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# FINLAND

## FINANCIAL SECTOR ASSESSMENT PROGRAM

January 2017

## TECHNICAL NOTE—STRESS TESTING THE BANKING SYSTEM AND INTERCONNECTEDNESS ANALYSIS

This Technical Note on Stress Testing the Banking System and Interconnectedness Analysis for Finland was prepared by a staff team of the International Monetary Fund as background documentation for the periodic consultation with the member country. It is based on the information available at the time it was completed in November 2016.

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November 2016

# TECHNICAL NOTE

## STRESS TESTING THE BANKING SYSTEM AND INTERCONNECTEDNESS ANALYSIS

Prepared By
**Monetary and Capital Markets Department, IMF**

This Technical Note was prepared in the context of an IMF Financial Sector Assessment Program (FSAP) mission in Finland during June 2016 led by Mr. Marco Pinon-Farah. It contains the technical analysis and detailed information underpinning the FSAP assessment's findings and recommendations. Further information on the FSAP program can be found at http://www.imf.org/external/np/fsap/fssa.aspx.

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# Glossary

| | |
|---|---|
| AFS | Available For Sale |
| CCP | Central Clearing Counterparty |
| CDS | Credit Default Swap |
| CET1 | Common Equity Tier1 |
| COREP | Common Reporting Framework |
| CRD | Capital Requirement Directive |
| CRR | Capital Requirements Regulation |
| CVA | Credit Valuation Adjustment |
| EBA | European Banking Authority |
| ECB | European Central Bank |
| EDF | Expected Default Frequency |
| EL | Expected Losses |
| ELA | Emergency Liquidity Assistance |
| EU | European Union |
| FDI | Foreign Direct Investment |
| FIN-FSA | Finland's Financial Supervision Authority |
| FINREP | Financial reporting |
| FSGM | Flexible System of Global Models |
| FSSA | Financial System Stability Assessment |
| GBP | Pound Sterling |
| HFCS | Household Finance and Consumption Survey |
| HFT | Held For Trading |
| IBB | Consolidated Banking Statistics on Immediate Borrower Basis |
| ICAAP | Internal Capital Adequacy Assessment Process |
| IMF | International Monetary Fund |
| NFC | Non Financial Corporations |
| OLS | Ordinary Least Squares |
| OTC | Over-the-Counter |
| O-SII | Other Systemically Important Institution |
| PIT | Point-in-time |
| RAM | Risk Assessment Matrix |
| RLS | Robust Least Squares |
| RWA | Risk Weighted Assets |
| STA | Standardized Approach |
| STeM | Stress Test Matrix (for FSAP stress tests) |
| TN | Technical Note |
| TTC | Through-the-Cycle |
| U.K. | United Kingdom |
| URB | Consolidated Banking Statistics on Ultimate Risk Basis |

| | |
|---|---|
| U.S. | United States |
| USD | United States Dollar |
| VAR | Vector AutoRegression |
| VIX | Chicago Board Options Exchange Volatility Index |

# EXECUTIVE SUMMARY

**Despite high capitalization levels, there are important vulnerabilities in the Finnish banking system.** Near-term risks are largely tilted to the downside, stemming from both external and domestic sources. A shaper than expected global growth slowdown would be a drag on Finland's export and GDP growth. Although so far high compared to the rest of the euro area banks, Finnish banks' profitability is facing challenges from the low interest rate environment and the low economic growth. Vulnerabilities include funding risks, contagion risks, and challenges related to long-term profitability. Relatively low levels of total equity resulting in part from an aggressive use by banks of their internal risk models might warrant additional buffers. Some banks are significantly exposed to the derivatives business and as a result to counterparty credit risks.

**Wholesale funding, particularly from external sources, plays a major role in financing credit in Finland**. Banks rely on wholesale funding, as reflected in the 124 percent loan-to-deposit ratio. Wholesale funding accounts for more than half of banks' funding and the main instruments are deposits from credit institutions, covered bonds, senior unsecured bonds, repo transactions, and commercial paper/time deposits. A majority of this wholesale funding is provided by foreign financial institutions, including parent banks.

**The stress tests examined the resilience of the Finnish banking system to *solvency*, *liquidity*, and *contagion* risks.** The stress tests included a top-down (TD) exercise based on macroeconomic scenarios and sensitivity analyses. The tests based on macroeconomic scenarios assessed the impact of these extreme but plausible external and domestic shocks on the economy over a three-year horizon (2016-2018), based on data available through December 2015. The effects of these shocks on individual banks' profitability and capitalization were assessed using satellite models and methodologies developed by Fund staff. In addition, sensitivity stress tests assessed vulnerabilities of the banking system to individual shocks. The TD liquidity tests assessed the capacity of banks to withstand large withdrawals of funding, using a maturity ladder analysis and supervisory information, both on an aggregate basis and by currencies. The contagion tests covered domestic interbank exposures, cross-exposures between domestic banks and insurers, cross-border interlinkages with supervisory and market data.

**The design of the stress tests incorporated the main external risks.** These risks arise mostly from a protracted period of weak growth in advanced economies, particularly in the euro area, and substantial declines in house and other asset prices in the Nordic neighbors, which would affect the Finnish economy through foreign banks' withdrawal of liquidity, lower investment and confidence effects. Moreover, a surge in global financial market volatility could increase interest rates and raise funding costs as investors may reassess underlying risks and move to safe-haven assets.

**The tests also incorporated key domestic risks.** First, domestic factors could amplify the effects of external shocks, such as a domestic confidence shock translating into a consumption and investment collapse, decline in wages, reduction in public safety net, and a house price decline triggering adverse wealth effects. Moreover, this adverse economic situation would result in a much

larger public deficit and debt, causing investors' concerns over the government's creditworthiness, a sovereign stress and translating into a 3-notch downgrade of the sovereign rating.

**Results of the solvency stress tests reveal several sources of vulnerabilities, and the banking system would be significantly affected under the severe stress scenario**. The key vulnerabilities in the banking system revealed in the severe stress scenario include funding risks due to a high reliance on unsecured wholesale funding, credit risk associated with domestic retail portfolios, and a high share of volatile trading income. The severe stress scenario combines extreme but plausible macrofinancial shocks. The capital of two of the four largest banks would fall slightly below minimum regulatory Capital Adequacy Requirements. Recapitalization needs would be manageable, at around EUR550 mn or just 0.3 percent of GDP. When considering total equity in relation to assets (leverage ratio), however, all four banks would fail to meet the 3 percent hurdle rate in 2018 when it becomes binding.[1] Recapitalization needs based on the leverage ratio would be equivalent to 2 percent of GDP. This discrepancy indicates that banks' internal models used to calculate risk weighted assets may underestimate risks.

**The solvency stress test results are largely driven by a significant deterioration in the households' situation.** Household stress tests reveal that current low credit risks are the result of the macroeconomic environment and social set-up in which private consumption and households' disposable income are actively sheltered from economic shocks, as has been historically the case in Finland. While in an economic downturn, credit risks can remain low if the government or the social safety nets continue to protect households, a substantial reduction in wages and social transfers may lead to a large increase in retail portfolio losses. Capital needs in our severe stress scenario are due to losses as well as an almost 10 percent increase in risk-weighted assets as a result of higher credit risks.

**Funding and liquidity risks are the main vulnerability.** The global liquidity stress tests reveal that most banks in the system would be exposed to liquidity risks in the event of large deposit withdrawals, under a more severe scenario than the Basel III LCR metrics, or of a dry-up of unsecured wholesale funding. In addition, some banks display material exposure to funding risks in foreign currencies. Finally, maturity mismatches are moderate at the aggregate level at the one-year horizon based on the NSFR results. At the individual level, however, some banks would be experiencing liquidity shortfalls, reflecting excessive maturity transformation.

**Banks are found to be less vulnerable to direct contagions risks through bilateral exposures although banks have large cross-border exposures.** The contagion risk analysis reveals that the risks stemming from domestic interbank exposures and from cross exposures between domestic banks and insurance companies are very limited. By contrast, cross-border bank linkages appear to be a concern and need to be monitored. The Finnish banking system is vulnerable to cross border spillovers due to the Nordic region linkages. The subsidiaries of foreign banks would be vulnerable to the failure of their parents on their asset side. Market data-based analysis confirms the strong

[1] Leverage ratio definition used for stress testing purposes was based on Basel III and might have discrepancies with the final EU rules.

implicit financial linkages among the Nordics. Sweden and Finland share the strongest implicit linkages, while Finland is the Nordic country the most strongly connected to developed economies in continental Europe.

**These findings may warrant a regulatory review of banks' Internal Ratings-Based models, as well as a ramping-up in monitoring of liquidity, funding and derivatives related risks.** Recent steps by the FSA to introduce regulatory floors on risk-weights for mortgage exposures for banks that apply Internal Ratings-Based (IRB) methodologies will increase capital buffers to cover unexpected losses due to potential system-wide vulnerabilities. However, additional stress testing elements, like performing regular micro-data based household stress tests to benchmark banks' risk parameters and monitoring potential aggressive use of modeling techniques to lower PDs and LGDs are also recommended. Moreover, there might be a need to improve liquidity monitoring by performing liquidity stress tests, including in foreign currencies, and conducting a Nordic-wide stress test coordinated exercise to take into account interlinkages and spillovers, include liquidity-solvency interactions and expand coverage beyond banks to cross-border regional insurance companies and financial market infrastructure. Finally, additional data collection about derivatives-related risks, especially on the nature of banks exposures and trading activities is important to understand and minimize potential spillovers related to cross-border contagion.

**Table 1. Finland: Recommendations on Banking Stress Testing and Cross-border Network Analysis**

| ***Risk analysis*** | **Time[1]** | **Responsibility** |
|---|---|---|
| Ensure banks' Internal Ratings-Based models take into account losses in stressed environments (see ¶ 45). | NT | ECB/Fin-FSA |
| Use of regular micro-data based household stress tests to benchmark PDs and LGDs for retail portfolios and effectively challenge banks in case of aggressive use of modeling techniques to lower risk parameters (see ¶ 45). | NT | ECB/Fin-FSA |
| Finalize plans to introduce regulatory floors for the risk-weights calculated by IRB banks (see ¶ 45). | NT | ECB/Fin-FSA |
| Examine banks' liquidity positions in foreign currencies in a stressed environment; and perform liquidity stress tests based on cash flows at various maturities (see ¶ 75). | NT | ECB/Fin-FSA |
| Discourage cross-ownership of covered bonds (see ¶ 75). | NT | ECB/Fin-FSA |
| Lead an effort to conduct a Nordic-wide stress test coordinated exercise, taking into account interlinkages and spillovers, as well as liquidity-solvency interactions, and expanding the coverage beyond banks to cross-border regional insurance companies and financial market infrastructure (see ¶ 93). | MT | FIN-FSA/ BoF |
| Collect additional data on cross-border derivatives activities with a breakdown between centrally-cleared and over-the-counter transactions (see ¶ 32). | NT | ECB/Fin-FSA |

[1] I-Immediate" is within one year; "NT-near-term" is 1–3 years; "MT-medium-term" is 3–5 years.

# INTRODUCTION[2]

**1. Despite high capitalization levels, there are important vulnerabilities in the Finnish banking system.** Near-term risks are largely to the downside, stemming from both external and domestic sources. Although quite high compared to the rest of the euro area banks, Finnish banks' profitability is negatively affected by the low interest rate environment and the low economic growth. Vulnerabilities include funding risks, contagion risks, and challenges related to long-term profitability. Relatively low levels of total equity resulting from an aggressive use by banks of their internal risk models might require additional buffers. Some banks are significantly exposed to the derivatives business and as a result to counterparty credit risks.

**2. Wholesale funding, particularly from external sources, plays a major role in financing credit in Finland**. Banks rely on wholesale funding, as reflected in the 124 percent loan-to-deposit ratio. Wholesale funding accounts for more than half of banks' funding and the main instruments are deposits from credit institutions, covered bonds, senior unsecured bonds, repo transactions, and commercial paper/time deposits. A majority of this wholesale funding is provided by foreign financial institutions, including parent banks.

**3. Finland's banking sector is open and extremely concentrated.** Total banking sector assets amount to 230 percent of GDP. The top four banks control 93 percent of system assets, with the subsidiaries of two foreign banks controlling 65 percent of total assets, a domestic private-owned banks making up 21 percent of banking system's assets and a domestic state-owned bank 6½ percent.

**4. In general, the objective of the FSAP stress testing exercise is to assess the capacity of the banking system to withstand *extreme* but *plausible* macroeconomic shocks.** The tests are meant to explore weaknesses in the financial system and the channels through which adverse shocks are transmitted. FSAP stress tests can help to identify priorities for policy actions, such as those aimed at reducing specific exposures or building capital and liquidity buffers. The FSAP stress testing process can also help authorities to identify informational and methodological gaps, and assess their preparedness to deal with situations of financial distress.

**5. FSAP stress tests may differ from stress tests conducted by central banks, including those previously undertaken by the FIN-FSA or the EBA and the ECB.[3]** The ECB and the FSAP team estimated separate credit risk models. The FSAP team carried out the tests in close

[2] Prepared by Mrs. Kay Chung, Messrs. Mindaugas Leika and Cyril Pouvelle, with the collaboration of Messrs. Luis Brandao-Marques and Benjamin Huston, all Monetary and Capital Markets Department of the IMF.

[3] It is important to note that the stress test conducted in the context of the FI FSAP is not comparable to the EBA 2016 Stress Test. This relates to the significant differences in assumptions, main characteristic of the exercise (top-down versus bottom-up) and as a consequence to the results of the two exercises.

cooperation with the FIN-FSA and was given access to a set of supervisory data in a physical data room, either on an aggregate or individual basis.

**6. Although stress tests are useful to explore weaknesses in a financial system, results must be interpreted with caution.** In all countries, the implementation of stress tests is conceptually challenging. Among other limitations, stress tests use macroeconomic and satellite models to calculate the impact of adverse scenarios or shocks on banks.[4] These models are estimated using historical data and are subject to estimation uncertainty. These limitations can be mitigated, but not eliminated, by using state-of-the-art techniques. Choices must also be made regarding the severity of shocks. In adverse scenarios, the economy is typically affected by a combination of external and domestic shocks that (*ex ante*) have a very low probability of occurrence.[5] Hence, by construction, adverse scenarios should not be interpreted as macroeconomic "forecasts".

**7. The stress tests examined the resilience of the banking system to *solvency*, *liquidity*, and *contagion* risks (Figure 1).** The stress tests included a Top-Down (TD) exercise based on macroeconomic scenarios and sensitivity analyses. The tests based on macroeconomic scenarios assessed the impact of combined external and domestic shocks on the economy over a three-year horizon (2016-2018), based on data available through December 2015.[6] The effects of these shocks on individual banks' profitability and capitalization were assessed using satellite models and methodologies developed by the ECB and Fund staff. The TD liquidity tests assessed the capacity of banks to withstand large withdrawals of funding. It used a maturity ladder analysis, i.e. a cash flow-based analysis with different maturity buckets, and supervisory information. The contagion tests covered domestic interbank exposures, interlinkages within the domestic financial system, and cross-border exposures between Finnish banks and foreign sectors.

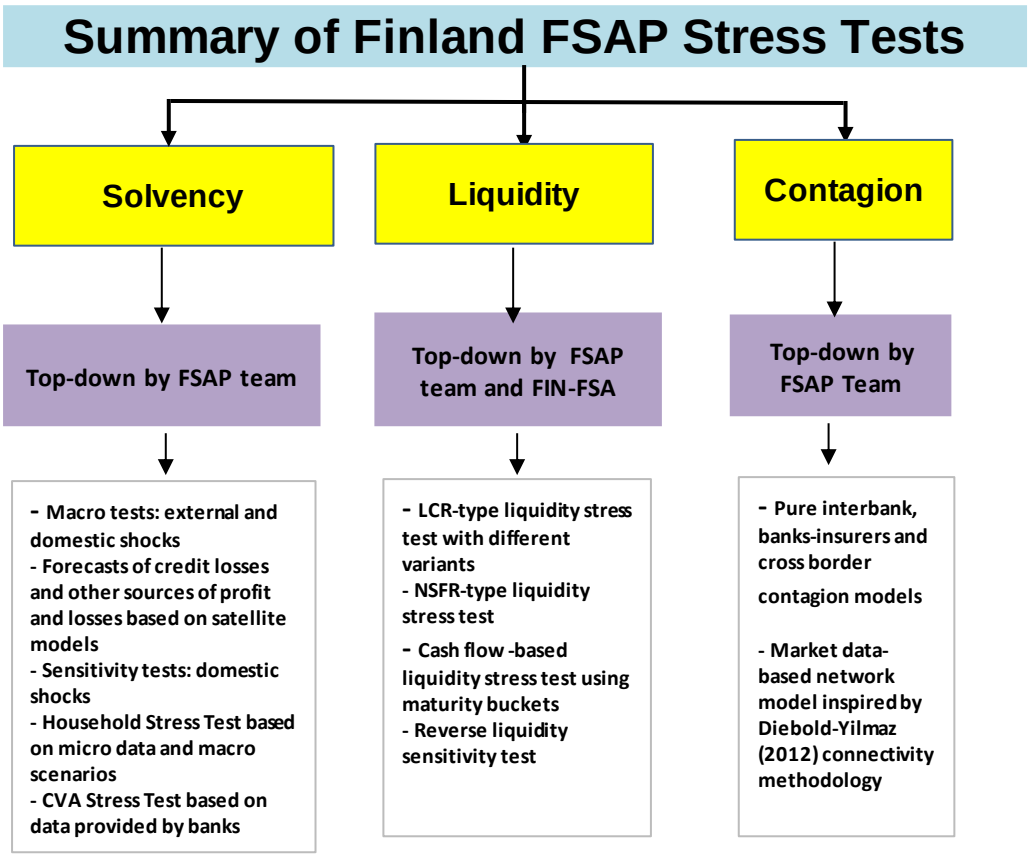
**8. An additional household stress test was conducted to assess the vulnerabilities of Finnish households to a significant drop in income, real estate prices and social transfers.** The stress test used household data obtained from the Households Finance and Consumption Survey (HFCS) collected by the ECB.

[4] Satellite models map the variables projected in the macroeconomic scenarios into credit factors that determine individual banks' gains or losses.

[5] The selection of the "relevant" historical episode and the length of data series used to construct severe stress scenarios are among the choices that must be made in the design of stress tests. There is often a temptation to dismiss the validity of historical episodes because structural changes alter the way in which economies function. Valid stress tests, however, should not fail to incorporate long history. As pointed out by Haldane (2009), stress testing exercises conducted before the global financial crisis failed to play a useful "early warning" role (in part) due to reliance on short data series – the tests underestimated true macroeconomic and financial volatility by failing to incorporate information contained in long data series, which undermined their validity and usefulness.

[6] It is common practice in FSAPs to implement the stress tests over a two- to five-year horizon. A two-year horizon is used in countries subject to a high degree of macroeconomic uncertainty at the time of the exercise. A five-year horizon is appropriate for countries subject to moderate or low macroeconomic uncertainty.

**Figure 1. Finland: Summary of Finland FSAP Stress Tests**




Source: IMF staff

**9. The TD stress test conducted by the FSAP team covered the four largest significant institutions.** Due to a restricted access to supervisory data, the TD stress test carried out by the FSAP team focused on the four systemically important institutions making up 93 percent of monetary and financial institutions (MFI) assets and 84 percent of the banking sector retail deposits. It included two subsidiaries of foreign banks. The highly concentrated nature of the Finnish banking system thus allowed the FSAP team to reach a very large coverage.

**10. The remainder of this technical note (TN) is structured as follows.** The second section presents the different components of the solvency stress tests based both on macroeconomic scenarios and sensitivity analysis: their description, design, methodology for implementation, and results. The following sections present the stress tests of liquidity risk, and the analysis of contagion risks.

# SOLVENCY STRESS TESTS

**11. The FSAP solvency stress tests were aimed at assessing banks' robustness to various shocks to their capital, namely credit, market as well as credit valuation adjustment (CVA) risks for derivatives exposures.** These tests covered the main risks faced by the banking sector. They included a Top-Down exercise based on macroeconomic scenarios and sensitivity analyses.

**12. The regulatory frameworks applied were Basel III, the European Union and the national frameworks, as defined by the Fourth Capital Requirements Directive (CRD IV), Regulation on Prudential Requirements, national law and FIN-FSA regulation.** The hurdle rates for total capital adequacy, Tier 1 capital, and Common Equity Tier1 capital were set according to the current minimum requirements (see Table 2 below), taking into account that the leverage ratio will become binding from 2018 onwards. The stress tests were based on minimum capital ratios under Pillar I and did not take into account any individual requirements under Pillar II. Banks were allowed to deplete a capital conservation buffer of 2.5 percent in the severe stress scenario. Every ratio was based on Basel III fully-loaded definitions. Banks included in the TD exercise had no capital instruments subject to the European framework for the phase-in of deduction from Common Equity Tier 1 and the phase-out portion of capital instruments that no longer qualify as additional Tier 1 capital or Tier 2 capital.

**Table 2. Finland FSAP Stress Test Hurdle and current rates**

| Scenario | Baseline and Moderate Stress scenarios hurdle rate (including capital conservation buffer) | Severe Stress scenario hurdle rate (excluding capital conservation buffer) | Actual ratio before stress |
|---|---|---|---|
| **Total Capital ratio** (total capital to RWAs, in percent) | 10.5 | 8 | 24.4 |
| **Tier I Capital ratio** (Tier 1 capital to RWAs, in percent) | 8.5 | 6 | 23 |
| **Common Equity Tier I Capital ratio** (CET1 capital to RWAs, in percent) | 7 | 4.5 | 21.9 |
| **Leverage ratio** (Tier 1 capital to total assets, in percent) | 3 | 3 | 4.2 |

**13. The effects of the shocks on individual bank's profitability and capitalization were assessed using satellite[7] models and methodologies developed by Fund staff.** In addition, sensitivity stress tests assessed vulnerabilities of the banking system to individual shocks. Sub-section A presents the main macrofinancial risks, the baseline and the macro scenarios that were applied for the conduct of the solvency stress test. Sub-section B describes the estimation of credit risks. Sub-section C sets out the analysis of market risks in the scenario analysis. Sub-section D provides the global results of the solvency stress tests based on scenario analysis. Sub-section E presents the results of the market risk sensitivity analysis. Sub-section F discusses the concentration risk analysis. Sub-section F presents the results of the household stress test.

## A. Macro-financial risks and Macroeconomic Scenarios

**14. The Finnish banking sector is exposed to several external risks.** The risks that are most likely to materialize are the following (see also Risk Assessment Matrix in Appendix I):

- *A structurally weak growth in key advanced and emerging economies, particularly the euro area.* Protracted euro area weakness could undermine domestic confidence, investment, and consumption as Finland's exports are tightly linked to euro area markets.

- *A euro area bond market contagion and higher-than-expected fallout from the UK referendum result on EU membership:* as a euro area member, Finland could be affected if sovereign and financial sector stress reemerges across the euro area due to protracted policy uncertainty and/or events related to Greece and the UK.

- *An adverse macroeconomic and house price shock in an interconnected neighboring Nordic country:* household debt is high in the Nordics due to easy access to credit, low interest rates, and tax incentives for housing; property prices remain elevated; two large banks in Finland are Swedish and Danish. A crisis in Denmark and Sweden could entail a significant drop in mortgage values, resulting in Danish and Swedish banks' large capital and liquidity needs. That would lead these banks to withdraw their funding from their Finnish subsidiaries, forcing the latter to deleverage on their assets and preventing them from extending any more loans.

- *Heightened risk of fragmentation/security dislocation in part of the Middle East, Africa, and Europe, particularly in Russia:* this would erode the globalization process and fosters inefficiency; Russia is Finland's fifth largest export market. Negative effects from a renewed increase in geopolitical tensions could spillover through further reductions in trade.

**15. Several features of the banking sector increase its vulnerability to shocks:**

- *Capitalization is low on a non-risk weighted basis:* Equity-to-total assets ratio amounts to 4.5 percent despite a high regulatory capital ratio of 21.7 percent of risk-weighted assets. The risk density (RWA to total assets ratio) of the four largest banks is considerably lower than among

[7] Satellite models link credit risk parameters (PDs) with various macrofinancial variables.

euro area peers (21.4 versus 39 percent in 2015), though it is higher when excluding traded assets (the credit risk RWA to gross loans ratio is equal to 42 percent). This reflects the size of the centrally-cleared derivatives portfolio at some banks, the share of zero risk-weighted exposures to the public sector in others, but also banks' reliance on low-risk weighted assets (especially mortgages) resulting from their internal models. The low capitalization on a non risk-weighted basis raises doubts on the banks' ability to have sufficient buffers to absorb heavy losses in the event of a crisis.

- *Liquidity risks are significant due to banks' reliance on wholesale funding:* banks rely on wholesale funding, in particular from external sources, as reflected in the 129 percent loan-to-deposit ratio. This makes Finnish banks vulnerable to freeze in international funding markets. This high reliance of external wholesale funding stems from the lack of a deep and large domestic debt market, rapid credit expansion in the last decade but reflects also intra-group operations and capital market operations in some banks.

- *Cross-border risks are elevated:* the substantial financial and economic integration amongst Nordic countries implies considerable exposure through valuations of banks' foreign assets and cross-ownership of covered bonds seems widespread in the Nordic region, entailing risks of systemic funding shocks. Moreover, investors in covered bonds are mostly banks, central banks and funds from the rest of the euro area, making Finnish banks vulnerable to possible changes in investors' sentiment. Finally, the interest rate risk embedded in the structure of covered bonds, with mortgage loans in the cover pools being primarily floating-rate loans while the covered bonds are issued as fixed-rate bonds, leads the banks to hedge this risk through derivatives.

**16. Stress tests are based on full-fledged macroeconomic scenarios**. Given the risks and vulnerabilities described above, the stress test examined a baseline macroeconomic scenario and two *extreme but plausible* adverse scenarios. All scenarios stretch over a three-year forecasting period[8]. The first year of the shock would then be 2016 and the scenario would run until 2018. These will comprise a baseline and two extreme but plausible adverse scenarios over a three-year horizon (2016-18), based on risks included in the Risk Assessment Matrix (Appendix Table 1).

**17. For the design of the macroeconomic scenarios, the following domestic variables had to be calibrated over a 3-year horizon:** real GDP growth, CPI inflation rate, unemployment rate, the nominal government bond rate, the euro-dollar exchange rate, and the real estate price growth. The two adverse scenarios are the following (see Figure 2 and Table 3):

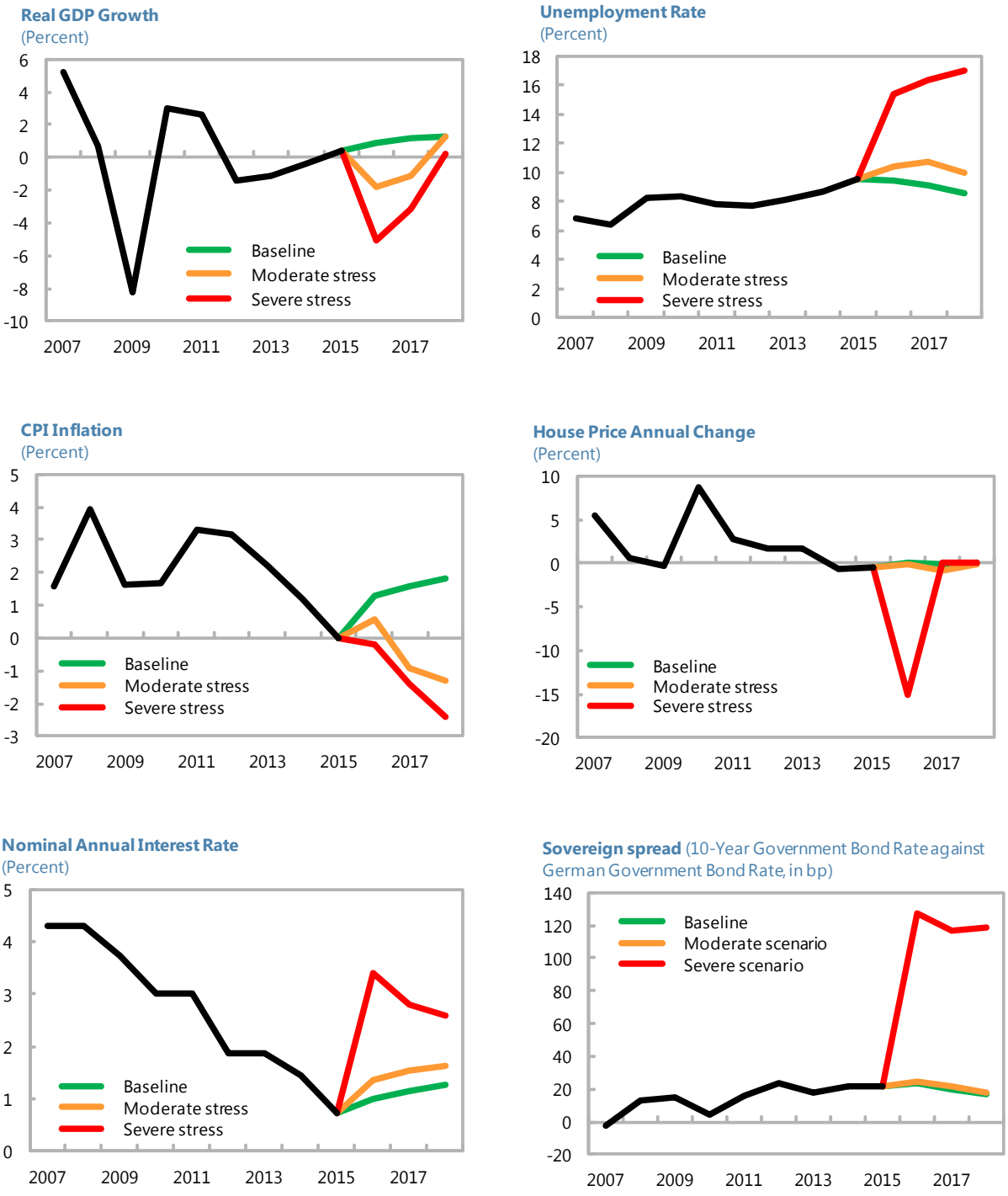
- **a moderate stress scenario,** driven by risk aversion affecting the European "periphery", adverse investment sentiment, and a sharp slowdown in emerging market economies. Finnish growth would experience a triple dip: continued low to moderately negative inflation; rising

[8] A three-year projection was chosen because, at the time of the FSAP, forecast errors appeared too large over periods longer than three years.

unemployment; and lower both bond and equity prices, increasing public debt and a one-notch downgrade of the sovereign debt rating.

- **a more severe stress scenario**: a severe disruption in Finland's European partners (in particular large declines in house and other asset prices in the Nordic neighbors) would be amplified by specific shocks in Finland. While the size of the overall shock is larger than the one experienced during the global financial crisis, it is in line with the one experienced during the mid-1990s banking crisis in the Nordic region (Figure 3). Specific shocks include: a domestic demand confidence shock and a decline in residential real estate prices, triggering adverse wealth effects. Moreover, this bad economic situation would result in a much larger public deficit and debt, causing investors' concerns over the government's creditworthiness, a sovereign stress and translating into a 3-notch downgrade of the sovereign rating. This in turn would lead to a procyclical consolidation fiscal policy, by reducing social benefits, in particular for the unemployed. The result would be a 2.7 per cent per annum decline in GDP on average, significantly higher unemployment, decline in wages and social transfers, and a persistent deflationary period.

## Figure 2. Finland: Macroeconomic Baseline and Stress Scenarios



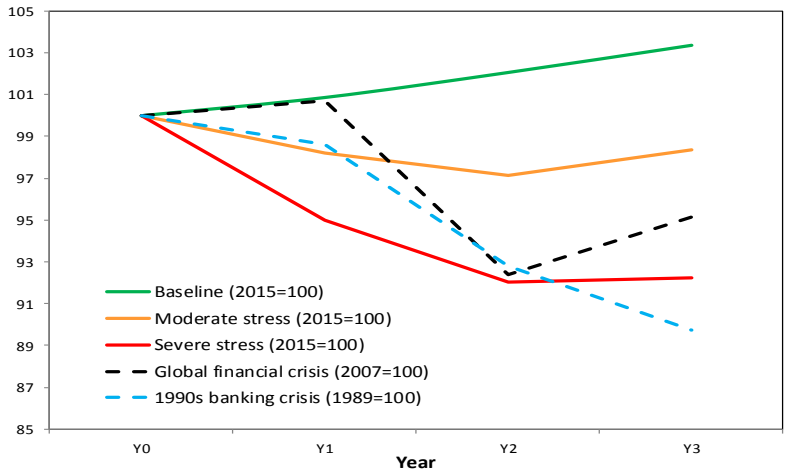

Source: IMF staff estimations.

**Table 3. Finland: Macroeconomic scenarios for Stress Tests: Assumptions for macroeconomic and financial variables (in percent)**

| | Est. | Projections | | |
|---|---|---|---|---|
| in % | 2015 | 2016 | 2017 | 2018 |
| **Real GDP growth** | | | | |
| Baseline | 0.4 | 0.9 | 1.2 | 1.3 |
| Severe stress | 0.4 | -5.0 | -3.1 | 0.2 |
| Moderate stress | 0.4 | -1.8 | -1.1 | 1.3 |
| **Real investment growth** | | | | |
| Baseline | -2.1 | 2.6 | 3.6 | 3.4 |
| Severe stress | -2.1 | -17.0 | -15.8 | -4.0 |
| Moderate stress | -2.1 | 0.2 | -0.9 | -2.1 |
| **CPI Inflation rate** | | | | |
| Baseline | 0.0 | 1.3 | 1.6 | 1.8 |
| Severe stress | 0.0 | -0.2 | -1.4 | -2.4 |
| Moderate stress | 0.0 | 0.6 | -0.9 | -1.3 |
| **Unemployment rate** | | | | |
| Baseline | 9.5 | 9.5 | 9.1 | 8.6 |
| Severe stress | 9.5 | 15.4 | 16.3 | 17.0 |
| Moderate stress | 9.5 | 10.5 | 10.7 | 10.0 |
| **Nominal annual interest rate (10-year government bond rate)** | | | | |
| Baseline | 0.7 | 1.0 | 1.1 | 1.3 |
| Severe stress | 0.7 | 3.4 | 2.8 | 2.6 |
| Moderate stress | 0.7 | 1.4 | 1.5 | 1.6 |
| **House price annual change** | | | | |
| Baseline | -0.5 | 0.0 | -0.1 | 0.1 |
| Severe stress | -0.5 | -15.0 | 0.0 | 0.0 |
| Moderate stress | -0.5 | -0.2 | -0.9 | 0.0 |

Source: IMF staff estimates and calculations

**Figure 3. Finland: Scenario severity from a historic perspective**
(Real GDP in year 0=100)




## B. Methodological assumptions for balance sheet and profit projections

**18. In all the scenarios, a number of adjustments and assumptions were made to track the change in individual banks' balance sheets and profits over time.**

- *Growth of banks' balance sheets.* Banks' balance sheet size was projected to grow in line with nominal GDP. Thus, the size of the banking system in terms of assets remains constant relative to the size of the economy. This assumption ensures that banks that pass the tests remain sufficiently capitalized to support lending in a severe downturn.[9] For this reason, this assumption reduces the need to quantify the second round effects triggered by banks' behavioral responses to the initial shocks. It should be noted that in adverse scenarios, the growth of net assets (total assets net of loan loss provisions) is usually lower than the growth of total assets because provisions are higher.

- *Projection of risk-weighted assets.* As three out of the four largest banks in Finland operate under Basel II Internal Rating-Based approach, risk weights are projected using the corresponding Basel II formula for credit risk whereby the capital requirement ratio depends on the value of PD, LGD and asset correlation. This means that typically risk weights should rise in a stress scenario. Therefore, RWAs are exogenously constrained not to decrease over the stress period.

[9] Due to the quasi-dynamic adjustments, banks' balance sheets in the stress test model can shrink if credit growth is negative. However, the limit of deleveraging is aligned with the negative nominal GDP growth rate.

- *Other assumptions* included projections for the income before losses, credit growth, behavioral adjustments related to distribution of dividends. Table 5 below summarizes all other assumptions and adjustments used in all three scenarios.

- *Evolution of profits*. As regards the income statement, non-interest profit items and lines such as operational and administrative expenses, and net fee and commission income, were projected to grow in line with nominal GDP, with a floor set at zero for the growth of operational and administrative expenses. However, it was assumed that income from extraordinary items did not recur again during the 2016-2018 period in the baseline and the adverse scenarios. Moreover, non-performing loans were assumed to not provide any accrued income. Lending rates were assumed to evolve in line with the changes in the Euribor rate.

- Finally, banks' funding costs were projected based on an econometric OLS panel model with fixed effects estimating the annual change in Finnish banks' average interest expense to total funding ratio, with annual data over 1999-2015. Explanatory variables were: the lagged dependent variable, the annual change in the 3-month money market interest rate, the annual change in the 10-year Finnish government bond rate, and the annual change in the amount of total funding in percent (see Table 4). By doing so, we were able to capture the relationship between banks' funding costs, funding availability, and banks' solvency. Banks' funding costs rise when funding evaporates, affecting banks' profit and loss account and thus possibly reducing their capitalization.

- The projection of interbank deposits was aligned with the parameter set for the liquidity stress test. That way, we could integrate the liquidity stress test parameters and the solvency stress test results. The change in the interbank rate was found to be the variable with the most significant effect on the change in Finnish banks' funding costs. Nevertheless, the largest contribution comes from the increase in the Finnish 10-year government bond rate in the severe stress scenario due to its large increase. This increase in funding costs was then applied to banks' liabilities subject to funding shocks, including parent funding. Two limitations of this approach should be borne in mind: (i) the absence of differentiation of the debt instruments by type and maturity; (ii) the limited number of observations (40).

**Table 4. Finland: Results from the Estimation of banks' funding costs**

(Dependent variable: annual change in ratio of banks' interest expenses to total funding, panel fixed-effects OLS model)[1]

| | |
|---|---|
| annual change in Euribor rate | 0.6217*** |
| | (4.87) |
| annual change in Finnish 10-year government bond rate | 0.2262* |
| | (2.20) |
| annual change in total funding (in percent) | -0.0107** |
| | (-3.99) |
| Constant | 0.1919** |
| | (-3.54) |
| R-square | 0.78 |
| # of observations | 40 |

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

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

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

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

  *ii)* Banks that pass all minimum requirements distribute their dividends according to the official plans (as publicly announced by the end of Q4 2015).

**Table 5. Finland: Summary of modeling approaches**

| | Baseline | Moderate stress | Severe stress |
|---|---|---|---|
| **PDs** | Satellite models | Satellite models | Satellite models |
| **LGDs** | No changes | 50% pass-through effect from the shock to real estate prices[1] | 100% pass-through effect from the shock to real estate prices |
| **Growth rates of interest bearing assets (credit growth), non-interest rate bearing assets, open positions** | In line with nominal GDP growth rates | In line with nominal GDP growth rates | In line with nominal GDP growth rates |
| **AFS/HFT own sovereign spread** | No changes | Respective three-year PDs and LGDs for sovereign defaults from Moody's data[2]: 0.822*0.63=0.517% plus shock to risk premium from the funding risk model; Shock applied for the first year (immediate downgrade) only. | Respective three year PDs and LGDs for sovereign defaults from Moody's data: 0.539*0.63= 0.33957% plus shock to risk premium from the funding risk model; Shock applied for the first year (immediate downgrade) only. |
| **Shocks to NPLs and provisions for STA portfolio** | Bayesian VAR model with adjustments and corrections due to change in definition (break-up of data series in 2014)[3]; shock as a multiplier compared to the last observed value of NPLs. No changes for the baseline scenario (most conservative approach) | Bayesian VAR model with adjustments and corrections due to change in definition (break-up of data series in 2014); shock as a multiplier compared to the last observed value of NPLs. | Bayesian VAR model with adjustments and corrections due to change in definition (break-up of data series in 2014); shock as a multiplier compared to the last observed value of NPLs. |
| **Funding risk shock** | Projected based on an econometric OLS model using annual changes in Euribor rate, sovereign rate and growth in total funding as explanatory variables | Projected based on an econometric OLS model using annual changes in Euribor rate, sovereign rate and growth in total funding as explanatory variables | Projected based on an econometric OLS model using annual changes in Euribor rate, sovereign rate and growth in total funding as explanatory variables |

| Table 5. Finland: Summary of modeling approaches (concluded) | | | |
|---|---|---|---|
| **Interest income growth** | Repricing gap model for shock to risk free interest rates; effective interest rate model for loans and other interest earning assets; shock to Euribor minus shock to risk free interest rate on loans. | Repricing gap model for shock to risk free interest rates; effective interest rate model for loans and other interest earning assets; shock to Euribor minus shock to risk free interest rate on loans | Repricing gap model for shock to risk free interest rates; effective interest rate model for loans and other interest earning assets; shock to Euribor minus shock to risk free interest rate on loans; |
| **Net fee and commission income growth** | Average growth rates for the period 2008-2015 | Half of the worst decline in the period from 2008 to 2015 | Worst decline in the period from 2008 to 2015 |
| **Other non-interest income growth** | Average growth rates for the period 2008-2015 | Half of the worst decline in the period from 2008 to 2015 | Worst decline in the period from 2008 to 2015 |
| **Non-interest expenses growth** | Average growth rates for the period 2008-2015 | Half of the worst decline in the period from 2008 to 2015 | Worst decline in the period from 2008 to 2015 |
| **Tax rate** | Actual statutory tax rate | Actual statutory tax rate | Actual statutory tax rate |
| **Trading losses** | Average growth rates for the period 2008-2015 | Half of the worst decline in the period from 2008 to 2015 | Worst decline in the period from 2008 to 2015 |

[1] The pass-through rates of 50% and 100% assume two effects: i) a decline in the activity in real estate markets when the volume of transactions falls, thus leading to the drop in prices; ii) discount effects when banks are not able to sell the assets and have to keep them as foreclosed. The lower pass-through rate in the moderate stress shock is arbitrary, based on the assumption that the effects will be smaller.

[2] See Moody's (2015) Sovereign Default and Recovery Rates, 1983-2014.

[3] The break in the series occurred due to a change in definitions when data was started to be collected by the ECB/SSM.

## C. Credit risks in the scenario analysis

### *Credit risks in the loan book*

**19. Credit risk in the loan book along with the market risk in securities portfolio and counterparty risk in derivatives portfolio constitutes one risk factor for the banking system.** Total loans represent 42 percent of total banking sector assets. Debt securities (22 percent), most of which are marked to market, and derivatives (close to 19 percent and subject to credit valuation adjustment (CVA) risk in the stress test) come next. Exposures in loan books are predominantly domestic. Therefore, the stress tests focused on how domestic, regional and global macrofinancial shocks affect domestic exposures.

**20. Exposures of the four banks included in the stress test exercise are almost evenly split between Internal Rating Based (IRB) and Standardized (STA) approaches.** The banks included in the exercise apply the STA approach to sovereign and other public exposures (e.g. public sector enterprises, development banks) exposures. The use of this approach, combined with the aggressive use of internal models for other exposures, leads to very low capital requirements, as most of these exposures are zero risk weighted (i.e. are associated with almost zero RWAs). That is why even if almost half (47 percent) of the loan portfolio is under STA approach, 76 percent of credit risk-related RWAs are reported and calculated under the IRB approach (see Figure 4). While retail loans (mortgages and other retail) constitute the largest item in loan books, associated capital requirements are fairly low due to very low PDs and LGDs (see Figure 5). The structure of banks' balance sheets as well as differences between STA and IRB approaches in terms of capital requirement calculations were taken into account in designing satellite models for credit risk. RWAs for exposures under IRB approach were calculated using the respective Basel II/III formulas, while RWAs under STA approach were calculated assuming standardized risk weights as well as exposure migration from lower to higher risk weights during the stressed period.

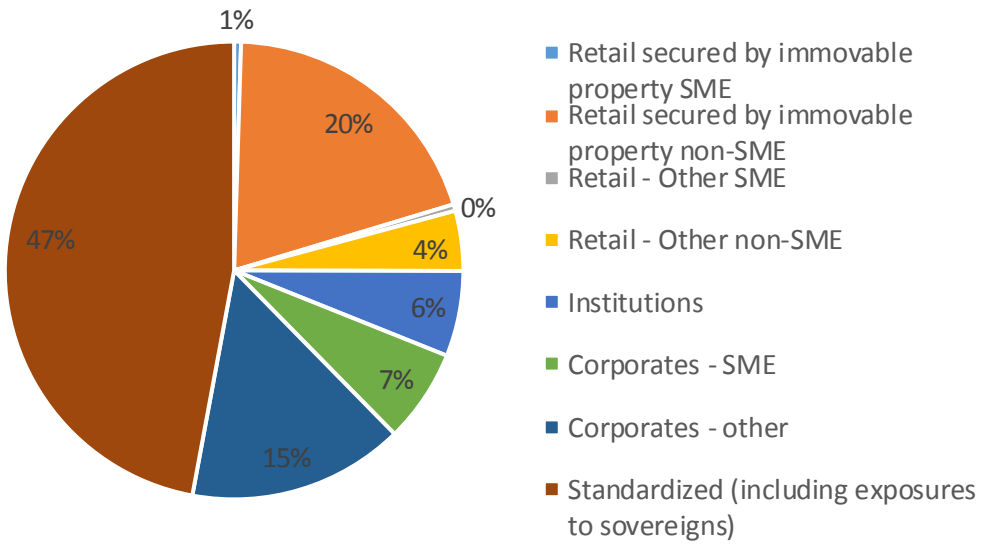
### *Solvency stress testing methodology*

**21. The transmission of macroeconomic shocks to probabilities of default and loan loss provisions of individual banks was assessed by estimating specific satellite models of credit risks.** Available public and supervisory data was used to build various credit risk satellite models and overcome multiple data limitations with the aim to replicate the regulatory approach as closely as possible. Supervisory as well as data provided by banks was used to construct credit risk satellite models for the five broad exposure classes, which were subsequently applied up to the maximum of 11 regulatory IRB exposure classes used by banks (see Figure 6)[10]. CRR standard risk weights were used for the migration of loans under the Basel II STA portfolio. Time series started in 2008 and cover one credit cycle when defaults increased above their means (2011-2013). PDs which were used

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

for satellite models were Through-The-Cycle (TTC) and hybrid PDs[11]; the latter being more volatile compared to the pure TTC PDs.[12] For exposures to which Basel II standardized approach is applied by banks, NPL data was used to construct a simple VAR-based satellite model. Finally, own sovereign exposures were stressed by migrating exposures by one and three notches and applying corresponding long-term PDs and LGDs from Moody's report[13].

**Figure 4. Distribution of banks' exposures by asset class**



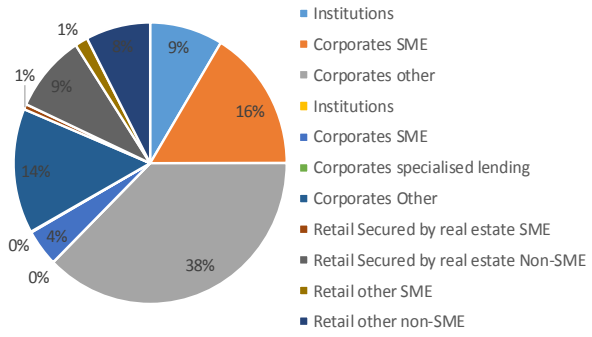

Source: IMF staff calculations

[11] These hybrid PDs were weighted average PDs, corresponding to a combination of Point-in-Time and Through-the-Cycle PDs. A rough calculation indicates a weight of 30 percent of PIT PDs and a weight of 70 percent of TTC PDs.

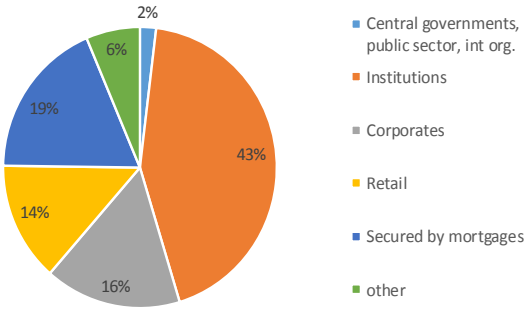
[12] The historic PD data series provided included defaulted exposures. PDs for each COREP exposure class are exposure-weighted averages of PDs across all rating grades, including the last rating grade – default. Defaulted exposures are typically provisioned, hence there is no need to calculate additional expected losses and capital requirements for them. Therefore, the inclusion of defaulted exposures into PDs leads to double counting of losses and is not desirable. By contrast, average PDs without defaulted exposures provide average probability of migration to the last obligor grade (default) across all non-default rating grades, they thus approximate risk of default better., Therefore, the FSAP team had to adjust the historic PD data series provided in order to use it for provisioning purposes (i.e. calculation of expected losses). For provisioning purposes, the ratio of PDs without defaulted exposures to PDs with defaulted exposures was calculated. This ratio then was multiplied to the TTC PDs with defaulted exposures to obtain shocked PDs without defaulted exposures which were used for expected loss calculation.

[13] See Moody's (2015), Sovereign Default and Recovery Rates, 1983-2014.

**Figure 5. Distribution of exposures under IRB and STA approaches (by risk weights)**




Source: IMF staff calculations




Source: IMF staff calculations.

**22. Expected losses were calculated separately for IRB and STA exposure classes.** For IRB portfolios, expected losses related to credit risk were calculated as the product of PIT or hybrid PDs, loss given default (LGD) and exposure at default (EAD). For STA portfolios (except sovereigns), flows of NPLs were multiplied by the average provisioning ratio of 60 percent. For sovereign exposures, RWAs were not stressed to be in line with CRR approach, and only expected losses were calculated for the own sovereign exposures. The FSAP team developed times series models to project PDs, while LGD projections were based on house and commercial real estate price projections.[14]

**23. For the estimation of the credit risk satellite models and the conduct of the solvency stress test, the FSAP team had access to supervisory data at the individual bank level, on solo and consolidated bases, in a physical data room only (Table 6).** In their analysis, the FSAP team also used publically-available data, like from commercial providers, data from the EBA Transparency exercise as well as banks annual reports. Some data, like pre-shock LGD data in supervisory data templates and the one received from banks, was cross-checked with the 2016 World Bank Doing Business report, which shows an average recovery rate of 90 percent for Finland, the highest among the countries surveyed. Data on PDs was cross-checked with additional information received from the banks themselves as well as the ECB. This was then used in the computation of Risk Weighted Assets (RWAs) and expected losses (ELs) in the stress test. Further details on the choice of modeling approaches are provided in Appendix II.

[14] A pass-through of house price changes to LGD of 100 percent was assumed for the stress test based on granular data from the FIN-FSA covering the 3 systemically-important banks.

**Figure 6. Reconciliation of exposure classes and satellite models**

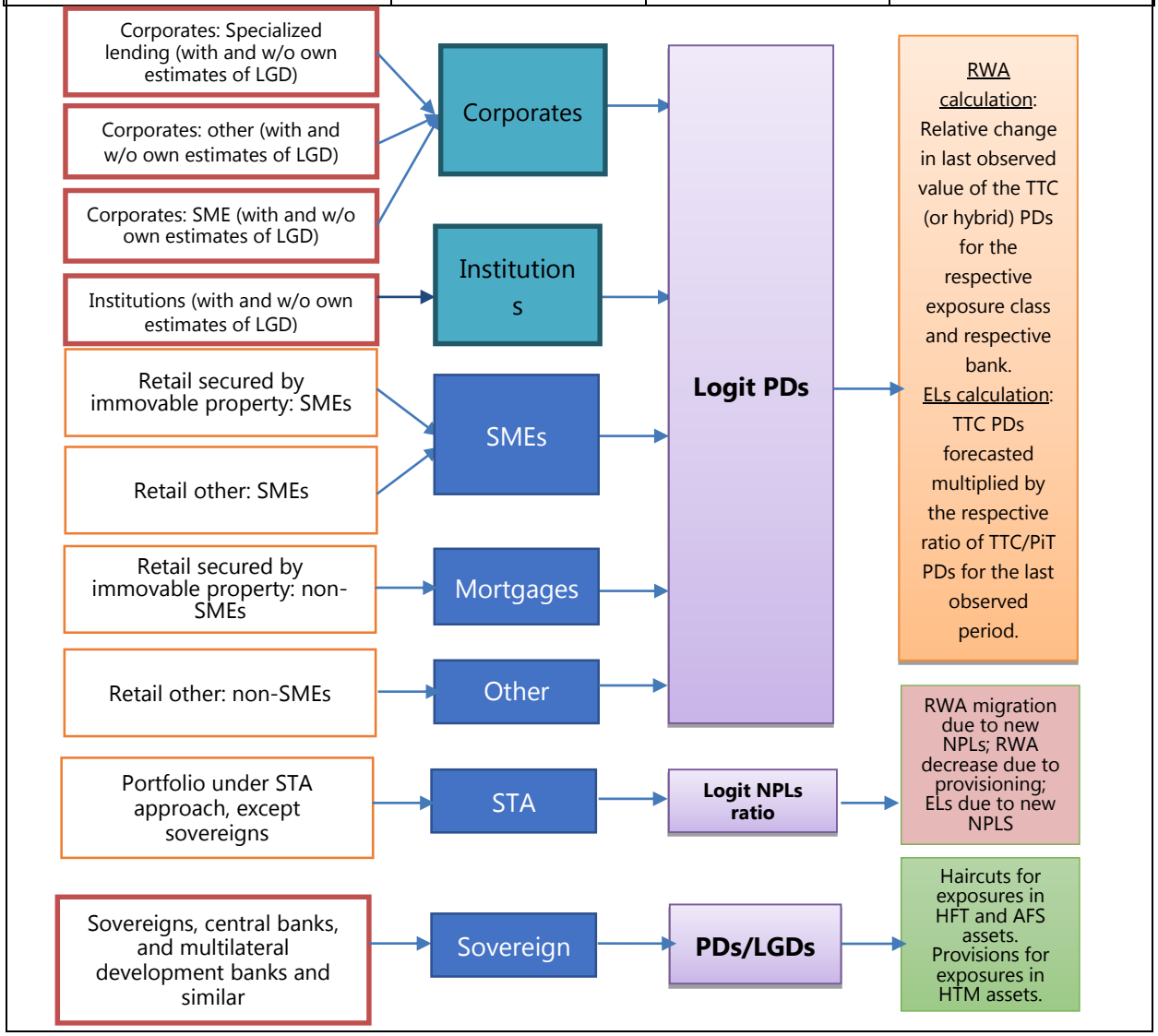


**Table 6. Finland: Summary of FSAP team access to supervisory data**

| | Fully available | Partially available | Not available |
|---|---|---|---|
| Data at the individual bank level | | ✓ | |
| Data aggregated along groups of banks | ✓ | | |
| Data aggregated at the banking system level | ✓ | | |

Source: IMF staff.

Note: This table only describes the availability of supervisory data for the stress tests conducted by the FSAP team, but does not present an assessment of data quality.

**24. Potential credit risk losses in the loan book represent a large vulnerability of the banking sector.** Top-down stress test results suggest that banks are likely to experience significant increases in PiT PDs under the severe stress scenario (see Figures 7 and 8), in contrast with the baseline scenario in which PiT PDs remain flat. The combined effects of higher unemployment rate, and the economic slowdown increase the banking system's average PD[15] from 1.9 percent in 2015 to 6 percent in 2018 under the severe stress scenario, compared to a peak of 3.9 percent under the moderate stress (euro area-wide) scenario, according to IMF model results.

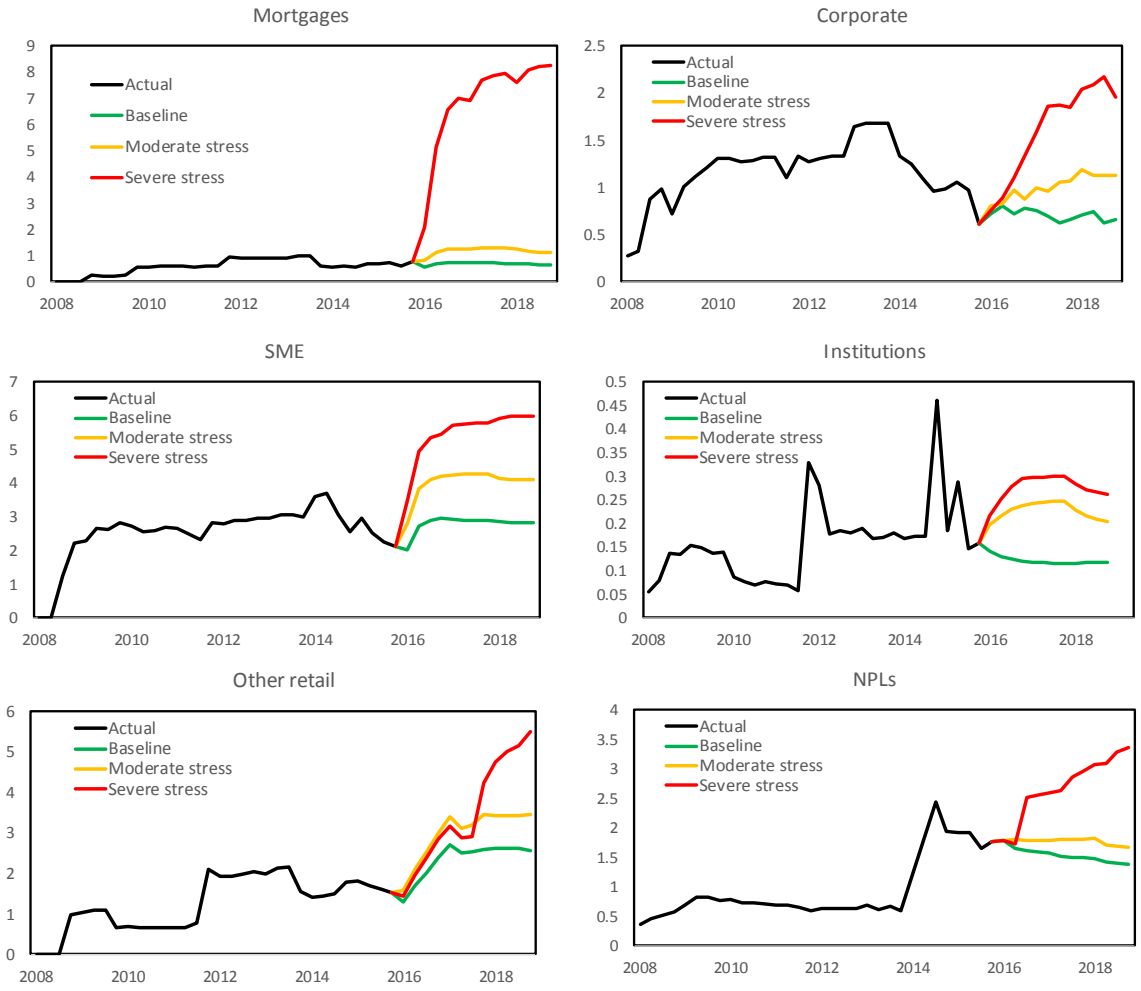
**25. It is worth noting that expected losses in the adverse scenario are mostly driven by losses in the retail portfolio.** Households' solvency is particularly affected by this scenario. This is in sharp contrast with the 1990s Nordic banking crisis which was characterized by the bankruptcy of large companies following the collapse of trade with the former Soviet Union. These big companies have largely been restructured since then and have diversified international exposures and business lines.

**26. The rise in PDs requires additional provisions that worsen bank profitability in the stress scenarios.** Credit losses over the three-year horizon in the loan book amount to EUR6.9 bn in the severe stress scenario, equivalent to 1.5 percent of total banking system assets, as a result of the credit risk increase caused by the severe macroeconomic conditions. By contrast, in the baseline scenario, the flow of new provisions is limited to EUR0.8 bn, equivalent to 0.2 percent of total banking system assets. These new provisions in the baseline scenario are more than offset by net income before losses (2 percent).[16]

[15] Weighted by banks' total capital.

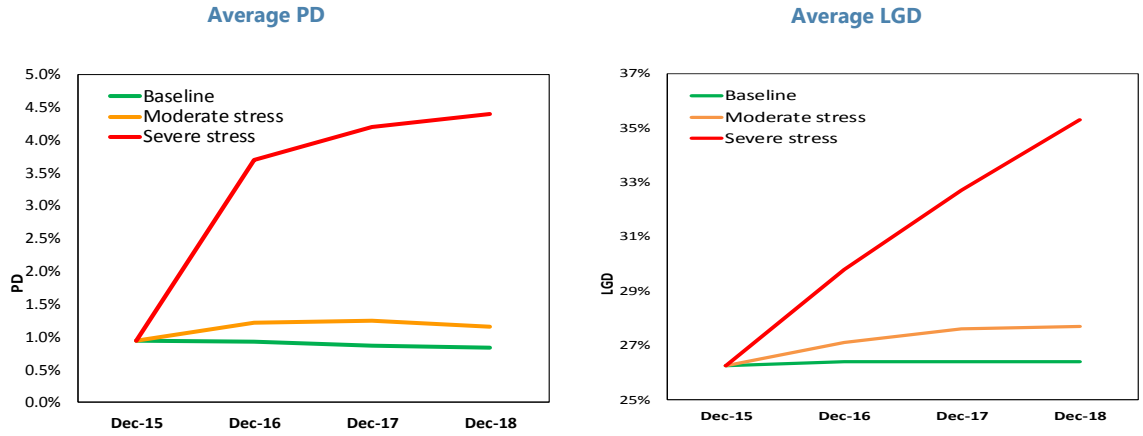
[16] It is important to notice that expected loss models used for provisioning purposes will be changed in 2018 when new IFRS standards become binding. It is expected that banks will form more provisions for expected losses. Top-down stress testing results partially accounted for that by using stressed PDs and LGDs.

**Figure 7. Finland: PD/NPLs and LGD Projections in the Baseline and Severe stress Macroeconomic Scenarios – IMF model**




Source: IMF staff calculations

**Figure 8. PD and LGD Projections in the Baseline and Adverse Macroeconomic Scenarios-FSAP team model**




Source: FIN-FSA, ECB, and IMF staff calculations

### *Household Stress Testing methodology and results*

**27. Despite an unfavorable macroeconomic environment, Finnish banks' internal models estimate low probabilities of default and loss given default in the housing loan segment**. Banks explain this by emphasizing their responsible lending practices as well as Finnish households' payment culture. However, it is also important to understand the underlying macroeconomic factors behind the benign credit risk assessment related to retail loans and especially mortgage portfolios.

**28. Typical stress testing approaches might underestimate non-linear effects due to large shocks.** They estimate portfolio losses based on standard assumptions, such as the business cycle (GDP growth rate, unemployment, interest, exchange rates, credit growth and so on). The correlation between household PDs and macro variables, however, can be weakened if public safety nets provide substantial cushions during downturns, even for heavily indebted households. Modeling of defaults of retail portfolios thus becomes challenging, and stress tests need to rely on multiple ad-hoc assumptions as well as expert judgment. To overcome these challenges and analyze non-linear effects of shocks related to households' financial condition and perform stress test we used micro data.[17.] The description of the methodology is provided in Appendix III of this note.

**29. Household stress test results suggest that households are particularly vulnerable to a significant drop in incomes.** Such a drop combined with a 15 percent shock to real estate prices, without any decline in average expenditure leads to a shock to implied households' PDs[18] from the current 3.9 percent (as estimated using micro data) to almost 13.6 percent (multiplier of 3.5). This multiplier was applied to correct for the relatively mild results obtained from the satellite models for

[17] We used 2011 micro data for Finland obtained from ECBS Household Finance and Consumption Survey (HFCS).

[18] These are not realized or true forward-looking PDs. See Appendix IV for details.

mortgage portfolios. At the same time, Finnish households do have room to reduce their expenditure, hence PiT PD multiplier estimated by the FSAP team is on a very conservative side. Bank of Finland (BoF) ran their own household stress testing model and obtained results which showed an increased share in households with negative income margin from 14.9 to 16.2 percent (shock to employment related income by -15 percent).[19]

### *Credit Valuation Adjustment Stress Testing methodology and results*

**30. Derivatives represent a significant share of banks' assets.** Therefore, Credit Valuation Adjustment (CVA) stress tests were carried out to estimate additional capital requirements due to the downgrade (i.e. increase in default risk) of banks' counterparties.[20] To conduct the stress tests, granular data on exposures grouped by rating classes of counterparties were obtained from banks. The EU Capital Requirement Regulation allows banks to use either the Standardized (STA) or the Advanced Method (AM) approach to model counterparty risk. It should be noted that many of the exposures within the EU are exempted from capital requirements.[21] Consequently, they were also excluded from the RWAs in line with regulatory requirements. These exposures, however, were included in the calculation of the shock multiplier.

**31. The CVA stress test assumed various downgrades of foreign exposures.** CVA risks were stressed as an increase in average probability of default of the counterparties grouped into the respective regulatory rating classes and excluded calculation of expected losses as well as shocks to Expected Positive Exposure (EPE). CVA risks were stressed for the severe stress scenario only. The methodology was the following:

**i)** For each bank exposures were broken down between 4 countries and one region, namely Denmark, Finland, Sweden, United Kingdom and the rest of the World;

**ii)** Within the geographical segments, exposures were grouped into STA and AM categories;

**iii)** Exposures under the STA approach were grouped into the 6 regulatory rating classes with respective risk weights ranging from 0.7 (class 1) to 10 (class 6) percent; exposures

[19] The FSAP team and BoF results are not comparable due to different methodologies and definitions of default. For details see Appendix III.

[20] The FSAP team carried out the test on additional capital needs due to a downgrade of banks' counterparties in derivative transactions. Other types of risks, like basis risks (i.e. difference between the price/interest rate of the instrument that is being used to hedge and the price/interest rate of the instrument that is being hedged), losses due to default of central clearing counterparty… were not tested.

[21] See CRR article 382. It needs to be noted, that while exclusion of certain counterparties reduces capital required to cover unexpected losses due to defaults, it does not shield banks from making provisions for incurred losses under accounting requirements. Actual losses in year 2015 due to defaults of counterparties were very small however (less than 0.01 percent of the notional amount of exposures).

under AM approach were grouped into 10 rating classes by Credit Default Swaps (CDS)[22];

**iv)** For the STA approach, the scenario assumed exposure migration by one notch for each regulatory rating class; for the AM approach, the stressed scenario included a simulation of the worst shock to the respective country's CDS (for "the residual" region, the shock was equal to Denmark's) observed in the last 12 years (see Table 7 below). The shocks to CDS included the market turmoil of 2008/09, and reflect investors' concerns regarding sovereign credit ratings. It was assumed that the pass-through of CDS shock was non-linear: in the first rating grades it was assumed to be 100 percent, 150 percent for middle ones and 200 percent for the last ones. For the stressed VaR calculations, it was assumed that the turmoil in the market would last for one month (25 days).

**v)** Obtained stressed RWAs were not directly applied in the solvency model. However, they were scaled to the existing level of RWAs for CVA. Shocked RWAs were obtained by multiplying existing RWAs by the percentage shock to RWAs obtained from the model. Average shock to RWAs for all banks included into the stress tests was 30 percent. This result, however, would be significantly higher 4 to 5 times) if all exposures, including those exempted by CRR, were to be included into RWAs reported under COREP requirements.

**Table 7. CDS spreads of Denmark, Finland, Sweden and the UK: 2003-2015**

| CDS spreads for 5 year sovereign bonds in bps. | Denmark | Finland | Sweden | UK |
|---|---|---|---|---|
| Maximum | 201 | 94 | 161 | 175 |
| Mean | 34 | 37 | 29 | 56 |
| Standard Deviation | 37 | 20 | 28 | 30 |

**32. The analysis of exposure data collected during the stress test exercise highlights risks related to the cross-border contagion among markets in Finland, Denmark, Sweden and the UK.** A large amount of derivatives is used to hedge against interest or exchange rate (FX) risks. At the same time, hedging of interest rate/FX risks is important for lenders with mismatches in the structure of their lending and borrowing, for example when they borrow under a floating interest rate/one currency and lend under fixed rate/another currency. Finnish banks fulfill an important role of market maker in the region. However, regional concentration of exposures also entails concentration of risks. A severe economic downturn in Sweden and Denmark, especially if it impacted their mortgage markets, would increase their respective CDS spreads and expected losses

[22] Using benchmark data from Markit.

for Finnish banks. Many of the derivatives, included Over-the-Counter (OTC) ones, are cleared through companies in the UK. While the Central Clearing Counterparty (CCP) assumes risks in case of defaults, the ability to fully compensate/minimize potential losses is not tested in a severe stress scenario. Consequently, a more detailed monitoring of the derivatives market and additional data on exposures would be beneficial to minimize related risks.

## D. Market risks in the scenario analysis

**33. Stress tests also assessed the resilience of banks when facing different sources of market risk.** In addition to credit risk related losses, banks can experience large losses due to changes in market variables (for instance, exchange rates and interest rates). These losses or gains might be due to the existence of "open positions" in banks' balance sheets (due to e.g. currency, maturity, time-to-repricing mismatches between assets and liabilities) or to valuation changes in the different securities (Available For Sale and Held For Trading) held by the banks. Interest and exchange rate risks were the two market risks included in the stress tests. Risks related to equity investments were not dealt with, as equity investments make up a negligible part of banks' assets and capital.

***Interest rate risk***

**34. The impact of interest rate risk on net interest income was assessed using time-to-repricing buckets.** Different interest rate sensitive assets and liabilities are grouped together in different buckets depending on their time-to-repricing. For instance, a loan and a deposit whose effective interest rate can change within the next month would be placed in the same bucket; their difference would represent the "time-to-repricing gap".[23] The expected losses – or gains – on interest income are simply computed as the product of this gap and the changes in the interest rate. This particular analysis only deals with the direct effect of interest rate risk. Indirect effects, that is through credit risk and the effect on asset quality in the loan portfolio, were dealt with in the credit risk section.

**35. In the severe stress scenario, Finnish banks lose a small amount of net interest despite the sharp rise in interest rates.** Banks are usually exposed to a rise in interest rates because they are performing maturity transformation. Banks' net interest income is a main source of profits for banks and is sensitive to changes in interest rates, as these could reduce the interest margin depending on the time to asset and liability repricing. Therefore, a maturity ladder approach was used to project net interest rate income in the baseline and the two adverse macroeconomic scenarios. Three out of the four banks composing our stress test sample display a negative time-to-repricing gap (i.e. liabilities are repriced faster than assets), leading them to lose interest income when interest rates rise. Indeed, equal increases in deposit and lending rates raise banks' interest

[23] Data were available for the following time-to-repricing buckets: less than one month; 1 to 2 months; 2 to 3 months; 3 to 6 months; 6 to 12 months; and more than 12 months. Conservatively, the largest net losses on any gap with a time-to-repricing less than 12 months were considered as representing the "instantaneous loss" due to the interest rate shock.

payments by a larger amount and faster than interest receipts. At the aggregate level for the four banks, the repricing gap amounts to EUR -1.9 bn as of December 2015 for maturities below one year. In the severe stress scenario, the aggregated loss directly due to the change in interest rates amount to EUR134 mn, with no material effect on the CAR over the entire stress horizon.

**36. Interest rate risk was also assessed through valuation effects on debt instrument holding.** The other potential source of gains or losses related to changes in interest rates are valuation changes on domestic government and corporate bond holdings. In the absence of data on the duration of banks' trading portfolios, the average maturity of the AFS and HFT portfolios of domestic sovereign exposures was taken as a proxy for Finnish banks based on the latest EBA Transparency Exercise data. Financial Reporting (Finrep) exposures to the Finnish general government were taken as a proxy for domestic sovereign exposures. Losses were then calculated as the product of the size of the bond portfolio, its average maturity, and the change in the interest rate. An increase in interest rates translates into a valuation loss in the bond portfolio, and vice versa.

**37. Potential valuation losses on own-sovereign debt remain very limited.** In the severe stress scenario, losses due to a decline in the price of domestic sovereign securities in the Available-for-Sale and Held-for-Trading portfolios amount to EUR293 mn, contributing by 0.3 percentage points to the decline in the CAR over the entire stress horizon. Two factors contribute to this result: (i) the moderate exposure of Finnish banks to their own sovereign, with an average AFS exposure of 0.9 percent of total assets and ratios at individual banks ranging between 0.7 and 3.5 percent; and (ii) the limited average maturity of Finnish banks' own sovereign AFS bond portfolio, averaging 4 years. These two factors mitigate the impact of the large increase in the Finnish government bond rates under the severe stress scenario (2.7 percentage points for the 10-year rate), resulting in large haircuts on bond prices (Figure 9).

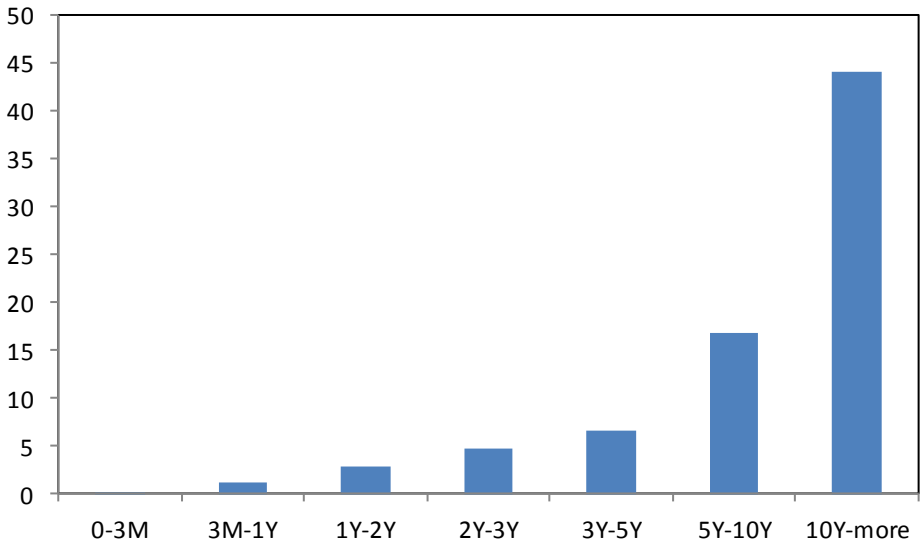
### *Foreign exchange rate risk*

**38. The direct effects of exchange rate risks were assessed based on banks' net open FX positions.** Data on net open FX positions were grouped by currency along the following six categories: USD, GBP, Swiss franc, Swedish krona, Danish krona and "other currencies". The implied gains or losses on these positions were computed as the product of the net open position and the expected change in the euro exchange rate in each of the scenarios.[24]

**39. The positive net foreign exchange position at the banking system level means that the banking system experiences direct market gains in the case of a euro depreciation**. Assets denominated in foreign currency outweigh liabilities denominated in foreign currency in three of the four banks. The net open FX position for the banking system amounts to EUR 130 mn as of December 2015, equivalent to 0.03 percent of assets and 0.6 percent of Tier 1 capital.

[24] For the currencies other than USD, GBP and Swedish krona, the path for the NEER was used.

**Figure 9. Finland: Haircuts on Finnish Sovereign Bonds in the severe stress scenario (in percent)**




Sources: Bloomberg; and IMF staff estimates.

**40. Losses on banks' net foreign exchange positions are very small in the severe stress scenario.** In this scenario, the euro is expected to slightly rise against the US dollar over the whole period, which results in a small loss of EUR4 mn.

## E. Results of the solvency stress tests based on macro scenarios

**41. In the stress scenarios, the materialization of risks affects the banking system through several channels.** The relative importance of the different channels described above can be seen in terms of their contributions to the changes in Common Equity Tier 1 capital ratio in Figure 10. Appendix V illustrates flow of CAR calculations, including high level assumptions.

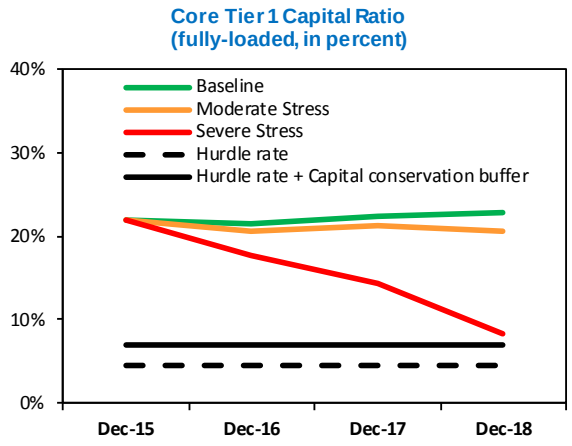
**42. The banking system would be very significantly affected under the severe scenario** (Figure 10). Under a fully-loaded Basel III definition, the aggregate Common Equity Tier 1 ratio would drop by 14 percentage points compared with the starting point and would be 15percentage points below the baseline in 2018. The main drivers of the change in capitalization in this scenario are the following: (i) funding costs (-6.4 percentage points of RWAs); (ii) loss provisions (-6.1 percentage points of RWAs); and (iii) changes in risk-weighted assets (-2.8 percentage points over the whole stress horizon) due to shocked credit risk parameters. Two banks would see their CET1 ratios fall below the hurdle rates of 4.5 percent, translating into a capital shortfall of 0.2 percent of GDP. In the baseline and moderate stress (euro area-wide) scenarios, every bank would stay above the regulatory minima. It should be noted that capital shortfalls would be larger on the basis of bank-specific Pillar II requirements which are not publically-available.

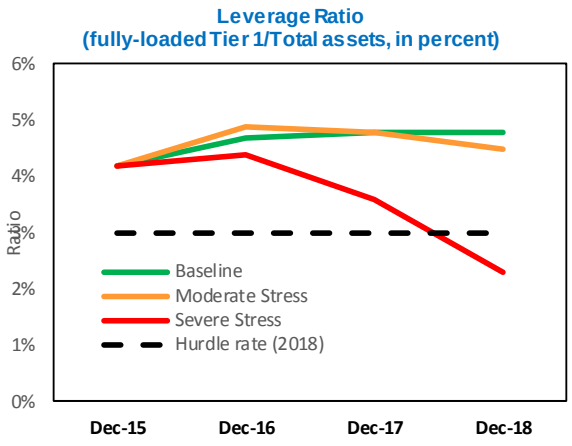
**43. Results measured in terms of the leverage ratio are more severe**. In the severe stress scenario, the leverage ratio at the aggregate level of the four largest banks would drop from 4.2 percent in 2015 to 2.3 percent at end-2018. Each of the four largest banks would see its leverage ratio fall below the hurdle rate of 3 percent in 2018. This would translate into capital shortfalls equivalent to 2 percent of GDP.

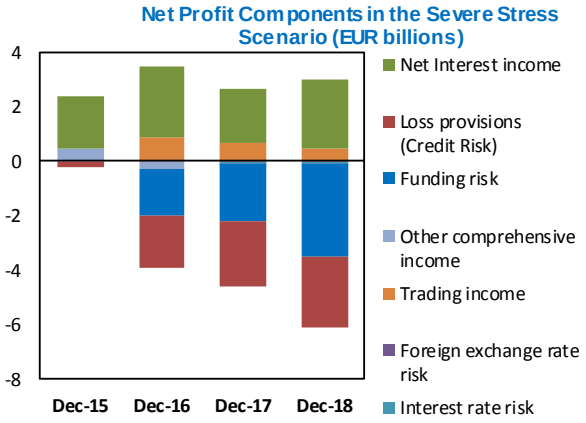
**44. One caveat that should be borne in mind is that our credit loss estimates and solvency projections in the severe stress scenario may be biased down- or upwards.** First, the top-down stress test carried out by the FSAP team did not take into account loan write-offs and cures due to data unavailability. Second, some assumptions had to be made in terms of Loss Given Default and other supervisory parameters.

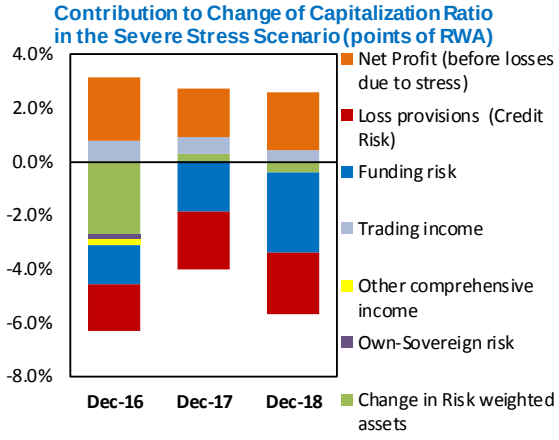
**45. These results point to the need to ensure that banks' Internal Ratings-Based models to take into account losses in stressed environments.** Current CRR regulation allows banks to put higher weights on recent PDs if banks think that recent data better reflects long-term risks. At the same time, in the case of Finland, this means that recent benign market conditions disproportionately lower long-term PDs. To avoid this shortcoming, regular micro-data based household stress tests could be used to benchmark PDs and LGDs for retail portfolios and effectively challenge banks in case of aggressive use of modeling techniques to lower risk parameters. Finally, the authorities' plan to introduce regulatory floors for the risk-weights calculated by IRB banks should be commended and finalized shortly.

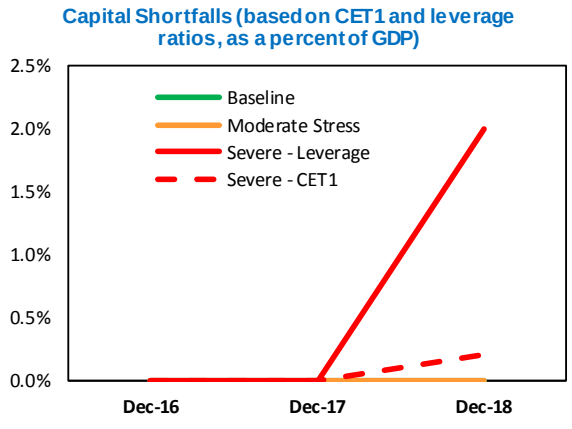
## Figure 10. Finland: Bank Solvency Stress Test Results

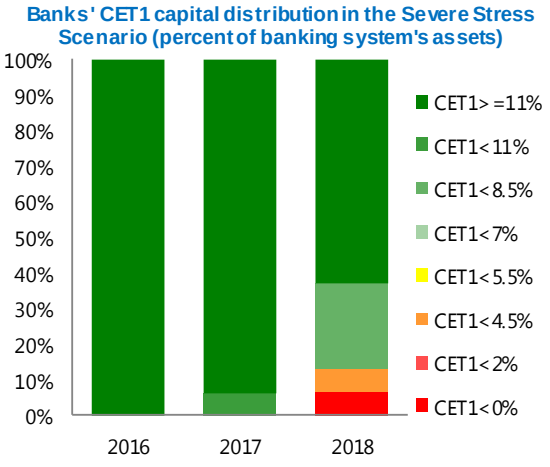



Sources: ECB; and IMF staff calculations

**Table 8. Finland: Results of the Top-Down solvency stress tests (severe stress scenario)**

| | Banking system's CET1 ratio (in percent) | Banking system's leverage ratio (in percent) | Number of banks with 6%<T1<8.5% (conserv. buffer) | Number of undercapitalized banks (CET1<4.5%) | Number of undercapitalized banks (leverage ratio<3%) | Max. capital shortfall in terms of CAR, T1, CET1 or leverage ratio (as a percent of GDP) |
|---|---|---|---|---|---|---|
| Baseline scenario | 20.7 | 4.8 | 0 | 0 | 0 | 0 |
| Moderate stress scenario | 20.0 | 4.5 | 0 | 0 | 0 | 0 |
| Severe stress scenario | 8.3 | 2.3 | 1 | 2 | 4 | 2 |

Source: IMF staff calculations

## F. Market risks based on sensitivity analysis

**46. In addition to stress scenario analysis, sensitivity stress tests assessed vulnerabilities of the banking system to key individual shocks.** These included: a decline in the prices of domestic sovereign securities; an increase in interest rates that affects banks' net interest income; an increase in interest rates that worsens the credit quality of bank loans; a decline in house prices that lowers the recovery rate of bank loans; a depreciation or appreciation of the euro nominal effective exchange rate that triggers direct gains or losses in banks with net open FX positions; a nominal depreciation of the euro that worsens the credit quality of certain types of borrowers; and a decline in stock prices. Indirect effects of a nominal depreciation of the euro on credit quality were not assessed because the share of foreign currency lending in total loans is very low in Finland (less than 1 percent). Unlike macroeconomic stress tests, sensitivity tests are static: they assessed the instantaneous impact of different shocks on the banks' balance sheet positions as of December2015. In all the sensitivity tests, banks' risk-weighted assets are assumed to stay constant after the application of the shocks.

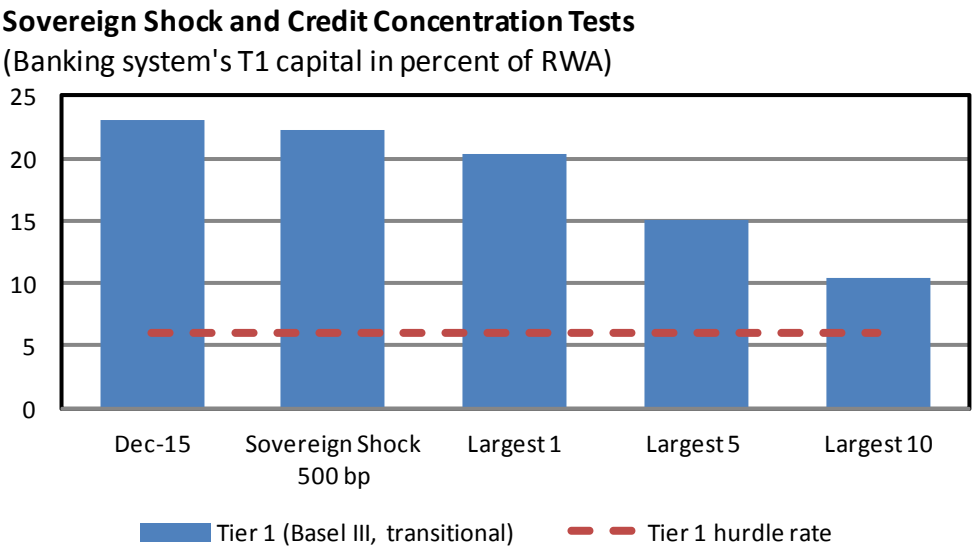
### *A decline in the prices of domestic sovereign securities*

**47. Sensitivity tests assessed the impact of increases in domestic yields by type of instruments on exposures in the trading book.** The tests assessed the sensitivity of banks' domestic bond AFS and HFT portfolios to a 500 bp increase in interest rates. In the absence of data on the duration of banks' trading portfolios, the average maturity of the AFS and HFT portfolios of domestic sovereign exposures was taken as a proxy for Finnish banks based on the latest EBA Transparency Exercise data. Finrep exposures to the Finnish general government were taken as a proxy for domestic sovereign exposures. Losses were then calculated as the product of the size of the bond portfolio, its average maturity, and the change in the interest rate.

**48. The results show that Finnish banks are little exposed to domestic sovereign bond risks.** The partial impact of domestic sovereign bond portfolio losses would be limited. Specifically, the CAR in the system would decline by 0.8 percentage points due to these losses taken in isolation

(assuming that no other shocks trigger simultaneous losses for these banks). The comfortable initial capitalization of Finnish banks on a transitional basis would provide them a large enough buffer to avoid undercapitalization as a result of this shock (Figure 11).

**Figure 11. Finland: Sensitivity Analyses for Sovereign and Credit Concentration Risks**




Sources: Corep; and IMF staff calculations

***Interest rate risk: net interest income effects***

**49. A sensitivity test based on a maturity ladder (gap) analysis suggests that the banking system would lose a moderate amount of net interest income in the event of an interest rate increase.** The gap analysis assesses the effect of an increase in interest rates by 500 basis points on banks' net interest income, taking into account the maturity transformation performed by banks. Changes in net interest income stem from the temporal dynamics of deposits, loans, and securities with maturities of up to one year. In the analysis, deposits maturing within one year must be rolled over at higher deposit rates, implying higher bank interest payments. Loans with maturities of less than one year are also renewed at higher interest rates, increasing bank interest income. Finally, treasury instruments with maturities of less than one year are reinvested at higher yields, earning higher interest income for part of the year. This shock taken in isolation would lower the total banking system's net interest income by EUR94 mn euro, and the aggregate Tier 1 capital ratio by 1.9 percentage points. It would not cause undercapitalization in any of the four banks.

***Interest rate risk: effects on credit quality***

**50. An increase in domestic interest rates could lead to a deterioration in the credit quality of loans, with a moderate effect on bank capitalization.** A tightening of domestic monetary conditions may be the result of a sovereign stress. Sensitivity tests based on credit risk models developed by the IMF team (also used in the tests based on macroeconomic scenarios) suggest that a 500 basis point increase in domestic real interest rates would increase the average PD (mostly for Corporate asset classes as well as NPLs for the STA portfolio) in the system by 2.4 percentage points (from 1.3 percent to 3.6 percent). This would result in credit loss provisions expenses equal to EUR0.8 bn and a decline in total CAR by 3 percentage points. This shock taken in isolation would not cause undercapitalization in any of the four banks.

**51. This result shows only the partial impact of changes in interest rates on credit quality and bank capitalization.** This test assumes that banks earn no-pre-impairment profits under stress; also, the increase in interest rates is sustained for one year and only affects banks' PD and credit losses directly, with output assumed to stay constant.[25] By definition, it may be limited as a measure of the overall impact as banks are likely to continue earning positive (or negative) pre-impairment profits that are not included in the analysis. This test also ignores second-round effects through which higher interest rates could be transmitted to banks. For instance, a monetary tightening could help contain deposit or capital outflows; it could also slow down output growth in the short term, exacerbating credit losses in the banking system.

***Foreign exchange rate risk: Direct effects on banks with net open FX positions***

**52. A separate sensitivity test assessed how banks would be affected by *market* risk in a scenario with euro depreciation or appreciation.** Setting the effect of the euro depreciation on credit losses aside, separate sensitivity tests were undertaken to assess how profits would be affected as a result of banks' net open foreign currency exposures. The test indicates that a 30 percent appreciation of the euro nominal effective exchange rate would cause a loss of EUR39 mn, with no material impact on the aggregate Tier 1 ratio. This shock, taken in isolation, would not cause undercapitalization in any of the five banks. Conversely, a 30 percent depreciation of the euro nominal effective exchange rate would cause a gain of EUR39 mn.

***A decline in real estate prices: effects on credit quality***

**53. A sensitivity test assessed potential losses from *credit* risks in a scenario with a decline in real estate prices.** For banks, a decline in the real estate prices increases credit risks in two ways: through its macroeconomic effects and through the loan recovery rate in case of default. First, real estate price fluctuations might entail wealth effects and affect investment and consumption in the economy. Second, if borrowers can no longer service their debt payments due to unemployment or

[25] We noted above that, in contrast to macroeconomic tests, sensitivity tests are "static". However, the credit risk model used to assess the effect of a rise in interest rates on PD is dynamic and estimated based on quarterly data. This implies that the interest rate effects are fully transmitted to PD only with the passage of time. These tests are still considered "static" because banks' balance sheets do not adjust over time, and are taken as observed in June 2015.

a rise in interest rates in case of floating interest rate loans, this would lead the bank to foreclose a loan and repossess collateral. However, the value of the collateral in such a situation might not cover the full amount of loan balance remaining to be repaid, translating into credit losses for the bank. Against this backdrop, loan foreclosures and events of a forced sell of collateral are rare events in Finland. Most of the households do keep repaying their mortgage debt even in the case of a decline of their real estate value.

**54. A sharp drop in real estate prices would not lead to undercapitalization of any of the banks included in the stress test.** Nevertheless, a 30 percent decline in domestic real estate (housing and CRE) prices would have large effects. It would bring about a rise in weighted average LGD in the system by 21 percentage points (from 27 percent to 48 percent). This would cause aggregate loss provisions of EUR0.8 bn. The loss of CAR in the system would be equivalent to 6 percentage points. As in the case of the interest rate sensitivity test, the result shows only the partial impact of a real estate price decline on credit quality and bank capitalization. One of the key determinants in the drop in the CAR ratio is the increase in risk weights due to very low risk weight density, especially for residential mortgages.

***A decline in stock prices***

**55. Another sensitivity test assessed how banks would be affected by a decline in stock prices.** Marked-to-market equity investments makes up a very low share of banks' total assets, ranging between 0 and 0.7 percent. The test indicates that a 50 percent decline in stock prices would cause a loss of EUR 1.1 bn, translating into a 1.1 percentage point decline in the aggregate Tier 1 ratio. This shock, taken in isolation, would not cause undercapitalization in any of the four banks.

## G. Concentration risk: Failure of a number of large corporate exposures

**56. Name concentration risk (i.e. exposure to a single borrower) was tested by assessing the impact of the default of the largest exposures.** Supervisory data on the large bank exposures were used to perform this sensitivity analysis type of stress test. The analysis included exposures to groups of non-financial interconnected clients, but excluded sovereign exposures and credit institutions (see section on interconnectedness analysis and contagion risks). Finnish banks' exposures are mostly made of direct credit risk exposures and derivatives. The test assessed the impact of the hypothetical default of up to ten of the largest borrowers, and computes the implied losses for various assumptions on the recovery rate. In our first scenario, we used the recovery rate calculated by banks within the national regulation framework, but alternative assumptions were also made.

**57. Sensitivity test shows that Finnish banks are adequately capitalized to absorb losses from the default of large exposures.** On average, the size of the gross largest exposure (before application of exemptions and credit risk mitigation) reaches 11½ percent of Tier 1 capital, whereas the size of the net largest exposure (after application of exemptions and credit risk mitigation) is limited at 6.2 percent. One bank mostly holds credit risk mitigation instruments in the form of financial guarantees. Under the national regulation regarding collateral valuation, the default of up

to the ten largest exposures of each of the four systemically-important banks in the system would not cause any undercapitalization (Figure 11). The results would be little changed if an additional 50 percent haircut was imposed on the valuation of real estate collateral held by Finnish banks against their large exposures as real estate makes up a very low share of credit risk mitigation techniques in Finland for large exposures.

**58. Under the most extreme scenario with a zero recovery rate on credit risk mitigation measures, one bank would become undercapitalized.** The default of the largest exposure of each bank in the system would imply a capital shortfall of EUR268 mn (0.1 percent of GDP) with regard to the 8.5 percent Tier 1 capital hurdle rate. Following the default by the five and ten largest exposures in each bank, the total Tier 1 capital shortfall would amount to EUR1.5 bn and EUR2.3 bn, respectively, equivalent to 0.7 percent and 1.1 percent of GDP. The haircut of 100 percent on collateral valuation and other credit protection instruments in stress periods results in an admittedly very conservative scenario. Indeed, as far as financial guarantees are concerned, it would imply a double default of the bank's obligor and guarantors. In absence of information on the guarantor's identity, it was not possible to the FSAP team to estimate the correlation between the obligor's and the guarantor's probability of default at the moment of the default of the obligor.

# LIQUIDITY STRESS TESTS

**59. Liquidity stress tests were based on the national transposition of the Liquidity Coverage Ratio, Net Stable Funding Ratio (NSFR), and a cash flow-based analysis by maturity bucket.** The LCR measures the bank's ability to meet its liquidity needs in a 30 calendar day liquidity stress scenario by using a stock of unencumbered high-quality liquid assets (HQLA).[26] Banks must maintain an LCR above 60 percent from October 2015 and 100 percent from 2018. Specific deposit run-off rates, roll-off rates for cash inflows and assets haircuts are included to simulate stressed conditions in three different scenarios.

**60. The national transposition of the LCR under the European Commission Delegated Act differs from the Basel III LCR on three main points**: (i) covered bonds are included in level 1 assets in the EU legislation; (ii) the latter includes a larger range of high quality liquid assets, but subjects them to high haircuts (e.g. equity is assigned a haircut of 50 percent); and (iii) the granularity of deposits is higher under the Commission Regulation. It has also an accelerated phase-in timetable relative to the Basel III LCR reaching the 100 percent hurdle in 2018 rather than 2019. The NSFR will require banks to maintain a stable funding profile in relation to the composition of their assets and off-balance sheet activities at a one-year horizon from 2018 in order to curb excessive maturity transformation and resulting liquidity mismatches.[27] Finally, the maturity bucket

[26] See Basel Committee on Banking Supervision (2013), "Basel III: The Liquidity Coverage Ratio and liquidity risk monitoring tools", January

[27] See Basel Committee on Banking Supervision (2014), "Basel III: The Net Stable Funding Ratio", October

liquidity stress test is based on the analysis of the full temporal structure of cash flows generated by different assets and liabilities.

**61. Top-down liquidity stress tests were conducted jointly by FIN-FSA and the FSAP team.** Cash-flow based liquidity stress tests were implemented through a Top-Down approach, using supervisory information on maturity structures of assets and liabilities at December 2015. They included the same sample of four banks covered in the solvency stress test. The tests were carried out at the aggregate level, i.e. combining every currency including the euro, and with separate tests on US dollar, British pound and Swedish krona positions. Foreign currency-denominated liabilities make up 17 percent of total liabilities. These tests assessed banks' resilience to strong shocks characterized by run-off rates on funding sources calibrated by type, and liquidation of assets subject to valuation haircuts. Specifically, the exercise captured (i) a bank's liquidity need derived from outflows, (ii) its available standby liquidity from inflows, and (iii) its buffers available to counterbalance liquidity gaps. The LCR-based analysis also included an alternative more severe scenario in terms of deposit withdrawals and a third scenario featuring a dry-up of unsecured wholesale funding, calibrated to meet very severe stress test conditions, such as those experienced during the 2008/2009 global financial crisis. It should be noted that common practice in FSAPs is to implement the liquidity tests assuming an underlying environment in which funding pressures are sizeable but limited to a number of banks (not systemic).[28]

## A. LCR-based stress test

**62. The LCR-based stress test was based on three scenarios, with various parameters in terms of deposit run-off rates, roll-off rates for cash inflows and asset haircuts.** These rates, together with the assumed asset haircuts, are presented in Table 9. The test was first carried out at the aggregate currency level, i.e. combining the bank's positions in every currency. Potential sources of funding pressures for banks consist mainly of deposits from individuals, businesses and large corporations. Cash outflows are generated by the need to pay contracted and contingent liabilities under specific assumptions regarding the capacity of banks to re-issue liabilities in adverse conditions. The funding structure of the banking system (excluding capital and including contingent credit lines) as of December 2015, can be described as follows (Figure 12):

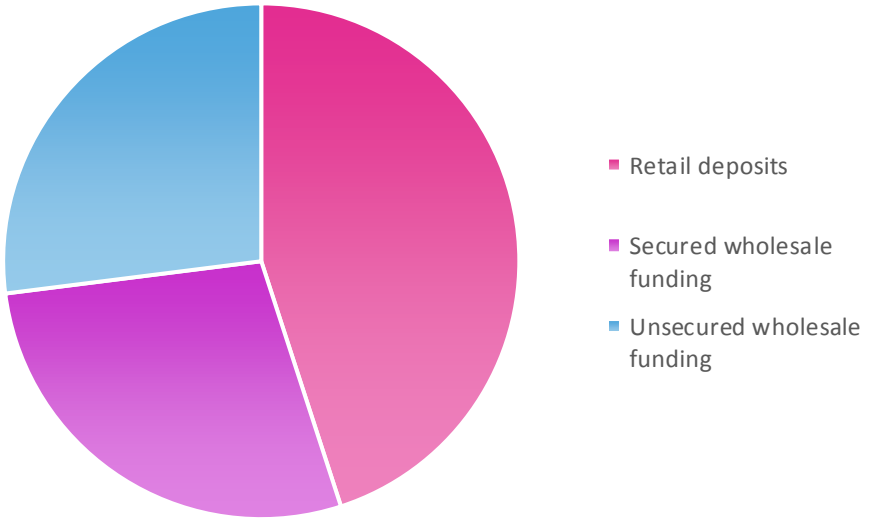
- 45 percent of funding comes from retail sight and time deposits;
- 28 percent comes from secured wholesale funding, e.g. funding from the Eurosystem and covered bonds;

[28] The underlying environment in which a bank's resilience to liquidity shocks is tested should affect the calibration of deposit run-off rates and asset haircuts. Under generalized banking panics (bank runs affecting many banks, including important ones), the scramble for liquidity usually results in fire sales of assets, and hence, larger haircuts. Similarly, run-off rates on deposits should be higher when a panic sets in and triggers widespread bank runs.

- 27 percent is unsecured wholesale funding, coming in particular from credit institutions (20 percent), and operational deposits generated by clearing, custody, and cash management activities.

- 8 percent of funding comes from undrawn but committed credit and liquidity facilities.

**Figure 12. Finnish Banks' Funding Structure – December 2015**




**63. Funding pressures were captured through specific time profiles of run-off rates for different funding sources.** A set of general principles guided the choice of run-off rates for the computation of the LCR. First, more informed and sophisticated depositors withdraw funding more rapidly than less informed ones. That is why run-off rates applied to wholesale funding sources are higher than those applied to retail funding sources. Second, run-off rates on secured funding sources are lower than those applied to unsecured funding sources.

**64. Banks' standby liquidity inflows stem mostly from maturing loans, deposits and credit facilities.** Assets that can generate cash inflows over one month mostly include derivatives (28 percent) and maturing loans from financial institutions and central banks (54 percent).

**65. For different assets and maturity buckets, specific roll-off rates were applied to convert the maturing amounts into cash inflows.** Specifically, 50 percent rates were applied to inflows from retail and nonfinancial wholesale counterparties, i.e. to performing loans to non-financial customers, and 100 percent rates were applied to maturing loans to financial institutions. This means that cash inflows from performing loans to non-financial customers were assumed to decline by 50 percent in a month, and cash inflows from maturing loans to financial institutions to dry up completely.

**66. Banks can counterbalance negative funding gaps by using their cash holdings and standard operations of the Eurosystem.** In the tests, banks were allowed to cover negative balances of cash inflows relative to cash outflows by using their sovereign securities as collateral to obtain liquidity through the standard ECB lending facilities – weekly repo operations or the more expensive overnight loans. At the banking system level, liquid assets make up 17 percent of total assets (including both on- and off-balance sheet items).

**Table 9. Finland: LCR-based Stress Test Assumptions on Run-off, Roll-off Rates and Haircuts (in percent)**

| | LCR - Basel III | FSAP scenario with retail shock | Dry-up of unsecured wholesale funding |
|---|---|---|---|
| **Run-off rates on potential *outflows*** | | | |
| Households Deposits | 5-10 | 20-30 | 5-10 |
| Corporate Deposits | 5-40 | 10-60 | 5-100 |
| Interbank Deposits | 100 | 100 | 100 |
| Non-deposit liabilities maturing in 1 month | 25-100 | 25-100 | 100 |
| Total contingent commitments | 5-100 | 5-100 | 5-100 |
| **Roll-off rates on cash *inflows*** | | | |
| Level 1 assets | 0 | 5 | 0 |
| Level 2a assets | 15 | 30 | 15 |
| Level 2b assets | 25-50 | 50-100 | 25-50 |
| Margin lending backed by all other collateral | 50 | 75 | 50 |
| All other assets | 100 | 100 | 100 |
| Other inflows, by counterparty | | | |
| *Retail counterparties* | 50 | 75 | 50 |
| *Nonfinancial wholesale counterparties* | 50 | 100 | 50 |
| *Financial institutions and central banks* | 100 | 100 | 100 |
| **Haircuts on liquidity *buffers*** | | | |
| Cash | 0 | 0 | 0 |
| Central bank instruments | 0 | 0 | 0 |
| Government securites eligible as collateral | 15 | 15 | 15 |
| Required reserves on deposits | 0 | 0 | 0 |
| Interbank claims with less than 1 month maturity | 100 | 100 | 100 |
| Loans (performing) maturing in 1 month | 50 | 50 | 50 |
| Monthy repayments on loans with maturities greater than 1 month | 50 | 50 | 50 |
| Other assets maturing in 1 month | 50 | 50 | 50 |

Sources: BCBS (2013) and IMF proposals
Note: Liquid assets are broken down between three categories: level 1 assets are highly liquid assets with excellent credit quality and comprise cash and debt securities issued by highly rated sovereigns; level 2a assets are very liquid assets with very good credit quality; and level 2b assets are liquid assets with good credit quality.

**67. The LCR-based stress tests reveal that short-term liquidity risks are limited in a mild stress scenario (Table 10, Figures 13 and 14).** Liquidity stress test results suggest that aggregate LCR using the European Commission Regulation parameters is equal to 124 percent at December 2015. Every bank passed the 60 percent hurdle rate, which is the initial rate imposed by national regulation in 2015 according to the LCR phase-in agenda, and even the 100 percent hurdle rate, which will be the binding level in 2018.

**68. However, several banks in the system would be exposed to some liquidity risks in the event of very large deposit withdrawals.** Higher run-off rates were applied in the first alternative scenario, especially to retail deposits, as well as higher roll-off rates for cash inflows and higher haircut on Level 1 and 2a assets, including covered bonds. Indeed, the LCR standard establishes a

minimum level of liquidity, but national authorities may impose higher minimum requirements. However, it should be noted that the severity of this scenario exceeds the one experienced during the 2008/2009 financial crisis as the peak of monthly funding withdrawal has been 4.1 percent for retail deposits since 2003 in Finland. Under this adverse scenario, banks lose 20 to 30 percent of their retail deposits and small business deposits, including sight deposits and term deposits with a residual maturity below 30 days, in a month. The results of this adverse liquidity stress test suggest that aggregate LCR would fall to 84 percent, translating into a liquidity shortfall of EUR 17 bn, equivalent to 8 9 percent of GDP.

**69. The second adverse scenario including a dry-up of unsecured wholesale funding provides much worse results.** Banks were assumed to face 100 percent run-off rates on unsecured wholesale funding, including corporate deposits other than from SMEs and parent funding. The latter is treated in the same way as any other unsecured wholesale funding item in this scenario as a Nordic crisis is assumed in which the parent companies in Sweden and Denmark would be severely impacted too. Admittedly, this scenario might be considered to be extreme but given the short-term nature of wholesale funding of Finnish banks, the analysis was deemed to be worth conducting. The results show that the aggregate LCR would fall to 66 percent. The total liquidity shortfall would amount to EUR45 bn, equivalent to 22 percent of GDP. In a combined shock, adding a retail shock and a dry-up of unsecured wholesale funding, the system-wide liquidity ratio would fall to 61 percent, the liquidity shortfall would amount to EUR57 bn, or 27.5 percent of GDP.

**70. Separate LCR-liquidity stress tests carried out on foreign currency positions revealed material shortfalls at some banks.** The test focused on the following foreign currencies: U.S. dollar, British pound and Swedish krona. These tests resulted in liquidity shortfalls ranging between EUR1.1 bn and 3 bn, i.e. 0.5 percent and 1.4 percent of GDP.

**71. In a reverse liquidity stress test, the withdrawal rates of retail deposits alone would need to be very high to lead the system-wide liquidity ratio to fall below 100 percent.** Leaving the other parameters unchanged compared to the standard LCR test, the withdrawals rates of the retail deposits covered by the deposit guarantee scheme and of the uncovered retail deposits would have to reach 30 percent and 40 percent, respectively in a month, to bring the aggregate liquidity ratio below 100 percent.

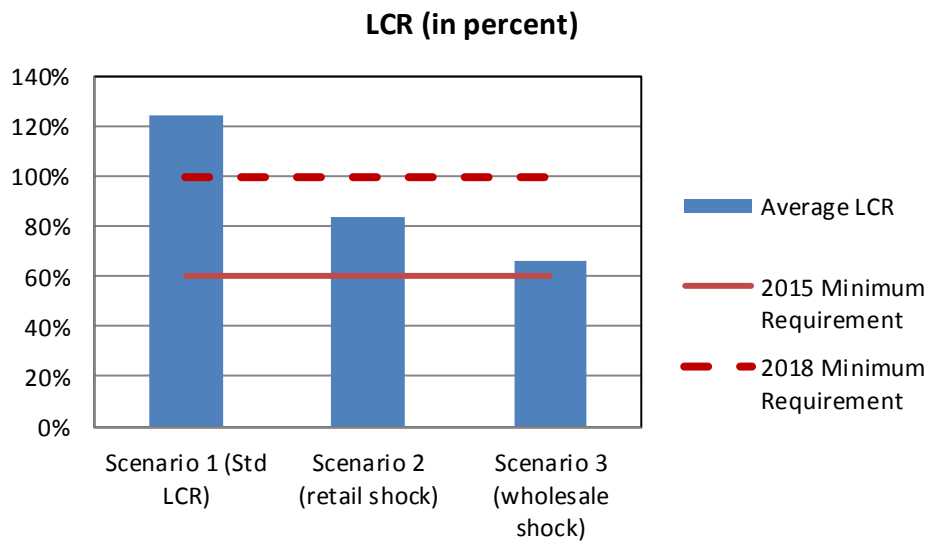
## Table 10. Finland: Summary of the Liquidity Stress Test Results

| | Liquidity stress tests summary results | | | | | |
|---|---|---|---|---|---|---|
| | LCR - Delegated Act | LCR Scenario with retail shock | LCR Scenario with wholesale shock | LCR - foreign currencies | NSFR | Outflow Analysis |
| System-wide Liq. ratio (in percent) | 124 | 84 | 66 | 17/158 | 113.9 | - |
| Liquidity shortfall 1/ | | | | | | |
| *EUR billions* | 0.0 | 16.9 | 45.4 | 1.1/3 | 25.4 | 1.7 |
| *as a percent of GDP* | 0.0 | 8.2 | 21.9 | 0.5/1.4 | 12.3 | 0.8 |

Sources: Fin-FSA and IMF staff calculations

Note: 1/ Liquidity shortfall is the amount required so that the Liq. Ratio in each bank in the sytem be equal to or above 100 percent.
For the LCR in foreign currencies, a range of results is presented as results depend on the currency considered

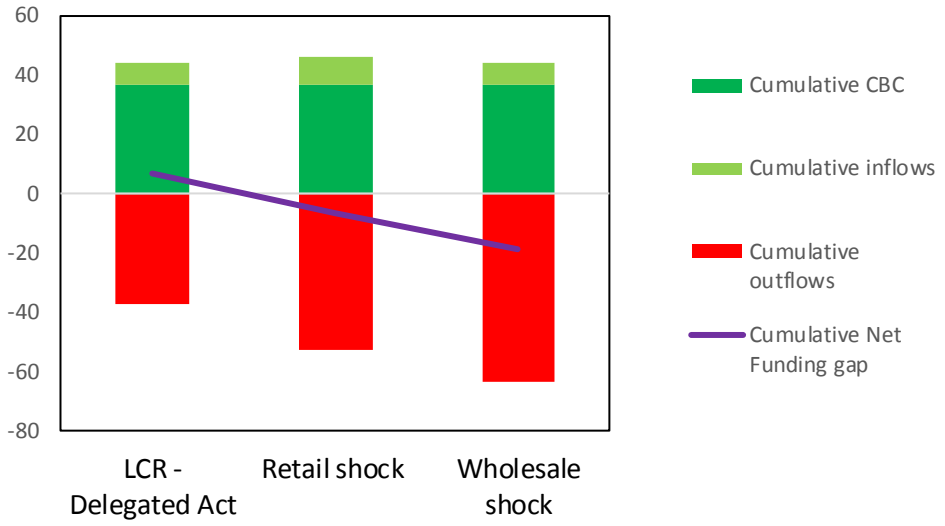
## Figure 13. Finland: LCR-based stress test results




Source: FIN-FSA

**Figure 14. Finland: Bank Liquidity Coverage Ratio Results, Cumulative inflows, outflows, net funding gap, and use of counterbalancing capacity**

(in percent of outstanding non-equity liabilities)




Source: FIN-FSA

## B. NSFR-based stress test

**72. The liquidity stress test results based on the NSFR do not suggest large maturity transformation at the aggregate level, although one bank stands out with a low ratio.** Under the NSFR methodology, available stable funding for the 4 largest banks amounts to EUR192.2 bn in December 2015 and the required stable funding to EUR168.7 bn, resulting in an aggregate NSFR of 113.9 percent, comfortably above the minimum requirement of 100 percent. Nevertheless, at the individual level, some banks would be experiencing liquidity shortfalls, reflecting excessive maturity transformation. The liquidity mismatches at the one-year horizon amount to EUR25.4 bn, equivalent to 12.2 percent of GDP. This reflects the size of the derivatives portfolio and the long-term loans to financial institutions at some banks as these items require stable funding and they show up on both sides of the balance sheet.

## C. Outflow analysis stress test

**73. The outflow analysis was based on six maturity buckets aimed at capturing the comprehensive time structure of banks' cash in- and outflows.** The maturity ladder was composed of the following buckets: 1 to 7 days, 8 to 15 days, 16 to 30 days, 31 to 90 days, 91 to 180 days, and more than 180 days. The pace of deposit outflows was assumed to slowdown as the time horizon increases (Table 11). For each bucket, the amount of net outflows was compared to the amount of counterbalancing capacity, with liquid assets subject to haircuts.

**74. The results of the outflow analysis suggest that the banking system as a whole would not have enough buffers to counterbalance net outflows at one maturity bucket.** For the 16 to 30 days bucket, the gap would be equal to EUR1.7 bn, equivalent to 0.8 percent of GDP (Figure 15).

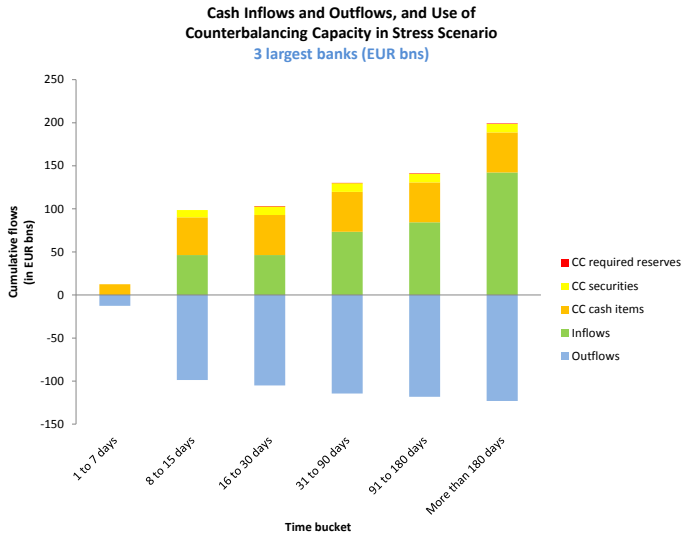
**75. The liquidity stress test results confirm Finnish banks' exposures to short-term liquidity risks stemming from their heavy reliance on wholesale funding and foreign currency funding.** Therefore, they call for an improvement by the authorities of their liquidity monitoring. This could be achieved by examining thoroughly banks' liquidity positions in foreign currencies in a stressed environment; performing liquidity stress tests using the structure of cash flows at various maturities; or applying customized versions of the LCR along the maturity ladder. Options to discourage cross-ownership of covered bonds should also be considered.

**Table 11. Finland: Outflow Analysis Stress Test Assumptions on Run-off, Roll-off Rates and Haircuts (in percent)**

| | 1 to 7 days | 8 to 15 days | 16 to 30 days | 31 to 90 days | 91 to 180 days | More than 180 days |
|---|---|---|---|---|---|---|
| ***Run-off rates on potential outflows*** | | | | | | |
| Retail funding: sight deposits | | | | | | |
| Stable | 8% | 4% | 4% | 3.5% | 0% | 0% |
| Unstable | 12% | 6% | 6% | 2.5% | 0% | 0% |
| Retail funding: savings deposits | | | | | | |
| Stable | 8% | 4% | 4% | 4% | 0% | 0% |
| Unstable | 12% | 6% | 6% | 3% | 0% | 0% |
| Retail funding: term deposits | 35% | 35% | 35% | 30% | 25% | 20% |
| Other deposits | 35% | 35% | 35% | 30% | 25% | 20% |
| Secured wholesale funding from other financial institutions | 100% | 100% | 100% | 100% | 100% | 100% |
| Unsecured wholesale funding from other financial institutions | 75% | 75% | 75% | 30% | 30% | 20% |
| Outflows from derivatives | 100% | 100% | 100% | 100% | 100% | 100% |
| Other obligations | 100% | 100% | 100% | 100% | 100% | 100% |
| Undrawn volume of commited credit/liquidity lines | 10% | 5% | 5% | 10% | 20% | 0% |
| ***Roll-off rates on cash inflows*** | | | | | | |
| Securities in trading book | 100% | 100% | 100% | 100% | 100% | 100% |
| Securities available for sale | 100% | 100% | 100% | 100% | 100% | 100% |
| Securities held to maturity | 100% | 100% | 100% | 100% | 100% | 100% |
| Inflows from derivatives | 100% | 100% | 100% | 100% | 100% | 100% |
| Loans maturing | 37% | 37% | 37% | 37% | 37% | 37% |
| Other | 80% | 80% | 80% | 80% | 80% | 80% |
| ***Haircuts on liquid assets*** | | | | | | |
| Cash items | 0% | | | | | |
| Securities in trading book | 20% | | | | | |
| Securities available for sale | 20% | | | | | |
| Securities held to maturity | 20% | | | | | |

Source: IMF proposal

**Figure 15. Finland: Outflow Analysis-based stress test results**




Source: FIN-FSA

# INTERCONNECTEDNESS ANALYSIS AND CONTAGION RISKS

## A. Domestic interbank contagion risks

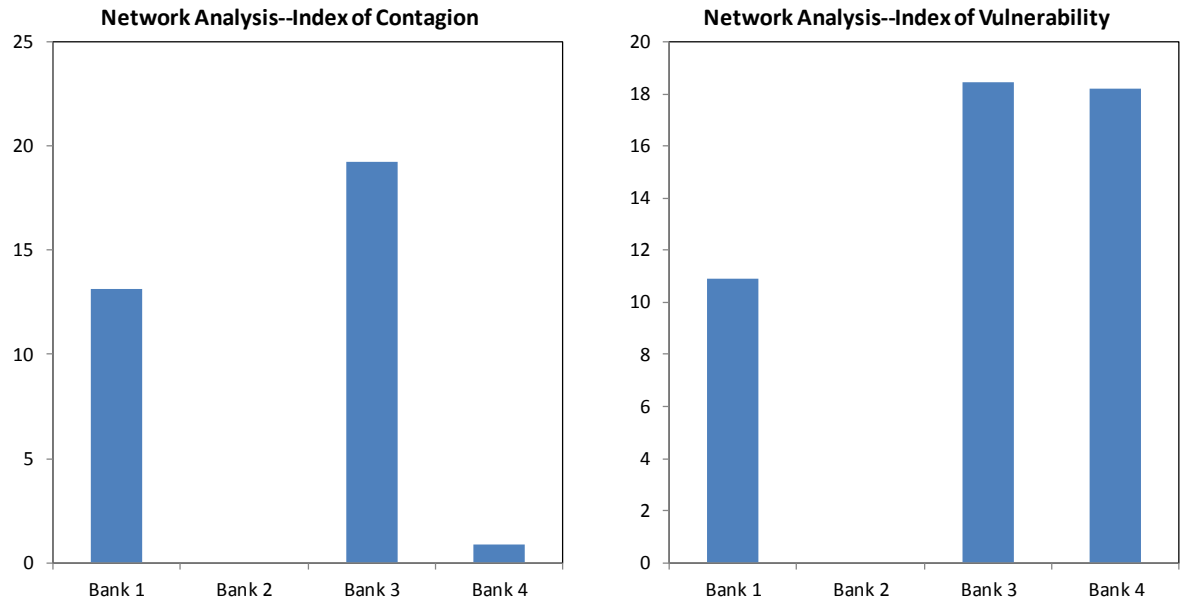
**76. Domestic interbank contagion risks were assessed using a network model of contagion based on Espinosa-Vega and Solé (2010).** The analysis is based on a matrix of bilateral domestic interbank gross credit exposures of the four largest banks composing our sample, with information as of end-December 2015.[29] Interbank exposures are taken from the large exposures quarterly template, on the asset side of banks' balance sheets, and not on the funding side. The analysis includes pure contagion whereby failure of a bank triggers direct credit and capital losses in other banks—and the subsequent fire sales caused by funding shocks (assuming a 50 percent haircut in the fire sale of assets and a 65 percent roll-over ratio of interbank debt).

**77. 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 (i.e. "cascade effects"). With regard to 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.

[29] In a system with 4 banks, the interbank exposure matrix is a square matrix of size 4x4.

**78. The analysis reveals that contagion risks stemming from domestic interbank exposures are very limited.** In Finland, domestic interbank positions are found to be small, especially compared to banks' capitalization. For the four largest banks in the system, the sum of their gross domestic exposures to the other three banks is smaller than their regulatory capital. Therefore, no single failure of a domestic bank would trigger the failure of another bank, and thus no "cascade effect" would take place through this four-bank market. Moreover, as of end-December 2015, none of the four largest banks is found to be undercapitalized with regard to the Tier 1 capital regulatory minimum after a shock on one or several of its domestic interbank exposures. Nevertheless, two of the four largest banks present a significantly higher level of vulnerability to spillovers from the two others. For these two banks, the index of vulnerability, which is the percentage of loss at a single institution due to the default of all other institutions, is significantly higher than for the other two banks (Figure 16). The index of contagion, which corresponds to the average percentage of loss of other banks due to the failure of a given bank, is higher at two banks.

**Figure 16. Finland: Bank Network Model Results (combined effects of credit and funding shocks)**




Sources: COREP; and IMF staff calculations

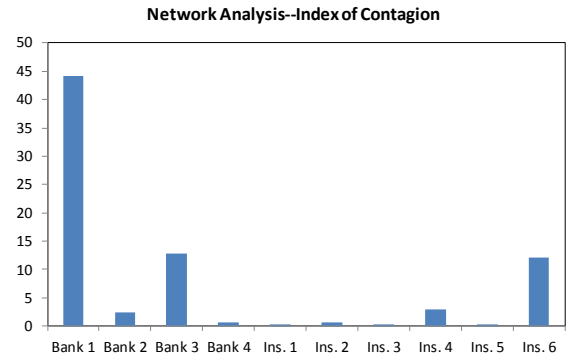
## B. Domestic bank-insurer contagion risks

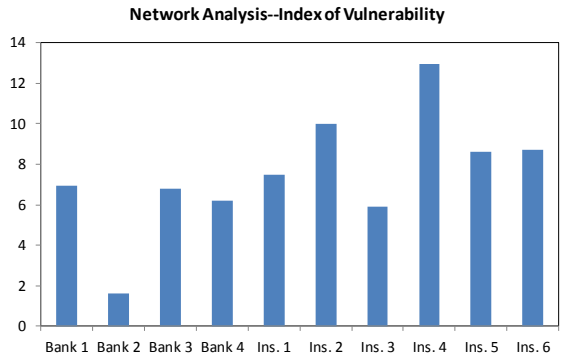
**79. A contagion stress test was carried out based on supervisory data on interlinkages between Finnish banks and insurance companies.** In order to assess the degree of vulnerability of

the largest Finnish financial institutions stemming from the interconnectedness within the financial system, the analysis was complemented by the computation of a matrix of bilateral domestic gross exposures between the 4 previous banks and the 6 largest Finnish insurance companies, including data on capital cross-participation, bonds, credit and deposits. As before, the analysis included pure contagion arising from default of institutions – whereby failure of a financial institution triggers direct credit and capital losses in other institutions. In addition, a funding shock was added, assuming again a 50 percent haircut in the fire sale of assets and a 65 percent roll-over ratio of interbank debt.

**80. The analysis shows that contagion risks associated with interlinkages between domestic banks and insurers are very limited.** For every bank in the system, the sum of all the domestic exposures to both other banks and insurance companies is smaller than its regulatory capital. The same is true for the six insurance companies. Therefore, no single failure of a domestic entity would trigger the failure of another entity, and thus no "cascade effect" would take place through this network. The index of contagion, corresponding to the average percentage of loss of other institutions due to the failure a single institution, ranges between 0.2 and 44.2 percent, the highest index of contagion being associated with a bank (Figure 17). Moreover, the index of vulnerability, which gives the mirror image, namely the percentage of loss at a single institution due to the default of all other institutions, ranges between 1.6 and 13 percent, the highest index of vulnerability being associated with an insurance company. The higher vulnerability of insurance companies to interconnectedness and the higher systemic importance of banks stem from the fact that the exposures of insurance companies to banks are larger relatively to their balance sheet size (13.7 percent of total assets on average) than the exposures of banks to insurance companies (0.2 percent of banks' total assets), but the average exposure of insurers to banks is distorted upwards by one insurance institution in particular which has a significant exposure to one bank.

**Figure 17. Finland: Bank- Insurance Companies Network Model Results (combined effects of defaults and funding shocks)**



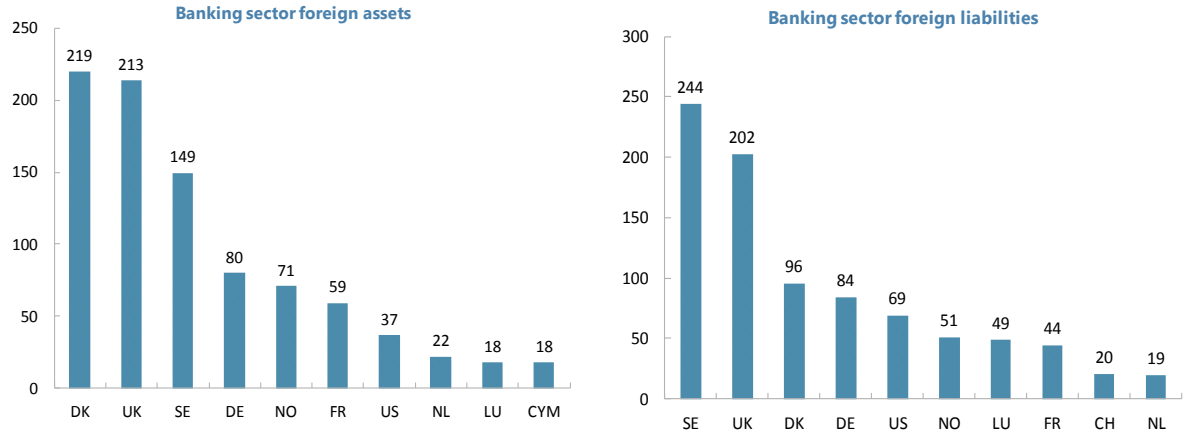



## C. Cross-border contagion and interconnectedness analysis

***Overview***

**81. Cross-border balance sheet analysis reveals strong linkages with the Nordic countries.** Cross-border exposures between credit institutions make up the bulk (63 percent) of total cross border exposures and take the form of loans, advances and debt securities; it typically involves intra-group exposure within Nordic banking groups. There are also significant exposures outside the Nordic region, particularly with the UK (derivatives in London Clearing House), Germany (debt securities, derivatives) and the USA (Federal Reserve) (Figure 18).

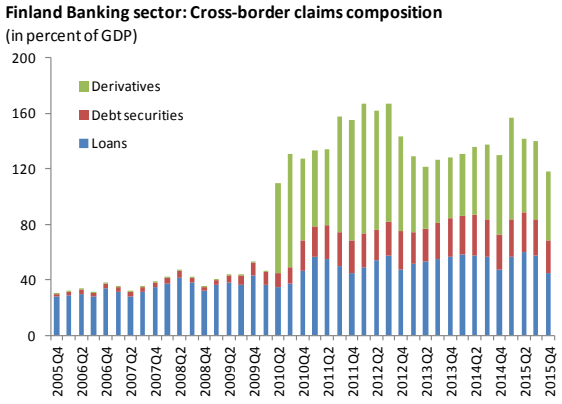
**Figure 18. Finland: Foreign assets and liabilities exposures by country**
(in percent of banking system capital; as of 2015Q3)

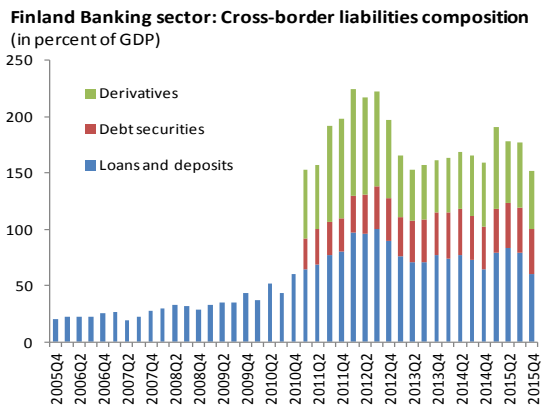



Sources: The Finnish authorities.
Note. These exposures include public sector, financial sector and nonfinancial sector. Most of the UK exposures represent derivatives exposures to central counter party clearing house and a majority of the US exposures are to sovereign debt

**82. Derivatives make up a large share of cross-border exposures but these will decline significantly after the planned conversion of a large subsidiary into a branch**. The Finnish banking system faces peculiar cross-border exposure with derivatives making up 42 percent of cross-border claims (and 36 percent of liabilities) (Figure 19). Nordea group made a decision to further concentrate their derivatives activities on the balance sheet of Nordea Bank Finland in 2010, which increased Nordea Bank Finland's (NBF) cross-border exposure dramatically to the London clearing house in the UK. A majority of (around 75 percent) of the derivatives are interest rate-related over the counter products and they are cleared in central counterparty clearing houses, reducing the counterparty risks. After the planned conversion of Nordea Bank Finland into a branch, this unique exposure will move to the Nordea group parent bank's balance sheet and Nordea Bank Finland's cross- border exposure will decline significantly.

**Figure 19. Finland: Cross-border Exposures**




Source: BIS and Fund staff calculations.

### *Stress test modalities*

This section examines bilateral balance sheet cross-border interconnectedness between credit institutions.

### *Data*

**83. The bilateral balance sheet analysis used two sets of supervisory data provided by the FIN-FSA.** The first set of data is composed of each bank's exposures to credit institutions in five countries (Denmark, Sweden, Norway, Germany and Russia). The channels of risk transmission are loans, debt securities on the assets side; deposits and debt instruments on the liabilities side.[30] The second set of data is constituted of large exposure data from COREP database which shows each bank's exposure by counterparty (single borrower).[31] The counterparties are consolidated group-based exposures, combining all the country exposures, since these are regarded as a single risk. For example, one bank's exposure to Nordea group combines this bank's claims to Denmark, Sweden, Norway and the rest of the world. The analysis used the gross data before credit risk mitigation.

[30] The large exposures to the UK are through derivatives (84 percent of total foreign exposure) at central counterparty clearing houses (CCP) and not included in this analysis, since these are exposures to the CCP in London, which is less likely to be affected by the UK's condition, but more by a large number of international members from the CCP. Derivatives are not included as Nordea's derivatives are disproportionately large and correspond to Nordea group level derivatives, which will become irrelevant to Finland after the conversion into a branch planned for 2017. *Brexit* could have an impact on UK CCP regulations depending on the new arrangements and orderly transition would be necessary.

[31] Large exposure regulation is to identify a large single borrower to monitor the credit risks. This data does not include largest depositors on the liabilities side.

### *Methodologies*

**84. Two separate scenarios were considered to estimate the potential impact of cross-border contagion on the Finnish banking system.** To test vulnerabilities arising from interconnectedness, two scenarios were considered:

- Credit risk: cross-border counterparties experience severe stress (a deterioration in macroeconomic conditions or a sudden fall in oil or other commodity prices) resulting in a partial default on their loans from Finnish banks;

- Funding risk: Global or regional liquidity strains reduce funding from parent banks and other credit institutions to Finnish banks and potentially lead to fire sales of some assets.

**85. These shocks are simulated through the bilateral balance sheet exposures between the four largest banks in Finland and their counterparties.** Channels of transmission include loans, debt securities, and deposits.[32] On the asset side, the tests considered how each bank's capital position evolves with an unexpected increase in the default of loans and debt securities. The test looked at which share of nonperforming exposures would be needed to bring the bank's CAR below minimum capital requirements. The simulations assume that the loss-given-default parameter equals 100 percent and banks are unable to recover any of their loans. On the funding side, the test assumed a dramatic contraction of cross-border funding flows to estimate banks' corresponding changes in liquid assets. The test focused on each bank's ten largest single borrowers and five countries with large exposures.[33]

### *Findings*

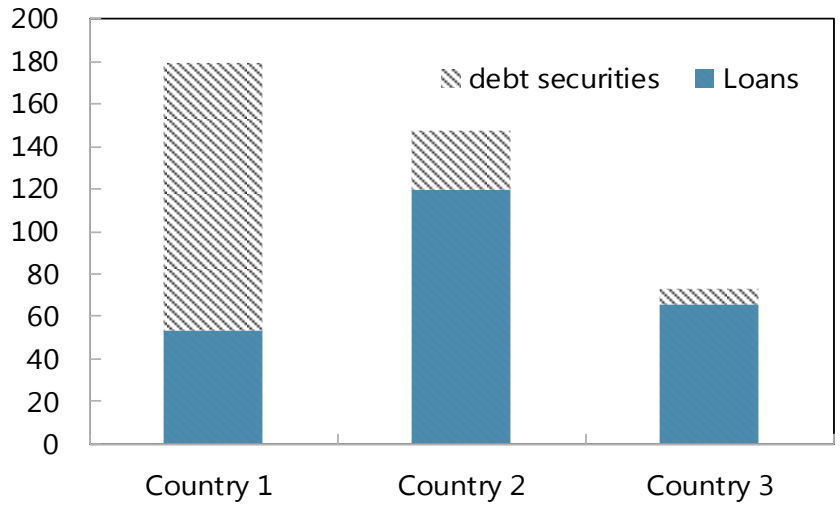
**86. An unexpected increase in the defaulted share of cross-border claims could pose a threat to subsidiaries of foreign banks' capital position.** The largest credit exposures are to the other Nordic countries (Denmark, Norway and Sweden) and the maximum credit exposures of the four largest Finnish banks to another Nordic country range from 75 to 180 percent of capital (Figure 20). The minimum Tier 1 capital requirements (including the capital conservation buffer) of the most exposed banks would fall below the hurdle rate of 8.5 percent if 39 percent of the payment obligations from one country could not be met. Due to Nordic intra-group exposures, the impact of the default of an exposure in another Nordic country would be more pronounced among the subsidiaries of foreign banks than domestically-owned banks. The latter would still meet minimum capital requirement under these shocks. Nevertheless, both foreign-owned and domestically-owned banks have sufficient capital to absorb full losses from exposures to Germany and Russia.

[32] See Cihak (2007) and Espinosa-Vega and Solé (2010).

[33] Iceland is not included since direct balance sheet exposure to Iceland is very limited according to the supervisory data.

**87. There is a heavy concentration in the exposures of the four Finnish banks to the same three foreign entities, through loans, debt securities holdings and intra-group funding.** Gross data before credit risk mitigation shows that significant intra-group exposures or exposures to the central government exceed the limit of 25 percent of eligible capital set by the large exposure regulation but these exposures are exempted from these limits. The four largest banks have significant gross exposures to same foreign entities and the hypothetical default of these counterparties could bring down the solvency ratio of three banks below minimum requirements at the same time.

**Figure 20. Credit Risk: Cross-border Exposures to Nordic Countries**
(in percent of a bank's capital; maximum country exposure among the four largest banks)

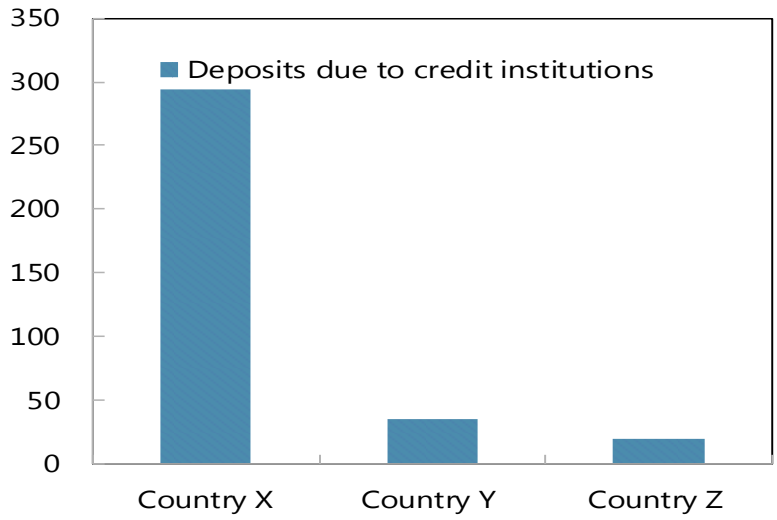



Sources: Fin-FSA and IMF staff calculations.

**88. A sudden contraction of intra-group funding could lead to liquidity pressures for the subsidiaries of foreign banks.** The test consisted of assessing the liquidity risk from cross-border funding a bank would be able to cope without resorting to liquidity assistance (other banks or central bank). Cross-border funding sources appear to be diversified geographically and by funding type (deposits and covered bonds/other debt securities) for most of the banks, although cross-border funding is concentrated in deposits from parent-banks for the subsidiaries of foreign banks. The contraction of 34 percent of funding from one country would deplete one bank's liquid assets. A contraction exceeding 34 percent of funding from one country may lead to a fire sale of assets and deteriorated capital positions of some banks through the liquidity-solvency nexus.

**Figure 21. Funding Risk: Cross-border Linkages with Nordic Countries**

(in percent of a bank's liquid assets; maximum country exposure among the four largest banks )




Sources: Fin-FSA and IMF staff calculations.

**89. Banks' intra-group exposures are significant but it is difficult to assess the contagion risks arising from them.** Given that the majority of exposures to Nordic countries are intra-group lending, the impaired share of these exposures is consistently low (0.02-0.08 percent over the past 8 quarters). Similarly, on the funding side, historic data on the evolution of deposits and funding shows no sudden contraction of intra-group funding. Intra-group funding tends to behave differently from arms-length interbank transactions and it is difficult to assess the risks arising from these exposures.

### *Domestic and Cross-Border Network Analysis with Market Price Data*[34]

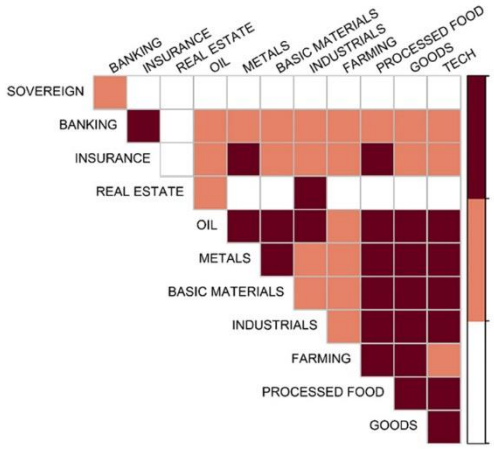
**90. A market data-based analysis carried out at the domestic level reveals that Finnish banks share strong linkages or spillovers with insurers.** The analysis was based on Diebold-Yilmaz (2014) error variance decomposition methodology based on the weekly equity returns (Figure 22).[35] "Implicit" financial linkages or spillovers are defined as directed connections which are statistically inferred from high-frequency market information. By contrast, more moderate linkages

[34] This analysis draws on the forthcoming IMF working paper by Luis Brandao-Marques, Ben Huston and Marco Pinon: "Nordic Linkages".

[35] See cross-border analysis sub-section and Appendix VI for technical details.

exist between banks and central government. This weak connection likely reflects the strong fiscal buffers in Finland and the low level of implicit sovereign guarantees against the default of major financial institutions. Finally, Finland's nonfinancial sectors are strongly connected amongst themselves, notably the technology and goods sectors.

**Figure 22. Finland: Domestic Linkages**




Note: Chart shows the intensity of total (to and from) implicit financial linkages between the sectors of the Finnish domestic economy. Linkages are estimated using sector-specific equity indices for each country and span the period of 2010-16Q1. Colors denote linkage strength, as measured in quantiles. White = bottom 1/3 of all linkages; pink = middle 1/3 of all linkages, red = top 1/3 of all linkages.
Source: Thomson Reuters Datastream; IMF staff calculations.

**91. Market data-based analysis confirms the strong implicit financial linkages among the Nordics.** The Nordic region clearly exhibits a great degree of integration. Evidence based on a variance decomposition of the week-over-week changes of equity prices[36] suggests that within the region[37], Sweden and Finland share the strongest implicit linkages, whereas those with Iceland are the weakest (Figures 23 and 24). These implicit financial linkages strongly corroborate the explicit economic and financial ties observed in official statistics on cross-border trade, banking, and investment activity. In particular, this strong intra-regional connection results from regional banking activity and regional banks' extensive use of wholesale funding and large cross-holdings of covered bonds by banks, insurers, and pension funds.[38]

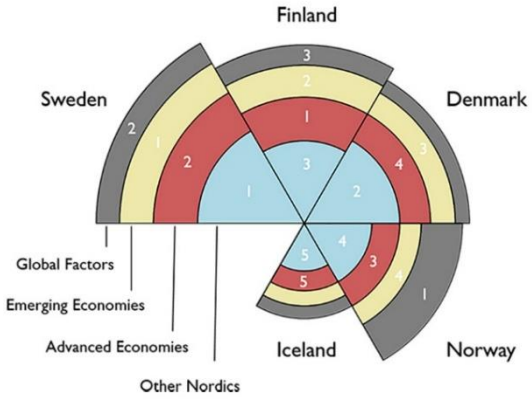
[36] For technical details, see Appendix VI, the forthcoming IMF working paper "Nordic Linkages" and Diebold-Yilmaz (2014).

[37] The Nordic region comprises Denmark, Finland, Iceland, Norway and Sweden.

[38] Many mechanisms could plausibly serve as transmission channels for implicit linkages. For example, regional bank reliance on wholesale funding markets; cross-holding of assets (e.g., covered bonds) by banks, insurers, and pension funds; direct business competition (e.g., for asset management fees among financial sectors); reliance on bank and nonbank sources of financing by nonfinancial firms; transactions between financial and nonfinancial firms as counterparties in bespoke hedging contracts, or in the multilateral netting arrangements of such contracts.

**Figure 23. Finland: Linkages with the Nordic Region**

*Among the Nordics, Sweden and Finland share the strongest implicit linkages, whereas those with Iceland are the weakest. Sweden's greatest links are to emerging economies and to other Nordics, while Finland is most strongly linked to developed countries elsewhere in Europe.*

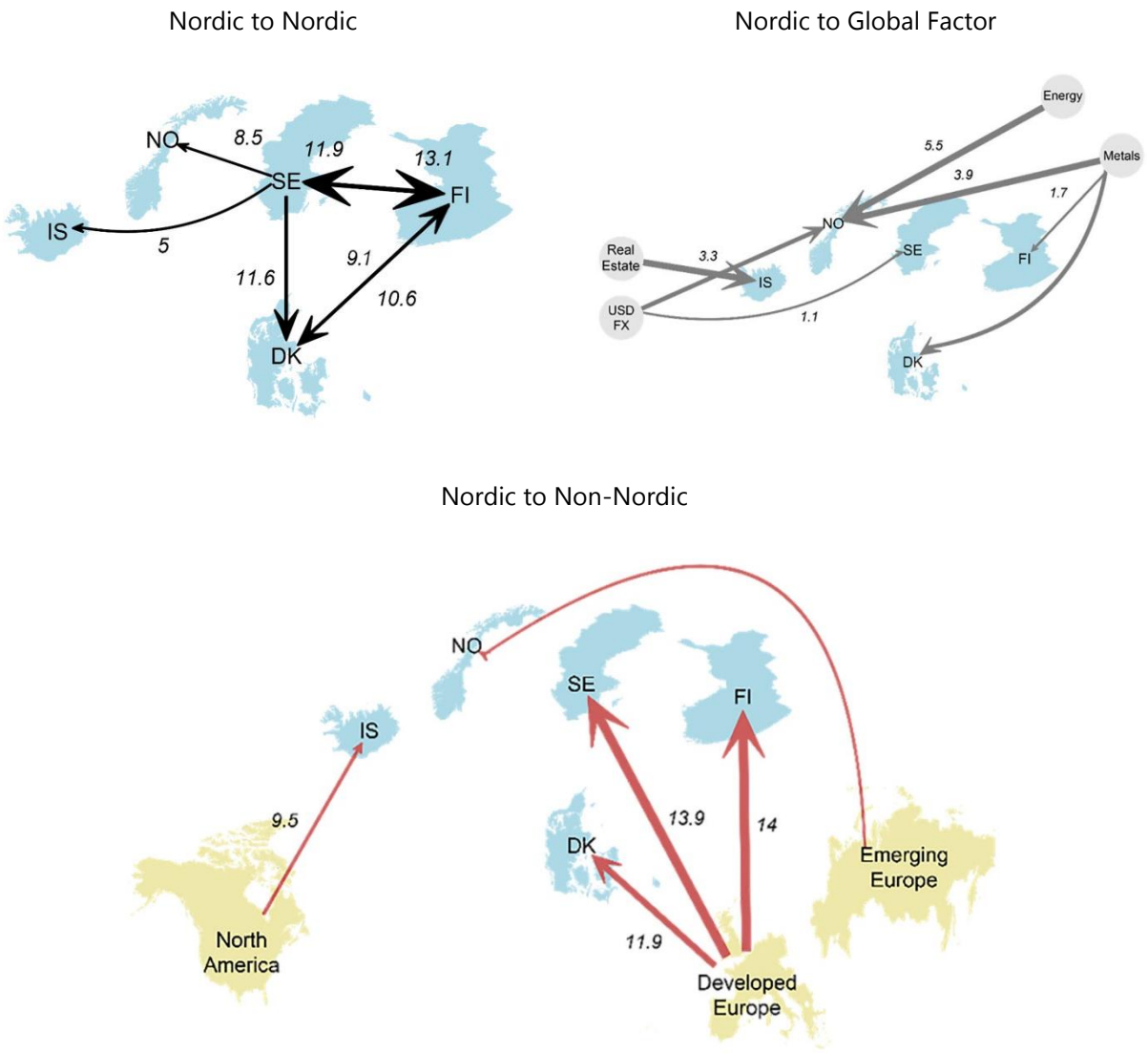



Note: Chart shows the ranking of each Nordic country's relative exposure to each linkage category. For example, Sweden is the Nordic country with the largest exposure to other Nordic countries while Norway is the most exposed to global factors. Results spans the period of 2010-16Q1.
Sources: Thomson-Reuters Datastream; IMF staff.

**92. In addition to regional linkages, Finland is the Nordic country the most strongly connected to developed economies in continental Europe.** Outside of the region, Finland is most strongly connected with the rest of advanced Europe, likely reflecting its membership of the European Union and the euro area. Moreover, Finland exhibits implicit links with metal commodity markets.

**93. Strong interconnectedness of financial systems within the Nordic region is a structural feature which requires high vigilance from the authorities.** This may warrant considering expanding existing protocols with other supervisors of the Nordic region to include formal, region-wide sharing of supervisory data. Moreover, there would be high benefits in terms of regional financial stability in conducting a Nordic-wide stress test coordinated exercise. The latter would provide an opportunity to take into account interlinkages and spillovers, including liquidity-solvency interactions and expanding coverage beyond banks to cross-border regional insurance companies and financial market infrastructure.

**Figure 24. Finland: Implicit Linkages: Nordic Countries, Global Factors, and the Rest of the World**




Note: Chart shows the largest implied financial linkages between countries, regions, and "global factors" (i.e., U.S. policy rate, energy prices, metal prices, the trade-weighted U.S. dollar nominal exchange rate, and global hedge fund returns), as estimated using the methodology of Diebold and Yilmaz (2014). The figures displayed next to each directed arrow denote the percentage of total equity return variation of each Nordic country that is attributable to a shock from another source – such as the equity returns of another country or region, or changes in the value of a global factor. Results are based on data which span the period 2010-16Q1. Black = Nordic-to-Nordic linkages; gray = Nordic-to-global-factor linkages; red = Nordic-to-other-region linkages. Directed arrow size denotes linkage strength. See Annexes for technical details.
Source: Thomson-Reuters Datastream; IMF staff calculations.

# CONCLUSION

**94. Stress tests assessed the stability of the banking sector in Finland.** Top-down stress tests performed by the FSAP team assessed the solvency and liquidity positions of a sizeable composition of the banking system. The Finnish banking system is characterized by its extremely high concentration, its heavy reliance on wholesale funding, its strong linkages with the rest of the Nordic region and low risk weight asset density. Against this background, stress tests assessed resilience of the four largest banks' capital and liquidity to various shocks coming from adverse foreign and domestic macroeconomic, financial factors, and how these shocks translate into credit risks and funding risks.

**95. The quantitative analysis included macroeconomic scenario-based stress tests, complemented by sensitivity analysis.** Scenario-based stress tests used three full-fledged macroeconomic scenarios (one baseline and two adverse scenarios) to assess the solvency of the banking system. These stress tests included comprehensive risk coverage, analyzing risk factors such as: credit risk in the loan book, market risk effects on interest income and valuation effects on the debt instrument holdings, and exchange rate related risks, among others. The risk analysis also included sensitivity tests to assess potential concentration risks, and an assessment of domestic interbank contagion risks and cross-border interconnectedness, and a household sector stress test. Finally, liquidity stress tests were carried out to assess the overall liquidity positions of the banks and liquidity positions in foreign currencies.

**96. The main results of the stress tests are the following:**

- **Results of the solvency stress tests reveal several sources of vulnerabilities, and the banking system would be very significantly affected under the severe scenario.** Banks' capital would be significantly affected by the severe stress scenario, although their initial level of capital is high. The key vulnerabilities in the banking system revealed in the severe stress scenario include funding risks due to a high reliance on unsecured wholesale funding, credit risk associated with domestic retail portfolios, and a high share of volatile trading income. The severe stress scenario combines extreme but plausible macrofinancial shocks. The capital of two of the four largest banks would fall slightly below minimum regulatory Capital Adequacy Requirements. Recapitalization needs would be manageable, at around EUR 550 mn or just 0.3 percent of GDP. When considering total equity in relation to assets (leverage ratio), however, all four banks would fail to meet the 3 percent hurdle rate in 2018 when it becomes binding. Recapitalization needs based on the leverage ratio would be equivalent to 2 percent of GDP. This discrepancy indicates that banks' internal models used to calculate risk weighted assets may underestimate risks.

- **Funding and liquidity risks are the main vulnerability.** The global liquidity stress tests reveal that most banks in the system would be exposed to liquidity risks in the event of large deposit withdrawals, under a more severe scenario than the Basel III LCR metrics, or of a dry-up of unsecured wholesale funding. In addition, some banks display material exposure to funding risks

in foreign currencies. Finally, some banks have excessive maturity transformation due to the size of the long-term mortgage portfolio, the derivatives portfolio and the long-term loans to financial institutions.

- **Banks' bilateral exposure to parent banks is significant but it is difficult to assess the contagion risks from intra-group exposure.** Intra-group funding has historically been very stable in the Nordic region. Since Nordic large financial conglomerates tend to centralize capital and liquidity management in their subsidiaries, the Finnish subsidiaries show strong ties to their foreign parent banks. However, it is difficult to assess the contagion risks from intra-group lending and funding. A study suggests interbank funding between unrelated banks is particularly vulnerable to global shocks, but intra-group funding between parent banks and subsidiaries can act as a stabilizing force, particularly for advanced economies with a high share of global parent banks.[39] Throughout the financial crisis, Finnish banks' strong ties with parent banks proved to be stable and did not negatively affect the solvency and liquidity management. However, this strong dependence could pose a threat to the system.

**97. Recommendations include reviewing banks' Internal Ratings-Based models**, finalizing plans to introduce regulatory floors to the risk-weights calculated by IRB banks, improving liquidity monitoring by performing liquidity stress tests, and conducting a Nordic-wide stress test coordinated exercise to take into account interlinkages and spillovers, include liquidity-solvency interactions and expand coverage beyond banks to cross-border regional insurance companies and financial market infrastructure.

[39] Reinhardt, D. and Riddiough S. (2014) **"**The two faces of cross-border banking flows: An investigation into the links between global risk, arms-length funding, and internal capital markets"

# Appendix I. Finland: Risk Assessment Matrix

| Source of Risks | Overall Level of Concern | |
|---|---|---|
| | **Relative Likelihood** *(high, medium or low)* | **Expected Impact** *(high, medium or low)* |
| **I. Euro area bond market contagion/ Higher-than-expected fallout from the UK referendum result on EU membership**. | Medium<br>As a euro area member, Finland could be affected if sovereign and financial sector stress reemerges across the Euro area due to protracted policy uncertainty and/or events related to Greece.<br><br>The UK referendum on 23 June 2016 resulted in a majority for the UK leaving the EU. The initial impact on financial markets was negative, with the pound Sterling depreciating sharply, highest-rated long-term bond yields declining further, and an uptick in spreads. The vote to leave the EU is expected to lead to a period of heightened uncertainty regarding cross-border trade, financial, and migration relationships between the UK and EU, and therefore, slower overall growth. These effects could be larger than projected in the (revised) baseline, especially if the process is volatile, looks likely to result in a large increase in barriers, or has significant political repercussions. | Medium<br>Finland is a core euro area member and its sovereign yields generally track German yields. Severe financial market stress could cause bank losses and funding difficulties, which could lead to curtailed lending, with negative effects on growth.<br><br>The direct impact of the UK leaving the EU on Finland is expected to be limited. However, Finland financial system might be affected by increased financial volatility due to the transactions with UK central clearing counterparties. |
| **II. Structurally weak growth in key advanced and emerging economies** | High<br>Finland's exports are tightly linked to Euro area markets. | High<br>With domestic demand already anemic, external demand will wane further, pushing Finland into a period of economic stagnation. Finland's direct trade exposure to emerging markets is more limited but the country might be affected by a contraction of world demand, trade, and foreign investment. |
| **III. Heightened risk of fragmentation/security dislocation in part of the** | Medium<br>Russia is Finland's fifth largest export market. Negative effects from a renewed increase in geopolitical tensions could | Low<br>Depending on the severity of a downturn in Russia and exchange rate depreciation, the reduction in |

| | | |
|---|---|---|
| **Middle East, Africa, and Europe.** | spillover through further reductions in trade. | trade in goods and services could shave as much as a couple tenths of a percent off GDP growth. |
| **IV. Severe stress macroeconomic and house price shock in an interconnected neighboring Nordic country.** | Medium<br>Household debt is high in the Nordics due to easy access to credit, low interest rates, and tax incentives for housing.<br>Property prices remain elevated.<br>The two largest banks in Finland are Swedish and Danish. | Medium<br>Declining in demand from other Nordics would lower growth.<br>Rising nonperforming loans and funding costs for Swedish or Danish banks could translate into curtailed lending in Finland, with negative effects on investment and housing. |
| **V. Persistently lower energy prices, triggered by supply factors reversing only gradually.** | Low<br>Continued global oil production in excess of oil consumption leads to an expectation of long-lasting low price levels, as currently suggested in futures markets. | Medium<br>An increase in commodity prices due to oil supply disruptions and geopolitical tensions in the Middle East would dent households' purchasing power, reduce firms' profitability and dampen the economic recovery. Conversely, lower oil prices could further reduce inflation and inflation expectations, lead to high savings and lower investment given slower decline in private debt burdens. |
| Note: The RAM shows events that could materially alter the baseline path (the scenario most likely to materialize in the view of IMF staff). It reflects current staff views on the sources of risk surrounding the baseline, their relative likelihood, and the overall level of concern. | | |

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

| Domain | | Top-down Stress Test by FSAP Team - Assumptions |
|---|---|---|
| **Banking Sector: Solvency Risk** | | |
| 1. Institutional Perimeter | Institutions included | • 4 banks |
| | Market share | • 93 percent of the MFI assets |
| | Data and baseline date | • Publically-available and set of supervisory data<br>• Baseline date: end- December 2015<br>• Bank consolidated level data for banks having their headquarters in Finland and sub-consolidated level data for the subsidiaries of foreign banks.<br>• Market-data |
| 2. Channels of Risk Propagation | Methodology | • Satellite models developed by the FSAP team<br>• Balance sheet-based approach<br>• Market data-based approaches |
| | Satellite Models for Macro-Financial linkages | • Models for credit losses, pre-impairment income, credit growth; expert judgment<br>• Models to integrate solvency-funding interactions<br>• Methodology to calculate sovereign risk<br>• Methodology to calculate losses from bonds and money market instruments (sovereign and other issuers). Haircuts are calculated based on a modified duration approach.<br>• Net fee income and commission income projected based on nominal GDP growth and expert judgment.<br>• No accrued income on NPL loans. |
| | Stress test horizon | • 3 years (2016/2018) |
| 3. Tail shocks | Scenario analysis | • Scenario-based tests, which assess the impacts on the entire portfolio including the loans and, if applicable, the trading book, were conducted in the TD exercise.<br>• Variables in the scenarios include domestic macro- financial variables (e.g., GDP, inflation), and GDP for key trading partners, interest rates, and real estate prices.<br>• In the Finland-specific severe stress scenario, the GDP growth rate declines to -5.0, -3.1 and +0.2 percent, in 2016, 2017 and 2018 respectively.<br>• A set of market shocks, including large and sudden changes in interest rates and exchange rates, is calibrated to magnitudes close to those observed in 2008/2009. |
| | Sensitivity analysis | • Sensitivity analyses were conducted in the TD exercises.<br>• They evaluate *domestic* shocks: direct effects of interest rate shocks; interest rate shock on credit quality; direct effects of exchange rate shocks; a decline in the prices of sovereign |

| | | |
|---|---|---|
| | | bonds; and failure of the largest to 10 largest corporate exposures. |
| 4.Risks and Buffers | Risks/factors assessed. | • Credit losses<br>• Losses from bonds and money market instruments (sovereign and other issuers) in the banking and trading books<br>• Funding costs<br>• Market risk, including foreign exchange risk |
| | Behavioral adjustments | • Balance sheet grows with nominal GDP.<br>• Dividends are paid out by banks that remain adequately capitalized throughout the stress. Dividend payout ratio is determined using historical data. |
| 5. Regulatory and Market-Based Standards and Parameters | Calibration of risk parameters | • Through the cycle and Point-in-time for credit risk parameters or proxies |
| | Regulatory/ Accounting and Market-Based Standards | • European and national regulation<br>• Basel II IRB approach + Basel III |
| 6. Reporting Format for Results | Output presentation | • System-wide capital shortfall<br>• Number of banks and percentage of banking assets in the system that fall below certain ratios. |
| **Banking Sector: Liquidity Risk** | | |
| 1. Institutional Perimeter | Institutions included | • 4 largest banks in the system |
| | Market share | • 93 percent of MFI assets |
| | Data and baseline date | • Latest data: December 2015.<br>• Source: supervisory data<br>• Scope of consolidation: perimeter of individual banks |
| 2. Channels of Risk Propagation | Methodology | • Basel III-LCR and NSFR type proxies, based on European Commission Delegated Act<br>• Cash-flow based liquidity stress test using maturity buckets by banks<br>• Reverse liquidity test by banks |
| 3.Risks and Buffers | Risks | • Funding liquidity (liquidity outflows)<br>• Market liquidity (price shocks) |
| | Buffers | • Counterbalancing capacity<br>• Central bank facilities |
| 4. Tail shocks | Size of the shock | • Run-off rates calculated following historical events and LCR/NSFR rates<br>• Bank run and dry up of wholesale funding markets, taking into account haircuts to liquid assets |
| 5. Regulatory and Market-Based Standards and Parameters | Regulatory standards | • European Commission Delegated Regulation (EU) 2015/61; and Basel Committee on Banking Supervision (2014), "Basel III: The Net Stable funding ratio" Basel, October. |

| | | |
|---|---|---|
| 6. Reporting Format for Results | Output presentation | • Liquidity gap by bank, and aggregated.<br>• Survival period in days by bank, number of banks that can still meet their obligations |
| **Banking Sector: Contagion Risk** | | |
| 1. Institutional Perimeter | Institutions included | • 4 banks<br>• Bank, insurance company and real estate investment trust sectors stock indices |
| | Market share | • 93 percent of MFI assets |
| | Data and baseline date | • Latest data: December 2015.<br>• Source: supervisory and market data<br>• Scope of consolidation: perimeter of individual banks |
| 2. Channels of Risk Propagation | Methodology | • Network interbank model by Espinosa-Vega and Solé (2010)<br>• Diebold-Yilmaz variance decomposition connectedness methodology<br>• Data-driven correlation networks |
| 3. Tail shocks | Size of the shock | • Pure contagion: default of institutions<br>• Spillover index and transmission |
| 4. Reporting Format for Results | Output presentation | • Number of undercapitalized and failed institutions, and their shares of assets in the system<br>• Evolution and direction of spillovers within the network |

# Appendix III. Satellite models for credit risk – Technical details

**Probabilities of Default (PDs) for credit risk estimation were projected for the five broad asset classes at the aggregated, system-wide level.** Due to relatively short time series for PDs and LGDs as well as different points in time when regulators approved banks' applications to grant permission to use the IRB approach for the respective asset classes, the FSAP team was not able to effectively use a panel-based approach. Alternatively, system-wide PDs were obtained using a simple arithmetic mean[1]. In addition, several banks (besides the four ones which were included in the exercise) which use the IRB approach were included to broaden the data sample. PDs obtained from supervisory authorities (both FIN-FSA and ECB) were mostly hybrid PDs, i.e. weighted averages of PIT and TTC PDs with defaulted exposures. Ideally, TTC PDs without defaulted exposures are required for RWAs calculation and one-year PIT PDs without defaulted exposures are typically used for ELs calculation.

**Another type of PDs series was constructed to estimate capital needs in line with prudential regulation, to smoothen the impact on capital requirements.** The calculation of risk-weighted assets requires Through-The-Cycle PDs. The latter have to be long-run averages of one-year PDs although they do not necessarily need to capture at least one stress period, if recent data is better predictor of loss rates. The last big crisis in the Nordic region was in 1990s. Therefore, risk parameters based just on the recent historic data might underestimate potential losses. To overcome this data challenge, the FSAP team developed a separate stress testing model based on individual household data to shock households' income. An output of this model was a multiplier which was applied to mortgages portfolio PDs.[2]

**The satellite models for hybrid PDs as a dependent variable were constructed as follows:**

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

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

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

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

[1] While this approach does not take into account individual bank's portfolio characteristics, it allows addressing the problems related to potential underestimation of PDs by some individual banks, especially those that are significantly below the mean.

[2] TTC PDs without defaulted exposures were updated with the simulated shocked PiT PDs to obtain shocked TTC PDs via simple equation: $PDs_{TTC\ shocked} = PDs_{PIT} * a + PDs_{TTC}$. Multiplier *a* was set to 10% to account for relative rigidity of TTC PDs, however the update was done for each year within stress testing horizon.

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

iii) While in multiple cases, several statistically and economically significant alternative specifications for the same assets class were obtained, the final selection of equations followed several principles. Namely, i) the specification with the lower number of lags for the macrofinancial explanatory variables was selected (with the aim of allowing the realization of shock within a relatively short three-year stress test time horizon); ii) inclusion of unemployment shock in the equation for mortgage portfolios; iii) specification with lower weight (elasticity) of lagged dependent variable to avoid long "memory" effects and PDs inertia; iv) in several cases where explanatory power was lower (R-square of 60-70 percent), available PDs were divided by (1-Rsquare) to take into account unexplained variance by the models. More specifically, the determinants of PDs included:

- for the Finnish retail mortgage loans: the one-quarter lagged unemployment rate, and contemporaneous real GDP growth rate. To correct for serial autocorrelation of residuals, the lagged dependent variable (PDs for the previous quarter) was included. The GDP growth rate was expected to have a negative effect on PDs because it is associated with higher income, which increases households' debt repayment capacity. A surge in unemployment increases the probability that a number of households in the loan portfolio would experience financial difficulties and thus would not be able to repay their debt. At the same time, given rather generous unemployment benefits (up to 80 percent of salary for up to two years) the immediate impact from a surge in unemployment level would be low, which is reflected in the lagged effect of the increase in unemployment on PDs. Real interest rates were expected to have a positive effect on PDs. However, many of the mortgages are provided to the higher income households with sufficient income buffers (see section on household stress tests); hence the effect was rather weak and was excluded from the final specification;

- for Finnish non-financial corporate loans: the year-on-year real GDP growth rate lagged by one period has a negative effect and the contemporaneous level of the 6-month Euribor interest rate has a positive effect as it increases funding costs for Finnish companies;

- for loans to financial institutions: the contemporaneous year-on-year real GDP growth rate, and the 6-month Euribor rate;

- for SMEs: unemployment rate as well as a dummy variable to reflect changes in PDs calculation methodology;

- for other retail loans: lagged unemployment rate as well as contemporaneous real GDP growth rate;

- for exposures under Basel II STA approach: a Bayesian VAR with the quarterly logit transformed NPL ratio and the nominal 10-year Finnish government bond, unemployment rates as endogenous variables, with a lag order of 2, and the quarterly year-on-year real GDP growth,

Euro/USD rate as exogenous variables. We also assumed that sovereigns will not default, hence sovereign exposures were excluded from our calculation of loan portfolio losses as well as migration of RWAs. Due to limited amount of historical data, the FSAP team was not able to add loan write-offs to the NPLs ratio. However, in light of the limited number of loan foreclosures in Finland as well as some recent data on write-offs, it can be assumed that the bias due to the absence of write-offs is not very significant; [3]

- for sovereign exposures: 3-year probability of default based on Moody's issue weighted cumulative default and recovery rates[4].

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

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

**PIT PDs and NPLs were projected using quarterly data over the period 2008Q1-2015Q4 and estimating time series OLS, RLS as well as Bayesian VAR models.** To minimize model error risks and for the sake of result conservatism, PD/NPLs projections were based on the most severe results between ECB benchmarks, and the Top-Down model developed by the FSAP team. Models differ as to their design and explanatory variables used. The ECB satellite models used for projecting the PIT PDs at the individual country and portfolio level rely on a Bayesian Model Averaging (BMA) technique. The BMA approach operates with a pool of equations per dependent variable to which weights are assigned that reflect their relative performance to then result in a so-called 'posterior model' equation. The dependent variable in these equations is the default rate at country and segment level. The PD multiples derived from these satellite models are attached to the starting point PD PIT of banks. The FSAP team Top-Down model used real PDs and LGDs data obtained from banks and the FIN-FSA. The coefficients of the explanatory variables based on the IMF Top-Down model are presented in Table A1 for the IRB asset classes.

**For the Finnish mortgage segment, the unemployment rate and, to a lesser extent, real GDP growth rates have the largest and most significant effects**. When the unemployment rate increases by one percentage point, PD rises by 0.6 percentage points; when the GDP growth rate decreases by 1 percentage point, PD rises by 0.2 percentage points. For the non-financial corporate loans, the year-on-year real GDP growth and the 6-month Euribor rate have the largest effects: a 1 percentage point decline in real GDP growth increases the PD by 0.1 percentage points; a 100 basis points increase in the Euribor rate results in a rise in PD by 0.2 percentage points. For SME loans, unemployment is the most significant factor explaining increase in PDs: a one percentage increase in

[3] Inclusion of write-offs would implicitly add another bias due to inability to differentiate between write-offs from loans that were subject to IRB and STA capital requirements.

[4] See Moody's, 2015 Sovereign Default and Recovery rates. 1983-2014.

unemployment leads to 0.7 percentage point increase in PDs. In the NPLs model, a decline in GDP growth rate as well as a shock to unemployment and interest rates increase NPLs.

**Appendix III. Table 1. Finland: Results from the Estimation of the IMF Credit Risk Satellite Models (Equations [2] and [3])**

(Dependent variable: logit transform of the PD)

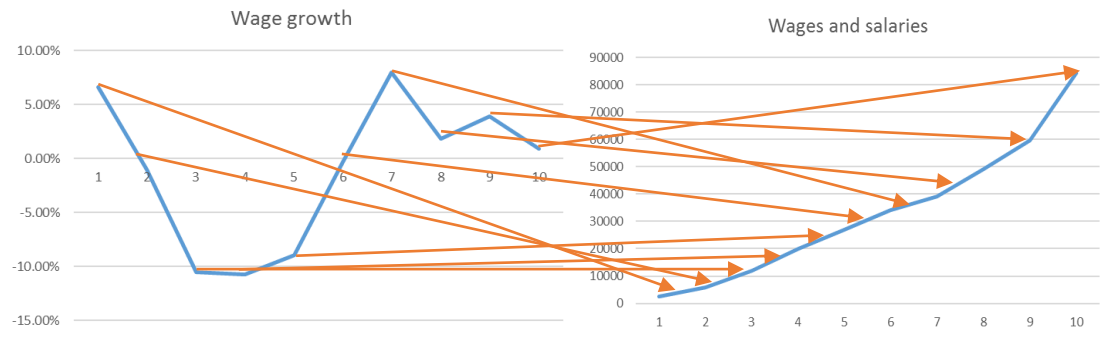
| Dependent variables: Logit transformed PDs | | | | | |
|---|---|---|---|---|---|
| **Asset class** | **Mortgages** | **Corporate** | **SMEs** | **Institutions** | **Retail(oth.)** |
| YoY real GDP growth (in log) | -0.018** | - | - | -0.02** | -0.02* |
| | (-2.18) | | | (-2.45) | (-1.98) |
| YoY real GDP growth (in log) | - | -0.01* | - | - | - |
| (lagged by 2 quarters) | | (-1.83) | | | |
| Unemployment rate (in percent) | - | - | 0.05** | - | - |
| | | | (2.05) | | |
| Unemployment rate (in percent) | 0.099** | - | - | - | - |
| (lagged by 1 quarter) | (2.44) | | | | |
| Unemployment rate (in percent) | - | - | - | - | 0.07* |
| (lagged by 7 quarters) | | | | | (1.76) |
| Euribor, 6M rate (in percent) | - | 0.06** | - | 0.06* | - |
| | | (2.5) | | (1.6) | |
| Dummy variable | - | | 0.06** | 0.18 | 0.19** |
| | | | (2.29) | (1.6)* | (2.46) |
| Lagged dependent variable | 0.32* | 0.88*** | 0.24*** | 0.63*** | 0.46*** |
| | (3.50) | (10.7) | (2.45) | (7.49) | (2.75) |
| Constant | -3.50* | -0.44* | -2.05*** | -2.46*** | -2.15*** |
| | (-6.59) | (-1.67) | (-5.5) | (-4.38) | (-3.59) |
| Estimation method | OLS | OLS | RLS | OLS | OLS |
| R-square | 0.51 | 0.83 | 0.53 | 0.88 | 0.74 |
| # of observations | 24 | 30 | 27 | 31 | 28 |

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

# Appendix IV. Households stress tests – Technical Details

A representative ECB's Household Consumption and Finance Survey sample contains detailed data about 10900 households, including their income, financial and non-financial assets as well as monthly payments for primary residential mortgage. However, survey data did not contain information on households' monthly or annual expenditure, hence we had to map this data using information provided by Statistics Finland annual surveys.[1] Moreover, data was collected in 2009; it thus became substantially lagged behind the latest macroeconomic developments. Therefore, in order to approximate households' financial situation in 2015, we had to update income and expenditure data with the latest available figures. To that end, we used a simple statistical approach grouping all households into deciles (to map updated numbers for income) and quintiles (to map expenditure data) according to their income (see example in Figure A1).

**Appendix IV. Figure 1. Mapping deciles of year X wage growth distribution into deciles of year X household's wage distribution**




Source: IMF Staff calculations

The next step was to update each household's income and expenditure data by mapping the respective growth rate (for income) and absolute number (average expenditure) from the corresponding decile and quartile[2]. Table A2 below shows dynamics of disposable income and wage growth during the last five years:

[1] Metadata description: http://tilastokeskus.fi/meta/til/tjt_en

[2] Due to differences in survey frequency we were able to obtain expenditure data for 2012, but used income data for 2014. It is also important to note, that our expenditure data are based on average expenditure data for the respective decile, and not on minimum expenditure data as in the Bank of Finland model.

**Appendix IV. Table 2. Income dynamics: 2009-2014**

| Income decile | Growth rates: wages | Growth rates: disposable income | Growth rates: transfers* |
|---|---|---|---|
| **1** | 6.59% | 2.78% | 0% |
| **2** | -1.01% | -1.43% | -2% |
| **3** | -10.52% | 0.22% | 10% |
| **4** | -10.75% | -1.06% | 11% |
| **5** | -8.96% | 2.19% | 10% |
| **6** | -0.29% | 5.57% | 18% |
| **7** | 7.95% | 5.07% | 9% |
| **8** | 1.80% | 7.65% | 20% |
| **9** | 3.91% | 5.68% | 10% |
| **10** | 0.91% | 4.56% | 27% |

* While high income households got biggest increase in transfers, these constitute relative low share of total income (compared to low and middle income households).

The analysis shows that middle class income growth (3-6 deciles) was related to households who experienced negative wage growth during recessionary years. At the same time, the effect of negative wage growth was partially compensated by growth in other income, mostly social transfers. Initial data also reveals that almost 27% of households who have mortgages or receive some social transfers. However only five percent have negative income and mortgage[3] (see Table A3).

For expenditure data, we used average expenditure per quartile and not the adjusted minimum expenditure. The rationale for the use of average expenditure was based on the need to apply a very conservative approach and the assumption that consumers will keep their average spending intact (i.e. otherwise there would be a need to estimate a second round effect on economic growth and other macro parameters). In this case, we obtained very conservative estimates of the share of households with negative margins, whereas assumptions about a decline in average consumption or the use of minimum consumption would lead to a much lower share of households with negative margins (and lower shock to quasi PDs). However, macroeconomic variables would be subject to higher shocks (consumption is a component of GDP).

[3] Negative income means that to cover income gap for that period household is consuming their accumulated financial wealth, for example savings. At the same time, data should be interpreted with appropriate care, as we used income/expenditure approximation by deciles and quintiles, thus some statistical errors might have an impact as well.

**Appendix IV. Table 3. Descriptive characteristics of households with mortgages**

| | |
|---|---|
| Are unemployed (i.e. no one member of household is employed) | 3.4% |
| Households which receive social transfers | 27% |
| Have negative income | 5% |

We assumed that households who have negative income margin are the ones who are most likely to face financial difficulties in repaying their debt. Net income margin was calculated as follows:

$$IM = [Employee\ income * (1 + g_i^e) * (1 + \alpha) + Regular\ Social\ Transfers * (1 + g_i^t) * (1 + \beta) + Other\ Income * (1 + g_i^o) * (1 + \gamma)] - Expenditure_{decile\ i} * (1 + \delta) - Residential\ Mortgage\ Payments * (1 + \varepsilon)$$

All income and expenditure data was annualized, with regular social transfers excluding pensions; expenditure was without residential mortgage payments. A,β,Y,δ, ε– were respective shock parameters and g – growth rates. If net income margin IM is negative, we can assume that such a household would first use other resources, like savings, borrow money from family member and other relatives, finally sell real estate before it defaults. So, we calculated net assets by assuming:

$$NA = Total\ real\ assets * (1 + \mu) + Total\ financial\ assets * (1 + \theta) - Total\ outstanding\ balance\ of\ household's\ liabilities$$

Where μ and θ are shocked growth rates of real estate prices and financial assets respectively. If a household has negative IM and negative net assets (NA) (i.e. higher total liabilities than the value of real and financial assets) we assume that such a household is in a default position[4]. We calculated implied PD using the following formula:

$$PD = \begin{cases} 1, if\ IM < 0, and\ NA < 0 \\ 0\ otherwise \end{cases}$$

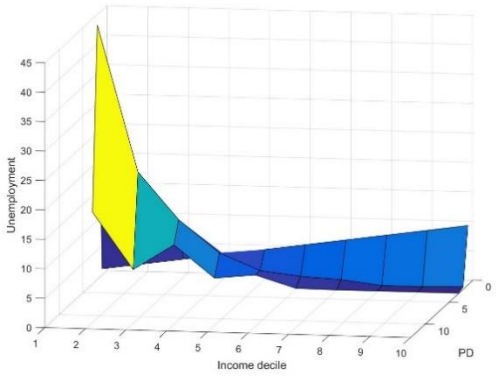
Pre-shock data analysis confirms that there are around 2.2% of defaulted households in our sample. This result is approximately in line with average PDs of banks' mortgage portfolios. We were not able to link the data with mortgage database and calculate actual historical PDs rate in order to calibrate the model. However, to make our assumptions closer to actual PDs estimated by commercial banks, we calculated implied weighted average PD for the mortgage portfolio by multiplying PDs for the respective income decile with the share of mortgages in that decile, i.e.:

$$PDs_t^P = \sum_{i=1}^{10} PDs_i * Share_i$$

[4] This is a simplification as even in such a case households' might tap other resources, like support from families and relatives.

Household analysis by their income, unemployment status and PD (i.e. negative assets and negative income margin) shows that, as expected, households with lower income have highest probability of being unemployed as well as higher PDs. At the same time, PDs are highest in 3rd and 5th deciles, which is not surprising, as households who belong to the first and second decile typically do not have mortgages. In line with reality, households with highest income have highest proportion of mortgage loans and lowest PDs[5] (in our sample, households in deciles 6 and above did not default).

**Appendix IV. Figure 2. PDs and Unemployment by income decile before shocks.**




**Appendix IV. Figure 3. Distribution of mortgage loans and implied PDs by income decile.**


Source: IMF staff calculations.

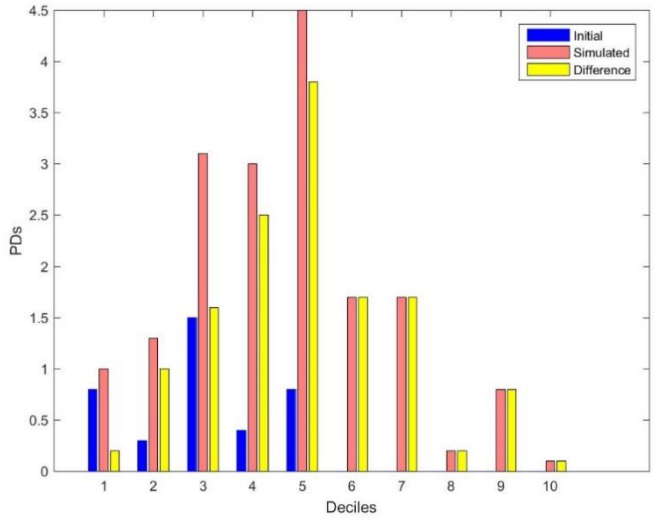
Mortgage loan distribution analysis (see Figure A3.) reveals that distribution of mortgage loans is shifted to the right, i.e. more households in higher income deciles have loans than lower income ones. To see how risk changed over time it would be useful to compare how this distribution changed over time, i.e. compared to several previous periods when banks were relaxing or tightening lending conditions.

We calculate final PDs as a difference of initial (realized PDs) and new simulated PDs for each decile. Final portfolio PD is simply a sum of PDs for all deciles multiplied by the respective probability of a household having a mortgage in each decile.

For our households ST simulation, we used assumptions according to the severe stress scenario. In addition, we also assumed that incomes (i.e. mostly social transfers and wages) would decline by 20% (instantaneous shock). Final distribution of PDs after our simulation is illustrated in Figure A4.

[5] These households also have highest wealth buffers, i.e. financial and other assets. Relaxing this condition (i.e. assuming that only financial assets are used to repay debt in case of default) makes PDs higher than zero for these income groups as well.

**Appendix IV. Figure 4. Distribution of mortgage PDs before and after shocks.**




Source: IMF Staff calculations.

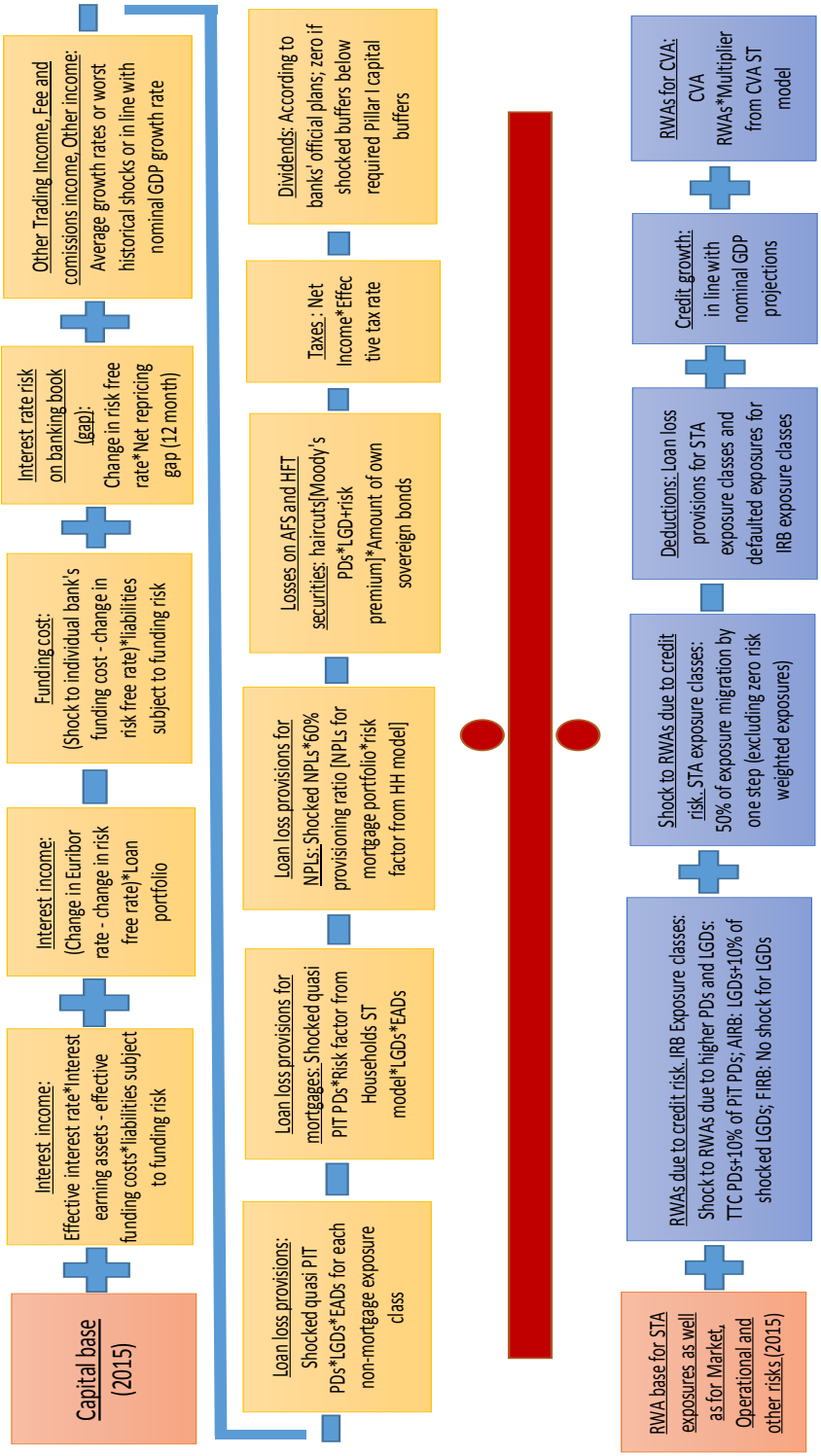
Average implied PD for the mortgage portfolio will increase from 3.9 to 13.6 percent. Without the effect of decrease in wages and social transfers, defaults will increase by 3.8 percentage points to 7.6 percent on average, which is comparable to the projections obtained using macroeconometric satellite models. At the same time, stress testing results should be interpreted with appropriate care. Income and expenditure update by deciles and quintiles contain additional error margins.

Bank of Finland run their own household stress testing model and obtained results which showed an increase share of households with negative income margin from 14.9 to 16.2 percent (shock to employment related income by -15 percent). The model used by the FSAP team and the one of Bank of Finland have some important differences which makes results not directly comparable:

i) The FSAP team used 2009 data and updated it with income and expenditure data by deciles; Bank of Finland uses actual micro data for 2015;
ii) The FSAP team uses different definition of default: households default when their income is negative and when assets are negative, while Bank of Finland definition is negative income;
iii) The FSAP team used average expenditure data for the respective quartile, while Bank of Finland uses minimum income.

Based on these differences, the FSAP team obtained higher multipliers assuming that higher income households will have higher expenditure, although it is also reasonable to assume that in the case of a loss of income and other financial difficulties households would reduce their expenditure. This would lower the shock to default rates in the FSAP team model.

# Appendix V. Flow of CAR calculations



# Appendix VI. Market data-based Interconnectedness Analysis – Technical Details

## Methodology

The methodology used to measure spillovers draws from Diebold and Yilmaz (2014) for market data analyses. The measurement of spillovers using market data starts with estimating a Vector Autoregression (VAR) based on a specification as follows:

$$A(L)Y_t + B(L)X_t = \varepsilon_t$$

$D^H = \left[d_{i,j}^H\right]$ is the H-step ahead variance decomposition matrix.

with *Y* being a vector of weekly equity returns, *X* a vector of control variables, usually the *VIX*, *A(L)* a lag polynomial with order chosen by the Bayesian Information Criterion (BIC), *B(L)* a vector of constants, and $\varepsilon_t$ an error term.

The VAR model above is used to build a generalized forecast-error variance decomposition to identify uncorrelated structural shocks to returns. To that end, Pesaran and Shin's (1998) methodology is used. The spillover measures consist of the percent contribution of entity A to the H-step ahead forecast error variance of entity B, where the entities can be banks, sectors or countries. The advantage of this approach relative to the more standard Cholesky ordering or a more structural approach is that it does not require the modeler to explicitly choose the ordering of the variables.[1]

Since variance decompositions do not fully control for common exposures, this approach was complemented with a Granger-causality test using the same VAR model. To that end, a Wald test is performed on each entity, with the null hypothesis being that lagged returns of entity A do not help to explain the returns of entity B in a statistical sense. If the null hypothesis is rejected at the five percent significance level, then a direct connection exists from A to B, beyond what can be explained by common exposures.

## Data

Analyses were conducted at the sectoral level. The network is meant to capture linkages between financial systems. Two worldwide indexes compose the network: the world real estate MSCI index and the global hedge fund index taken as global factors. Countries covered are: Finland, China, France, Germany, Greece, Italy, the Netherlands, Portugal, Spain, the U.K and the U.S. The number of indexes varies from country to country. For China, France, Greece, the U.K and the U.S, sectoral indexes were available for banking, insurance and real estate sectors. For the other countries, including Finland, a stock price index for the financial system as a whole was chosen. For Finland, this choice allowed us to circumvent the problem of entities' representativeness as most Finnish

[1] Although in some cases market size may be a natural order, experiments based on trying different ordering showed that results were moderately sensitive to the choice of ordering.

banks are currently state-owned and only a small part of their capital is publically-traded. The ISEQ financial index was deemed to be the most representative and diversified of the available indexes and to face the least data gaps.

Data for equity returns comes from Bloomberg and spans from January 1, 2000 to February 4, 2016 at the daily frequency. Forecast error variance was calculated on a 10 days ahead basis.

The market data used to measure implicit financial linkages consisted primarily of country- and sector-level equity price indices sourced from Thomson-Reuters Datastream. All equity price data was measured from a total return perspective (i.e., equity price plus dividend yield) and was of daily frequency. Ultimately, the analysis of implied finanical linkages used *equity returns* as input, and these were computed as week-over-week log-differences to control for influence of different time-zones on observed equity prices. In the case where implied linkages were estimated between Nordic sovereigns and other sectors, week-over-week changes in yield-to-redemption on 10-year sovereign bond indices were used in place of equity returns.[2] Data on control variables and global factors were computed and sourced in a manner identical to that of equity returns.

**Appendix VI. Table 4. Financial Variables Used in Analysis**

| *Implicit cross-border financial linkages, country-level* |
|---|
| **Equity Indices:** OMX Iceland All shares, Sweden DS Market, Denmark DS Market, Finland DS Market, Norway DS Market, North America DS Market; Developed Europe DS Market; Developed Asia DS Market; Developing Europe DS Market; Developing Asia DS Market; Latin America DS Market; Middle East and Africa DS Market<br><br>**Global Factors:** GSCI Four Energy Commodity, Industrial Metals, Precious Metals, and Agriculture indices; Citibank Global Bond Index; MSCI World Real Estate Index; HFRX Global Hedge Fund Index; JPM Trade-weighted USD REER Index; US Economic Policy Uncertainty Index; Citi Short- and Long-Term Macro Risk indices; Citi Global Economic Surprise Index<br><br>**Controls:** CBOE S&P500 Skew, S&P500 VIX, and OVX indices; Merrill Lynch MOVE Index; and ASR Global Equity Risk Premium Index |
| *Implicit cross-border banking and insurance financial linkages, sector-level* |
| **Nordics:** Sweden Banks and Insurance; Denmark Banks and Insurance; Finland Banks and Insurance; Norway Banks and Insurance<br>**Non-Nordic:** United States Banks and Insurance; United Kingdom Banks and Insurance; France Banks and Insurance; Germany Banks and Insurance; Japan Banks and Insurance; China Banks and Insurance; Brazil Banks; India Banks and Insurance; Turkey Banks; Russia Banks |

[2] Changes in bond yields were calculated in the same manner as equity returns. All bond index data was of daily frequency and sourced from Thomson-Reuters Datastream. For robustness, Sovereign-to-Other implied financial linkages were also estimated using single name 5-year CDS on senior sovereign debt. The results were analgous to those based on bond yields.

**Controls:** Sweden DS Market, Denmark DS Market, Finland DS Market, Norway DS Market; , S&P500; FTSE 100, CAC 40, DAX 30, Topix, Shanghai SE A Shares, CNX 500, BIST National 100, Russia MICEX; GSCI Four Energy Commodity, Industrial Metals, Precious Metals, and Agriculture indices; Citibank Global Bond Index; MSCI World Real Estate Index; HFRX Global Hedge Fund Index; JPM Trade-weighted USD REER Index; US Economic Policy Uncertainty Index; Citi Short- and Long-Term Macro Risk indices; Citi Global Economic Surprise Index; CBOE S&P500 Skew, S&P500 VIX, and OVX indices; Merrill Lynch MOVE Index; and ASR Global Equity Risk Premium Index

*Implicit domestic financial linkages, sector-level*

**Denmark:** Banks; Construction Materials; Consumer Goods; Consumer Services; Food Beverages; Food Producers; Health Care; Industrials; Insurance; Oil and Gas; Real Estate; Technology; Telecom, Media, IT

**Finland:** Banks; Basic Materials; Construction Materials; Consumer Goods; Consumer Services; Electricity; Forestry Paper; Health Care; Industrials; Industrials Metals Mines; Oil Gas; Real Estate; Retail; Technology; and Telecom Media IT

**Iceland:** OMX All Shares

**Norway:** Banks; Basic Materials; Chemicals; Consumer Goods; Food Beverages; Food Producers; Industrials; Industrials, Metals, and Mines; Insurance; Oil and Gas; Real Estate; Telecom, Media, and IT; and Farming and Fishing

**Sweden**: Banks; Basic Materials; Construction Materials; Consumer Goods; Health Care; Industrial Metals and Mines; Insurance; Oil and Gas Producers; Real Estate; Retail; Speciality Finance; Technology, Hardware, and Equipment

**Nordic Sovereigns:** Iceland 10-Year Government Benchmark Bid Yield Index; Sweden 10-Year Benchmark Government Bond Index; Finland 10-Year Benchmark Government Bond Index; Norway10-Year Benchmark Government Bond Index; Denmark 10-Year Benchmark Government Bond Index

**Controls:** Sweden DS Market; Denmark DS Market; Finland DS Market; Norway DS Market; Russia MICEX; GSCI Four Energy Commodity, Industrial Metals, Precious Metals, and Agriculture indices; Citibank Global Bond Index; MSCI World Real Estate Index; HFRX Global Hedge Fund Index; JPM Trade-weighted USD REER Index; US Economic Policy Uncertainty Index; Citi Short- and Long-Term Macro Risk indices; Citi Global Economic Surprise Index; CBOE S&P500 Skew, S&P500 VIX, and OVX indices; Merrill Lynch MOVE Index; and ASR Global Equity Risk Premium Index

*Direct/indirect trade, banking, and investment ties*

**Trade:** IMF Direction of Trade Statistics (DOTS), Total Trade, as of 2014Q2

**Banking:** BIS Consolidated Banking Statistics, International Claims over All Sectors, as of 2015Q2

**Investment:** IMF Coordinated Portfolio Investment Survey (CPIS), Net Inward Equity Investment and Net Inward Position in Debt Instruments, as of 2015Q2; IMF Coordinated Direct Investment Survey (CDIS), Net Inward Foreign Direct Investment, as of 2015Q2

*Concurrent sovereign and financial sector credit risk*

**Sovereigns:** 5-year single-name CDS spreads on senior debt for Denmark, Finland, Iceland, Norway, and Sweden

**Financials:** 5-year single-name CDS spreads on senior debt for Danske Bank, DnB, Nordea, and Sampo Bank

*Implicit sovereign guarantee of financial sectors*

Moody's CreditEdge 5-year fair value CDS and aggregate CDS spreads for Dankse Bank, DnB, and Nordea

Notes on implicit financial linkages:

- All sector-level bond and equity indices were sourced from Datastream. High-quality sector-level equity indices were not available for Iceland and so the OMX All Shares Index was used as a proxy to measure implied sector-to-sector financial linkages. Data availability also precluded including Iceland in analysis of cross-border banking and insurance linkages. Insurance sector equity indices of sufficient length were not available for Brazil, Turkey, or Russia. Publically available equity price data on Swedish insurers was also limited, with consituents comprised of at most three insurers depending on the time period, and thus linkages infered for Swedish insurers should be viewed cautiously.
- The motivation for the choice of controls in each model specification are as follows: 1) Implicit financial linkages (country-level): minimize influence of global changes in investor risk appetite for equities and commodities, 2) Implicit financial linkages (sector-level): minimize influence of global changes in investor risk appetite for equities and commodities; minimize influence of country-specific changes in investor risk appetite for equities; minimize influence of country-specific broad equity prices trends; minimize influence of idosyncratic tends in behavior of global factors.
- The endogenous variables of each VAR specification were ordered by descending degree of percieved exogenity – global factors were included first, when applicable, and then equity and bond indices. The choice of ordering of global factors was determined by the authors' subjective perception of these variables' degree of exogeneity; alternative orderings had no discernable impact on results. In specficiations where global factors were treated as endogenous, the following ordering was used: Citi Short- and Long-Term Macro Risk indices;

Citi Global Economic Surprise Index; US Economic Policy Uncertainty Index; JPM Trade-weighted USD REER Index; GSCI Four Energy Commodity, Industrial Metals, Precious Metals, and Agriculture indices; Citibank Global Bond Index; MSCI World Real Estate Index; HFRX Global Hedge Fund Index. Country and sector bond and equity indices were ordered in terms of total market value, from largest to smallest.

Other notes:

- 5-year CDS spread data for Sampo Bank begins in 2012, thus all bivariate copula modeling between Sampo Bank and other entities reflects only the period of 2012 onward. 5-year CDS spread data was not available for the Iceland Housing Finance Fund (HFF), so yields on long-dated HHF bonds were used as a proxy. Entity-level 5-year fair value CDS spreads and aggregate CDS spreads are pre-computed financial variables which are sourced directly from Moody's CreditEdge. In instances where fair-value CDS spread data was missing, predictive means matching was used to impute values (see van Buuren and Groothuis-Oudshoorn, 2011).
- DS = Datastream; CDS = credit default swap; other acronymes are considered common knowledge and not explictly defined.

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