models are estimated on quarterly frequency series from Q2 2009 to Q4 2021 (46 observations).

Table 4. Finland: Deposit Rates Model				
Variable		**Deposits**		
		Term	**Overnight**	**Other**
ARt-1	Estimate		-0.2783	
	SE		0.1301	
	pValue		0.0382	
d EURIBOR t	Estimate	0.3508	0.2940	0.2658
	SE	0.0724	0.0376	0.0820
	pValue	0.0000	0.0000	0.0023

Debt Securities

6. Three average debt securities rates are available, debt securities in assets, unsecured debt securities in liabilities and secured debt securities in liabilities. All three are estimated through single equation time series models. The quarterly change of risk-free rate is an exogenous variable in all three models. The secured debt model includes the quarterly log difference of property prices to capture the impact of collateral on the rate of interest of the security. Interest

rates of both secured and unsecured debt securities in the liabilities are cointegrated with the risk-free rate, so they are estimated through single equation ECMs. All three models are estimated on a quarterly frequency from Q1 2015 to Q4 2021 (24 observations).

Table 5. Finland: Debt Security Rates Models

Variable		Debt Securities		
		Assets	**Liabilities Unsecured**	**Liabilities Secured**
d Risk Free t	Estimate	0.7819	0.6059	0.4941
	SE	0.1497	0.2780	0.1125
	pValue	0.0000	0.0402	0.0003
d LN Property Prices t	Estimate			-2.2130
	SE			1.4451
	pValue			0.1406
Lambda	Estimate	-0.1747		-0.1200
	SE	0.0804		0.0861
	pValue	0.0409		0.0302
Error correction				
Constant		0.1431		-0.1113
Risk Free t-1		0.2777		0.1083

7. Over the baseline scenario, projections of debt securities in liabilities are estimated as the actual forecast of the model. Over the stress scenario, 10,000 alternative paths have been simulated, and the path in the 90th percentile has been selected for the projections, capturing the expected increase in risk premia.

Appendix VI. Liquidity Stress Test Scenario Specification

LCR Scenario Weights

Table 1. Finland: Stress Test Liquid Asset Haircuts		
	Basel	**Stressed**
Level 1 Assets	100 percent	95 percent
1. Cash		
2. Qualifying marketable securities (sovereigns, central banks, PSEs, and MDBs)		
3. Qualifying central bank reserves		
4. Domestic sovereign or central bank debt for nonzero risk-weighted entities		
Level 2a Assets	85 percent	50 percent
1. Qualifying marketable securities from sovereigns, central banks, PSEs, and MDBs (with 20 percent risk weighting)		
2. Qualifying corporate debt securities rated AA- or higher		
3. Qualifying covered bonds rated AA- or better		
Level 2b Assets		
1. Qualifying Mortgage-Backed Securities	75 percent	50 percent
2. Qualifying corporate debt securities rated between A+ and BBB-	50 percent	25 percent
3. Qualifying common equity shares	50 percent	0 percent

Table 2. Finland: Inflows Roll-off Rates		
	Basel	**Stress**
Level 1 assets	0 percent	0 percent
Level 1 assets (extremely liquid)	7 percent	0 percent
Level 2a assets	15 percent	5 percent
Level 2b assets		
-Eligible RMBS	25 percent	10 percent
-Other	50 percent	30 percent
Margin lending backed by all other collateral	50 percent	30 percent
All other assets	100 percent	75 percent
Credit or liquidity facilities	0 percent	0 percent
Operational deposits held at other financial institutions	0 percent	0 percent
Other inflows, by counterparty		
-Retail counterparties	50 percent	25 percent
-Nonfinancial wholesale counterparties, transactions not listed above	50 percent	20 percent
-Other inflows from non-financial counterparties, non-principal repayment	100 percent	50 percent
-Financial institutions and central banks, transactions not listed above	100 percent	50 percent
Net derivative cash inflows	100 percent	50 percent
Other (contractual) cash inflows	100 percent	50 percent
Loans with an undefined contractual end date	20 percent	10 percent

Table 3. Finland: Outflows Run-Off Rates		
	Basel	**Stress**
Retail Deposits		
Demand deposits		
- *Stable deposits*	5 percent	20 percent
- *Less stable retail deposits*	10 percent	30 percent
Term deposits, residual maturity > 30d	0 percent	0 percent
Other forgone retail deposits	100 percent	100 percent
Unsecured Wholesale Funding		
Demand and term deposits, residual maturity < 30d, small business		
- *Stable deposits*	5 percent	20 percent
- *Less stable deposits*	10 percent	30 percent
Operational deposits generated by clearing, custody, and cash management activities	25 percent	50 percent
- *Portion covered by deposit insurance*	5 percent	5 percent
Cooperative banks in an institutional network	25 percent	25 percent
Nonfinancial corporates, sovereigns, central banks, MDBs, PSEs		
- *Fully covered by deposit insurance*	20 percent	20 percent
- *Not fully covered by deposit insurance*	40 percent	60 percent
Other legal entity customers	100 percent	100 percent
Secured Funding		
Secured funding with a central bank, or backed by Level 1 assets	0 percent	0 percent
Secured funding backed by Level 2A assets	15 percent	20 percent
Secured funding backed by non-Level 1 or non-Level 2a asset (domestic sovereign, MDBs, or domestic PSEs as a counterparty)	25 percent	50 percent
Funding backed by RMBS eligible for Level 2B	25 percent	50 percent
Funding backed by other Level 2B assets	50 percent	50 percent
Other secured funding transactions	100 percent	100 percent
Additional Requirements		
Valuation changes on non-Level 1 posted collateral securing derivatives	20 percent	20 percent
Excess collateral held by bank related to derivate transactions that could be called anytime	100 percent	100 percent
Liquidity needs related to collateral contractually due on derivatives transactions	100 percent	100 percent
Increased liquidity needs related to derivative transactions allowing collateral substitution	100 percent	100 percent
ABCP, SIVs, conduits, SPVs, or similar		
- *Liabilities from maturing*	100 percent	100 percent
- *Asset backed securities*	100 percent	100 percent

Table 3. Finland: Outflows Run-off Rates (Concluded)		
Undrawn but committed credit and liquidity facilities		
- *Retail and small business*	5 percent	50 percent
- *Nonfinancial corporates, sovereigns, central banks, MDBs, PSEs*		
* *Credit facilities*	10 percent	50 percent
* *Liquidity facilities*	30 percent	50 percent
- *Supervised banks*	40 percent	50 percent
- *Other financial institutions*		
* *Credit facilities*	40 percent	50 percent
* *Liquidity facilities*	100 percent	100 percent
- *Other legal entity customers, credit and liquidity facilities*	100 percent	100 percent
Other contingent funding liabilities		
- *Trade finance*	5 percent	50 percent
- *Customer short positions covered by customers' collateral*	50 percent	75 percent
- *Other product and services*	10 percent	25 percent
Additional contractual outflows	100 percent	100 percent
Net derivate cash outflows	100 percent	100 percent
Any other contractual cash outflows (not listed above)	100 percent	100 percent

Cashflow Analysis Weights

Table 4. Finland: Cash Flow Rates and Cumulative Asset Sales								
	Up to 1 d	**1d to 1 wk**	**1wk to 1m**	**1m to 2ms**	**2ms to 3ms**	**3ms to 6ms**	**6ms to a Y**	**1y to 2ys**
Cash-Outflow Rates	60 percent	60 percent	40 percent	40 percent	40 percent	40 percent	40 percent	20 percent
Cash-Inflows Rates	50 percent	50 percent	50 percent	30 percent	30 percent	10 percent	10 percent	10 percent
Cumulative Assets Sales	30 percent	70 percent	90 percent	100 percent	100 percent	100 percent	100 percent	100 percent

Table 5. Finland: Fire-Sales Haircuts		
Fire-Sales	**Market Haircut**	**Counterbalancing Haircut**
Unencumbered Assets and Collateral	20 percent	10 percent
Other Eligible Securities	50 percent	30 percent

Appendix VII. Bond Yield Model Calibration

1. **A panel model is calibrated, where the dependent variable is bank specific 5-year bond yields, and independent variables are indices that show banks' financial position and the risk-free rate.** Banking position fundamentals consist of four dimensions: i) solvency, ii) profitability, iii) asset quality, and iv) liquidity. The FSAP team tested several dimension-specific indices that have proxied these four dimensions. None of the potential solvency measures have been proved significant, probably because Finnish banks are well-capitalized, and the volatility of their solvency is low. The remaining variables that have been implemented are:

- *Profitability:* Return on assets (total profits over total assets - ROA)
- *Asset quality:* Provisions over total credit exposures (POE)
- *Liquidity:* Liquid assets over total assets (LOTA)
- *Risk-free rate:* German sovereign bond yields

2. **The data consist of an unbalance panel on a quarterly frequency.** The cross-sectional dimension is 5 (five banks) and time dimension ranges from 30 to 47 (total observations are 175). The range of the longest series ranges from Q3 2010 to Q1 2022. The model is implemented in first differences and all variables are seasonally adjusted.

Table 1. Finland: Panel Model Estimation

Name	Estimate	SE	tStat	pValue
ROA t	-3.4671	1.3745	-2.5224	0.0126
Log POE t	0.9483	0.3189	2.9739	0.0034
LOTA t	-0.0038	0.0020	-1.8738	0.0627
Risk-Free t	0.9817	0.1428	6.8733	0.0000