INTERNATIONAL MONETARY FUND

IMF Country Report No. 22/337

# IRELAND

## FINANCIAL SECTOR ASSESSMENT PROGRAM

November 2022

## TECHNICAL NOTE ON STRESS TESTING AND SYSTEMIC RISK ANALYSIS

This paper on Ireland was prepared by a staff team of the International Monetary Fund as background documentation for the periodic consultation with the member country. It is based on the information available at the time it was completed on November 2, 2022.

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November 2, 2022

# TECHNICAL NOTE

## STRESS TESTING AND SYSTEMIC RISK ANALYSIS

Prepared By

**Monetary and Capital Markets Department**

This Technical Note was prepared by IMF staff in the context of the Financial Sector Assessment Program in Ireland. It contains technical analysis and detailed information underpinning the FSAP's findings and recommendations. Further information on the FSAP can be found at http://www.imf.org/external/np/fsap/fssa.aspx

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# Glossary

| | |
|---|---|
| AC | Amortized Cost |
| AE | Asset Encumbrance |
| ASF | Available Stable Funding |
| AUM | Assets Under Management |
| BIS | Bank for International Settlements |
| BMA | Bayesian Model Averaging |
| BPS | Basis Points |
| BSCR | Basic Solvency Capital Requirement |
| CAR | Capital adequacy ratio |
| CBI | Central Bank of Ireland |
| CCB | Capital Conservation Buffer |
| CCyB | Countercyclical Buffer |
| CET1 | Core Equity Tier 1 |
| CFLST | Cash Flow-based Liquidity Stress Test |
| COREP | Common Reporting Framework |
| CRE | Commercial Real Estate |
| CRR | Capital Requirements Regulation (EU) |
| CSO | Central Statistics Office |
| EA | Euro Area |
| EAD | Exposure at default |
| EBA | European Banking Authority |
| ECB | European Central Bank |
| EDF | Expected Default Frequency |
| EIOPA | European Insurance and Occupational Pensions Authority |
| EMIR | European Markets and Infrastructure Regulation |
| EOF | Eligible Own Funds |
| EU | European Union |
| FINREP | Financial Reporting Framework |
| FSAP | Financial Sector Assessment Program |

| | |
|---|---|
| FSB | Financial Stability Board |
| FV | Fair Value |
| FVC | Financial Vehicle Corporations |
| FVOCI | Fair Value through Other Comprehensive Income |
| FVTPL | Fair Value through Profit and Loss |
| FX | Foreign Exchange |
| GAAP | Generally Accepted Accounting Principles |
| GDP | Gross domestic product |
| GFC | Global Financial Crisis |
| GFM | Global Macro-financial Model |
| HQLA | High-quality liquid assets |
| IF | Investment Funds |
| IIFA | International Investment Fund Association |
| IMF | International Monetary Fund |
| IRB | Internal ratings-based (approach) |
| IRRBB | Interest Rate Risk in the Banking Book |
| LCR | Liquidity Coverage Ratio |
| LGD | Loss Given default |
| LSI | Less Significant Institution |
| LTG | Long-Term Guarantee |
| MBF | Market-based Finance |
| MFI | Monetary Financial Institutions |
| MCR | Minimum Capital Requirement |
| MMF | Money Market Funds |
| NBFI | Non-Bank Financial Institution |
| NFC | Non-Financial Corporate |
| NGFS | Network for Greening the Financial System |
| NII | Net Interest Income |
| NIM | Net Interest Margin |
| NPL | Nonperforming Loan |

| | |
|---|---|
| NSFR | Net-Stable Funding Ratio |
| OFI | Other Financial Institution |
| ORSA | Own Risk and Solvency Assessment |
| OSII | Other Systemically Important Institution |
| PEPP | Pandemic Emergency Purchase Program |
| PD | Probability of Default |
| PiT | Point-in-Time |
| QRT | Quantitative Reporting Template |
| RAM | Risk Assessment Matrix |
| REIT | Real Estate Investment Trust |
| RFR | Risk-Free Rate |
| ROW | Rest of the World |
| RSF | Required Stable Funding |
| RWA | Risk-Weighted Assets |
| RWD | Risk Weight Density |
| SCR | Solvency Capital Requirement |
| SI | Significant Institution |
| SMEs | Small- and Medium-Sized Enterprises |
| SPE | Special Purpose Entity |
| SPV | Special Purpose Vehicle |
| ST | Stress Test |
| STE | Short-Term Exercise |
| STeM | Stress Testing Matrix |
| TD | Top-Down (stress test) |
| TN | Technical Note |
| TTC | Through-The-Cycle |
| UCITS | Undertaking for the Collective Investment in Transferable Securities |
| U.K. | United Kingdom |
| U.S. | United States |
| VA | Volatility Adjustment |

| | |
|---|---|
| WEO | World Economic Outlook |

# EXECUTIVE SUMMARY[1]

**The FSAP took place against the background of a fast-evolving financial sector in Ireland and heightened uncertainty in the global economy.** The Irish financial landscape has undergone significant changes since the global financial crisis with increasing divergence between an innovative and fast-growing international finance sector and the retail banking sector that has been consolidating and faces post-GFC operating restrictions and increasing competition from non-bank players. In the meantime, both the global pandemic and Brexit have left uneven marks across the economy, while there are risks from the unwinding of public support that has softened COVID-19 shock's impact on the economy. Going forward, various ongoing and emerging risks, such as persistent inflationary pressures, fueled by supply bottlenecks, and the war in Ukraine, may impede recovery, and magnify vulnerabilities to downside shocks.

**The banking sector weathered the pandemic with strong fundamentals, although pockets of vulnerabilities remain.** While the pandemic was a significant shock to the economy, banks continued to maintain strong capital and liquidity buffers. Going forward, profitability challenges and long-term mortgage arrears by retail banks, high exposure to the CRE segment, and significant off-balance sheet exposures of large international banks may expose banks to both domestic and cross-border challenges.

**Irish insurers also proved to be resilient during the COVID-19 pandemic, although the full effects have yet to be seen.** Primary drivers of solvency ratios have been financial market valuations and interest rate movements affecting insurers' investment portfolios and liability valuations. COVID-19 has led to spikes in claims on some non-life lines of business, most notably business interruption and event cancellation, which was partially offset by reductions in motor and liability claims. Life insurance claims for Irish exposures have been muted, reflecting the age profile of Covid deaths, but reinsurers with U.S. mortality exposure were more materially affected. Uncertainties remain as to how the pandemic and its aftermath will further impact the sector, particularly regarding: further market volatility and potential changes in investor sentiment, economic downside risks, "long COVID" effects on mortality and morbidity, and the impact of the pandemic on future lapse rates and premium income.

**The FSAP conducted a comprehensive set of stress tests and risk analyses to assess the resilience and vulnerabilities of the banking, insurance, and investment fund sectors in Ireland.** The banking analysis used scenario-based stress test to assess the resilience of retail and large international banks, while applying a streamlined sensitivity test on other international banks, which are all LSIs. The bank risk analysis also covered liquidity stress tests and contagion analysis, assessing domestic and cross-border interbank exposures, as well as domestic and cross-border cross-sectoral interlinkages between banks and non-bank financial institutions. The banking analysis

[1] This Technical Note (TN) was prepared by Xiaodan Ding, Tara Iyer (both MCM), Anna Shabunina (EUR), and Timo Broszeit (Expert). The team is grateful to the Central Bank of Ireland (CBI) and the European Central Bank (ECB) for their excellent collaboration in this exercise.

included an assessment of climate change-related risks (both transition and physical) facing the sector. The insurance stress tests covered solvency, liquidity, and climate physical and transition risks. The analyses used both top down and bottom-up methodologies, with input from the (re)insurers. The stress testing analysis for investment funds assessed the liquidity resilience of the investment fund sector, focusing on potential liquidity mismatches when faced with severe, but plausible, redemption shocks.

**The scenario-based bank solvency stress test confirmed the sector's resilience to severe macroeconomic shocks, while revealing pockets of vulnerabilities as the economy is exiting from pandemic-related policy support.**

- The baseline scenario confirms banks' strong capital positions, with further capital accumulation. Both retail and large international banks would see their fully loaded CET1 ratios trending upwards, from 16.4 percent to 17.8 percent for retail banks and from 19.9 percent to 27.9 percent for large international banks, with no banks falling below the hurdle rates.[2] The slower accumulation of capital for retail banks, relative to large international banks, reflects their lower pre-provision income, driven by their limited income generation capacity.

- The adverse scenario confirms banks' resilience to severe yet plausible adverse shocks. Although the adverse scenario produced a significant impact on bank capital ratios, no bank saw its capital ratios fall below the hurdle rates, owing to the high initial capital positions of both retail and large international banks, as well as the high pre-provision income of the large international banks. On aggregate, the fully loaded CET1 ratio declines by about 6.7 percentage points for retail banks and 0.4 percentage points for large international banks by the 5th year. When looking at the trough, however, capital depletion can reach 7.2 and 2.3 percentage points for retail and large international banks, respectively. Among risk factors considered[3], credit risk provisioning is by far the largest contributor to the decline in capital ratios, with the cumulative effect amounting to 7.4 percentage points over five years.

**The bank stress test results paint a slightly more adverse picture when assuming an additional impact from the unwinding of pandemic support policies.** To address the uncertainties surrounding the impact on portfolios that have benefitted from payment breaks, and broad policy support during the pandemic, the FSAP carried out a separate sensitivity analysis. The analysis assumed that 50 percent of loans with either active or expired moratoria deteriorate from stage one and two assets into stage three assets, which resulted in one retail bank's CET1 and Tier 1 ratio

[2] Thresholds considered are: (i) CET1: 4.5 percent plus O-SII buffer; (ii) Tier 1: 6.0 percent plus O-SII buffers; and (iii) CAR: 8 percent plus O-SII buffer. Capital conservation buffer is allowed to be used under the adverse scenario.

[3] In addition to credit risks, the solvency stress test also covered sovereign risk, interest rate risk and other market risk, although their impacts were identified to be smaller than credit risks. Detailed information can be found under top-down solvency stress test of banks.

falling below the hurdle rates under the adverse scenario, with the capital shortfall against the CET1 hurdle rate amounting to 0.2 percent of GDP.

**The LCR-based stress test suggests that banks are resilient to adverse liquidity conditions.** On aggregate, banks saw a meaningful decline of their LCR ratios across stress scenarios, with retail banks experiencing a larger impact under the retail scenario and international banks facing higher stress under the wholesale scenario. All banks are able to withstand the most severe shock within the 30-day window, underpinned by a high initial level of liquidity buffers, which rose further during the pandemic.

**The bank cashflow-based stress test indicates potential liquidity gaps when extending the analysis beyond 30-days.** Banks are broadly resilient against liquidity outflows thanks to their existing counterbalancing capacities in the short-term. However, their liquidity position becomes weaker beyond three months owing to a maturity mismatch characterized by more frontloaded cash outflows and backloaded cash inflows. Large international banks are more prone to liquidity shortfalls even in the short-term, due to their high share of wholesale funding[4] and larger off-balance sheet exposures, which highlights the importance of regular monitoring of large off-balance sheet exposures.[5,6]

**Both the LCR and cashflow-based stress tests focusing on major foreign currencies reveal some vulnerabilities to U.S. dollar and U.K. Sterling denominated outflows.** The same LCR and cashflow-based exercises were applied to significant foreign currencies of the banks, even though there is no regulatory minimum currency-specific liquidity requirement at present. The results indicate vulnerabilities across currencies, particularly for international banks in U.S. dollars. This can be explained by various factors, such as weaker initial positions, non-trivial off-balance sheet exposures,[7] as well as high reliance of international subsidiaries on foreign currency backstop from their foreign parents.

**The interconnectedness analysis, which covers interbank, bank-NBFI and cross-border contagion risks, identified significant linkages of the large international banks with cross-border banks and NBFIs.** While interbank linkages appear to be muted both for the domestic and the cross-border interbank market, the network results points to a high degree of connectivity

[4] About 40 percent of the wholesale funding for large international banks are intra-group funding.

[5] Off-balance sheet exposure in the form of contingent liabilities amount to €108 billion or 40 percent of total contractual outflows within 12 months for large international banks.

[6] One component of the off-balance sheet items includes the issuance of Insurance Letters of Credit ("ILOCs"), which is the key business line of the one of the large international banks and is similar to traditional trade finance letters of credit. It is approximately 80 percent collateralized on average and therefore is considered by the CBI to pose less liquidity risk relative to the other components of committed facilities such as credit lines.

[7] Off-balance sheet exposures consist of mainly credit lines and FX-related derivative transactions. In line with EBA reporting instructions, inflows/outflows in the LCR of significant foreign currencies include principal exchange on FX derivative contract whereas the aggregate LCR reports FX derivative flows on a net basis. Such differences may contribute to a lower initial level of LCR for individual foreign currencies compared to the aggregate LCR.

between large international banks and NBFIs, accounting for 45 percent of the total exposures of the large international banks. The inward spillover risks of the large international banks become much more pronounced when adding the top NBFIs by exposure size into the network, suggesting larger vulnerability of large international banks to shocks from NBFIs

**Banking sector climate risk analysis studied the relevance of both transition and physical risks facing the banking sector.** For transition risks, the FSAP first carried out a single factor analysis simulating carbon-tax shocks, which revealed a meaningful impact on Irish corporates, with energy-intensive sectors experiencing the largest PD increases. Then, the direct impact on the banking sector was studied to gauge the solvency implications of higher default frequencies driven by the carbon-tax shock, which leads to notable CET1 capital depletion of up to 3.5 percentage points (or 15 percent of existing CET1 capital) under the most severe scenario. The evolution of the impact over the risk horizon also confirms important non-linear effects of carbon taxation on corporate financial health, which warrants a speedy transitioning to greener technology to ensure business viability for carbon-intensive sectors.

**The physical risk analysis showed important linkages between domestic physical hazards and bank financial health going forward.** Simulating a severe flooding event and applying the same methodology used in the scenario-based stress test, the analysis produced a non-trivial depletion of bank CET1 capital (around 2.4 percentage points) at trough, before recovering to close to pre-shock levels. This non-trivial depletion suggests the need for enhanced monitoring of banking sector exposure to climate sensitive sectors and precautionary action (e.g., ensure loans are secured with high quality collateral or insured against physical damage) to mitigate climate-related risks to financial stability.

**The insurance sector ST analysis focused on market and credit risks and showed an overall broad resilience of insurers against the adverse scenario.** The ST analysis followed a top-down approach and covered 25 (re)insurers, or more than 70 percent of the market in each sub-sector (life, non-life, and reinsurance). The vast majority of insurers remain well-capitalized, but one insurer would not be able to meet the solvency capital requirement (SCR) following the stress, taking no reactive management actions into account—although the capital shortfall would amount to less than €10 million. Non-life insurers are affected most from the shocks, while several life insurers in the sample benefit from a higher Volatility Adjustment (VA). The coverage of the SCR decreases by 13 percentage points for the median non-life insurer. The median post-stress SCR ratio in the life sector is 6 percentage points higher than pre-stress—however, this overstates the impact on the sector, as the SCR ratio declines for the majority of life insurers.

**Most of the decline in asset values for insurers stems from higher corporate and sovereign spreads, while equity and property shocks have a more muted impact.** Higher interest rates and the depreciation of the Euro offset other adverse shocks as most insurers in the sample have a slight excess of foreign-denominated assets compared to their liabilities, resulting in a net valuation gain. These combined declines in asset values cannot be fully compensated by lower liabilities (mainly due to higher discount rates).

**A liquidity shock is unlikely to have a systemic impact on the insurance sector, in fact, the central bank's bottom-up analysis indicates that results are very much driven by company specifics.** The relatively small sample of only ten insurers does not reveal vulnerabilities at the sector level. On aggregate, the share of liquid assets is relatively high, and the sum of inflows even increases in the adverse scenario (compared to the baseline) as a result of its impact on the direction of derivative-related collateral flows at some firms. This, however, is unlikely to be a sector-wide phenomenon given the limited use of derivatives across the entire market. Additionally, the FSAP's top-down analysis of risks from margin calls for interest rate swaps confirms the low vulnerabilities stemming from this channel, albeit reporting data for other derivative types is incomplete. The results underline the importance for the supervisor to understand liquidity flows and liquidity risk management practices, which also needs to include the insurance group structures.

**The insurance sector is exposed to climate risks mainly through its non-life underwriting.** The FSAP analysis indicates that even large natural catastrophes, when seen in isolation, would likely not have a pronounced impact on solvency levels. Domestically, the most important natural perils are windstorms, floods, and freezes, but many Irish (re)insurers underwrite business globally, exposing them also to other types of international climate-related risks, such as U.S. hurricanes or wildfires. The impact of a major windstorm in Ireland and the United Kingdom would be seen mostly on profits, and SCR ratios would decline, on average, by less than 3 percentage points. However, modeling challenges regarding physical risks persist, and Irish insurers rely heavily on intra-group reinsurance.

**The impact of transition risk overall is manageable, but larger for life insurers, mainly due to a comparably riskier asset allocation[8]—however, results come with considerable modelling uncertainties.** Transition risks were analyzed via a top-down approach, assuming that the effect of the NGFS scenario of an orderly 1.5 degree increase until 2050, is priced by investors instantaneously. A lower valuation could be expected particularly for equity investments, while bond valuations and default rates are expected to be more stable. In absolute amounts, asset values could decline by around €7 billion (or 2.3 percent of total investment assets).

**The stress tests for investment funds indicate that the sector is generally resilient to redemption shocks, but pockets of vulnerability exist.** Resilience is measured here in terms of ability to meet large redemption requests in a stressed market, without the use of liquidity management tools or the sale of less liquid assets. Most fixed-income investment funds in Ireland, which are the focus of the liquidity stress test, would be able to weather severe but plausible redemption shocks under a wide range of shock scenarios. However, certain categories of funds, including high-yield bond funds and emerging-market focused fixed-income funds, which are more susceptible to liquidity mismatch, may be less resilient to severe market stress.

**Ireland has made good progress in implementing the recommendations from the 2016 FSAP on stress-testing of investment funds, but some work remains.** The central bank has made

[8] Which in turn is largely due to the importance of unit-linked business and the type of funds chosen by customers.

significant strides in building a stress-testing framework for funds based on recommendations in the 2016 FSAP, but the model remains a work-in-progress. Given the size, accelerating growth, and systemic importance of the investment fund sector, the central bank should reinforce its efforts in completing the model and simulations and conducting regular stress tests of Irish-domiciled funds.

**Table 1. Ireland: Recommendations**

| Recommendation | Addressee | Timing* | Priority** |
|---|---|---|---|
| **Banking – Risk Analysis** | | | |
| 1. Continue to closely monitor portfolios that benefited from pandemic payment breaks and broader policy support, including other forms of forbearance measures to ensure banking sector resilience with the phase-out of pandemic supportive policies. (¶3, ¶48) | CBI | C | H |
| 2. Continue to regularly perform liquidity stress tests by individual bank and significant foreign currencies to identify and provide early warning signals to banks with liquidity gaps over short and long-term horizons. (¶66, ¶76) | CBI | C | H |
| 3. Continue to regularly monitor large off-balance sheet exposures (via credit and liquidity facilities). Provide early warning signals to banks with associated liquidity risks. (¶58, ¶75) | CBI | C | H |
| 4. Expand data collection on interbank and bank-NBFI exposures at entity level (in addition to existing large exposure dataset) to complete interbank and bank-NBFI network analysis. (¶85, ¶93) | CBI | MT | H |
| 5. Analyze the riskiness of banks-NBFI linkages and their direct and indirect impact on the banking sector, with a particular focus on international banks. (¶81, ¶94) | CBI | ST | H |
| 6. Initiate data collection on banking exposures to both transition and physical climate risks, such as bank specific carbon exposures as well as leveraging geospatial data to assess exposures to corporate and mortgage borrowers facing high flooding risks, to allow in-depth analysis on climate related risks to financial stability. (¶110, ¶111, ¶112, ¶120) | CBI | MT | M |
| 7. Develop models to properly assess the impact of transition and physical climate risks on the banking sector. (¶110, ¶111, ¶112, ¶120) | CBI | MT | M |
| **Insurance – Oversight** | | | |

| Table 1. Ireland: Recommendations (Concluded) | | | |
|---|---|---|---|
| 8. Continue strengthening the supervision of intra-group transactions and concentrations, with a focus on post-Brexit group structures, recovery planning, and liquidity risk management. (¶142, ¶152) | CBI | ST | H |
| **Insurance – Risk Analysis** | | | |
| 9. Conduct regular top-down solvency stress tests of insurers, also to validate scenarios and assumptions used by insurers in their recovery plans. (¶138) | CBI | ST | M |
| 10. Monitor protection gaps at regional and local level, including price dynamics and the cost of insurance, and consider options to narrow protection gaps wherever material, particularly with respect to flood risks. (¶155) | DoF, CBI | MT | M |
| **Investment Fund – Risk Analysis** | | | |
| 11. Complete the internal stress-testing framework for investment funds and money market funds. (¶191) | CBI | MT | H |
| 12. Determine the common asset holdings of investment funds, banks, and relevant non-banks. (¶192) | CBI, CSO | MT | M |
| 13. As part of the ongoing policy development on IF liquidity risk management and taking into account developments at the EU and international level, review the use of liquidity management tools by IFs, with a particular focus on funds that have demonstrated liquidity challenges in recent periods of stress. (¶193) | CBI | ST | H |

* C = Continuous; I = Immediate (within one year); ST = Short Term (within 1-3 years); MT = Medium Term (within 3-5 years).

** H = High; M = Medium; L = Low.

# INTRODUCTION[9]

**1. The Irish banking landscape has undergone significant changes since the global financial crisis** (Figure 1). In contrast with the large and growing presence of market-based finance, which has grown rapidly since the GFC[10], the banking sector assets have contracted from 780 percent in 2009 to about 200 percent of GDP in 2021.[11] After the GFC, the domestic banking system went through a long period of a necessary deleveraging and restructuring, with the government rescue resulting in the state becoming a majority shareholder in several banks. Multiple banks left the market and there was further consolidation. As a result, the sector is highly concentrated with the two largest retail banks, both of which are partially state-owned,[12] holding about one-third of system assets. At the time of the government bailout restrictions were placed on bailed-out banks, which include caps on executive pay, a penal tax on all employee bonuses (89 percent), and a bank levy to reduce the impact of large loss carryforwards on tax revenue. The announced withdrawal of the two foreign retail banks is expected to increase concentration even further, and acquisition of their assets by the remaining retail banks may increase the systemic importance of those banks. In the meantime, growing competition from nonbank intermediaries, particularly from nonbank mortgage lenders, SME loan providers and other digital competitors, may further compress banks' market share and profit margin. On the flip side, the declining asset trend has been more than offset since 2019 by the entrance of large international banks due to Brexit, further accelerating the transformation of the Irish banking system.

**2. Irish banks vary considerably in their business models and market orientation.** For analytical purposes, authorities group banks into three main categories based on differences in market size and orientation, balance sheet composition, as well as systemic importance (Table 2).

- **Retail banks** mainly operate in the domestic economy. With total assets of €317 billion at Q2 2021, they attract household and corporate deposits and lend mostly domestically. They account for more than 90 percent of lending to households in the form of mortgages and consumer credit. Four of the retail banks are supervised as Significant Institutions (SIs) by the European Central Bank's (ECB) Single Supervisory Mechanism, and one retail bank is supervised directly as a Less Significant Institution (LSI) by the central bank. Retail banks hold 40 percent of total bank assets. Two of the retail banks are foreign owned. Loans account for 60 percent and debt securities account for 13 percent of their total assets.

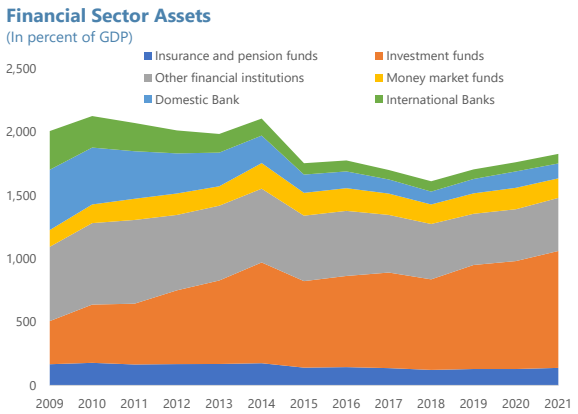
[9] All figures presented in the report, unless otherwise indicated, are based on a cut-off date of mid-2021.

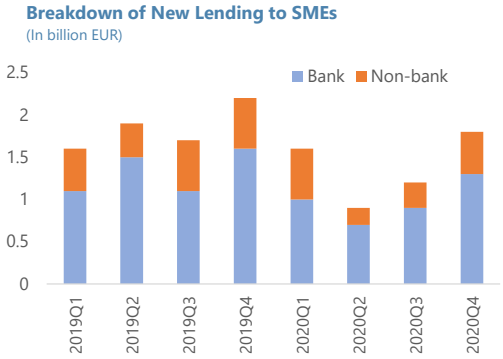
[10] Total assets of the funds sector have grown from 4.7 times GDP in 2009 to more than ten times in 2021.

[11] The winding up banks, purchase of 'bad assets' from the banks by the National Asset Management Agency (NAMA) (completed in 2011), conditions on the sale of assets as part of Ireland's program of external assistance were all mechanisms that contributed to the shrinking of banking sector assets over this period.

[12] Current state holdings: AIB 72%; BOI 4% (as of May 2022).

**Figure 1. Ireland: Financial Sector Overview**




Source: CBI.

- **Large international banks** are foreign-owned and mostly engage in cross-border activities with insignificant domestic exposures. Their total assets amount to €276 billion and they rely mostly on wholesale non-resident and intra-group funding. They focus on activities for their group (e.g., custodian services, trade finance, investment banking) and generally do not engage in retail business. These banks account for 70 percent of the banking system's total non-resident deposits and about 70 percent of lending to non-residents. Out of a total of three entities, two are subsidiaries of US-based entities and one is a subsidiary of U.K.-based entities. All three entities are considered as SIs by the ECB.

- **Other international banks** comprise nine foreign owned Less Significant Institutions (LSIs)[13] that are foreign market oriented with diversified and heterogenous business models. With total assets at €62.5 billion, this segment is established in Ireland mostly to have an EU presence to support their global franchise clients. Core business lines in this segment include secured and non-secured lending, merchant payment services, fixed income and equity financing, commodity derivatives, finance, and operating leases to end users of corporate products (captive financial institutions), and custodian and asset management services. Some banks within this segment continue to undergo business model changes to accommodate re-domiciled business lines from United Kingdom due to Brexit, and therefore are expected to grow over short- to medium-term.

[13] Four of these LSIs were included in the stress test sample, while the rest were excluded due to data limitations, small asset size or unique business models (captive or custodian banks, etc.). Two of the excluded entities are also exiting the market and undergoing significant business restructuring, due to recent changes in the business strategy of their parent entities.

**Table 2. Ireland: The Banking System**

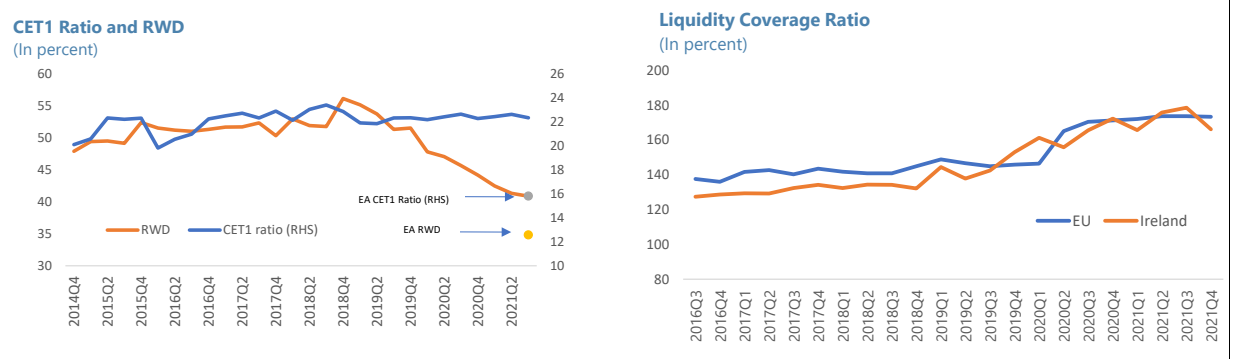
| Bank Number | CBI Classification | ECB Classification | Stress Testing Scope | Asset as of Q2 2021 (Mil. EUR) | Asset Share of Group (%) | Asset Share of Banking System (%) |
|---|---|---|---|---|---|---|
| 1 | Retail Bank | SI | Scenario-based | 122,867 | 19.8 | 15.7 |
| 2 | Retail Bank | SI | Scenario-based | 129,095 | 20.8 | 16.5 |
| 3 | Retail Bank | LSI | Scenario-based | 21,503 | 3.5 | 2.7 |
| 4 | Retail Bank | SI | Scenario-based | 30,634 | 4.9 | 3.9 |
| 5 | Retail Bank | SI | Scenario-based | 12,272 | 2.0 | 1.6 |
| 6 | Large International Bank | SI | Scenario-based | 69,489 | 11.2 | 8.9 |
| 7 | Large International Bank | SI | Scenario-based | 141,945 | 22.8 | 18.1 |
| 8 | Large International Bank | SI | Scenario-based | 64,889 | 10.4 | 8.3 |
| 9 | Other International Bank | LSI | Sensitivity-analysis | 9,236 | 1.5 | 1.2 |
| 10 | Other International Bank | LSI | Sensitivity-analysis | 5,093 | 0.8 | 0.7 |
| 11 | Other International Bank | LSI | Sensitivity-analysis | 3,219 | 0.5 | 0.4 |
| 12 | Other International Bank | LSI | Sensitivity-analysis | 11,503 | 1.9 | 1.5 |
| Total asset of sample banks | | | | 621,745 | 100.0 | 79.5 |
| Total asset of the banking system | | | | 782,083 | | |

Source: Fitch Analytics and IMF staff estimates.

Source: Fitch, Haver, CBI and IMF staff.

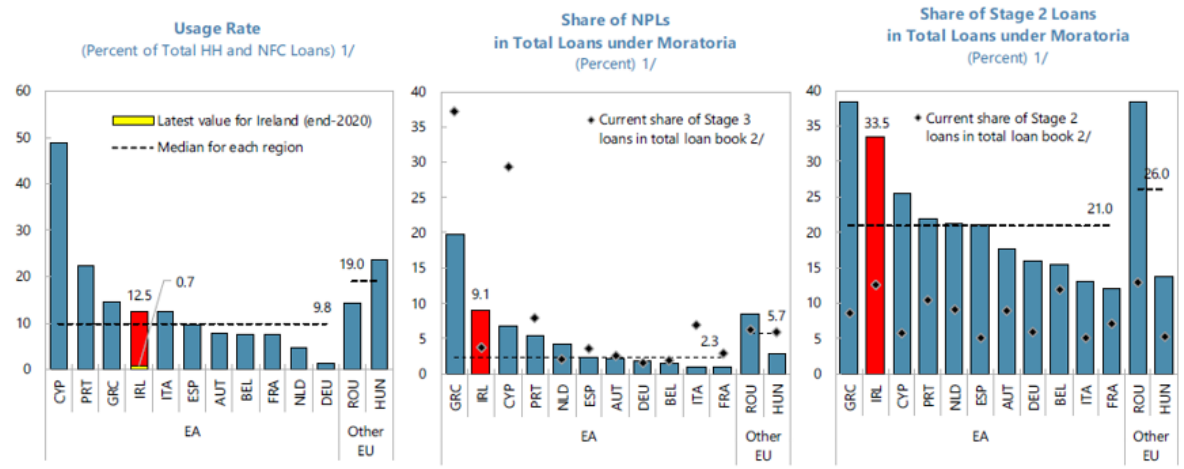
**3. The Irish banking system has weathered the pandemic thus far on the back of strong buffers and supportive policies, although there are risks associated with the withdrawal of public pandemic support** (Figures 2, 3). The banking sector entered the pandemic on a strong footing, with an aggregate CET1 ratio of 22 percent in the beginning of 2020, well above the EA average at 15 percent. The impact of the pandemic on banks' capital and liquidity position has also been broadly contained so far, as CET1 ratio sustained its level at around 22 percent and liquidity coverage ratio sat comfortably above the 100-threshold at 178 percent as of Q3-2021, thanks to the unprecedented payment relief and public liquidity supports which expanded the scope of banks' collateral eligible for liquidity facility and boosted customer deposits. On the flip side, although payment breaks, among other supportive policies, have been largely phased out later 2021, the full impact on bank asset quality and financial stability has yet to be seen as the transmission of downside risks to banks' balance sheet takes time. Further, banks are encouraged to work with distressed borrowers to restructure or re-negotiate loans so that outright default could be prevented. Nevertheless, the high take-up rates of payment break on sectors severely impacted by the pandemic and borrowers facing pre-pandemic payment difficulties may lead to rising non-performing loans (NPLs) over the medium term, partly unwinding recent reductions in NPLs.

**Figure 2. Ireland: Bank Liquidity and Capital Position**




Sources: ECB Statistical Data Warehouse and IMF staff calculations.
Notes: 1. "CET 1 Ratio" reflects traditional (non-fully loaded) measure of CET 1. RWD refers to risk weight density.
2. Data represents total Irish banking sector which is different from sample used in the bank stress test.

**Figure 3. Ireland: COVID-19 Pandemic-Related Payment Relief – Usage Rate and Share of Impaired Loans**

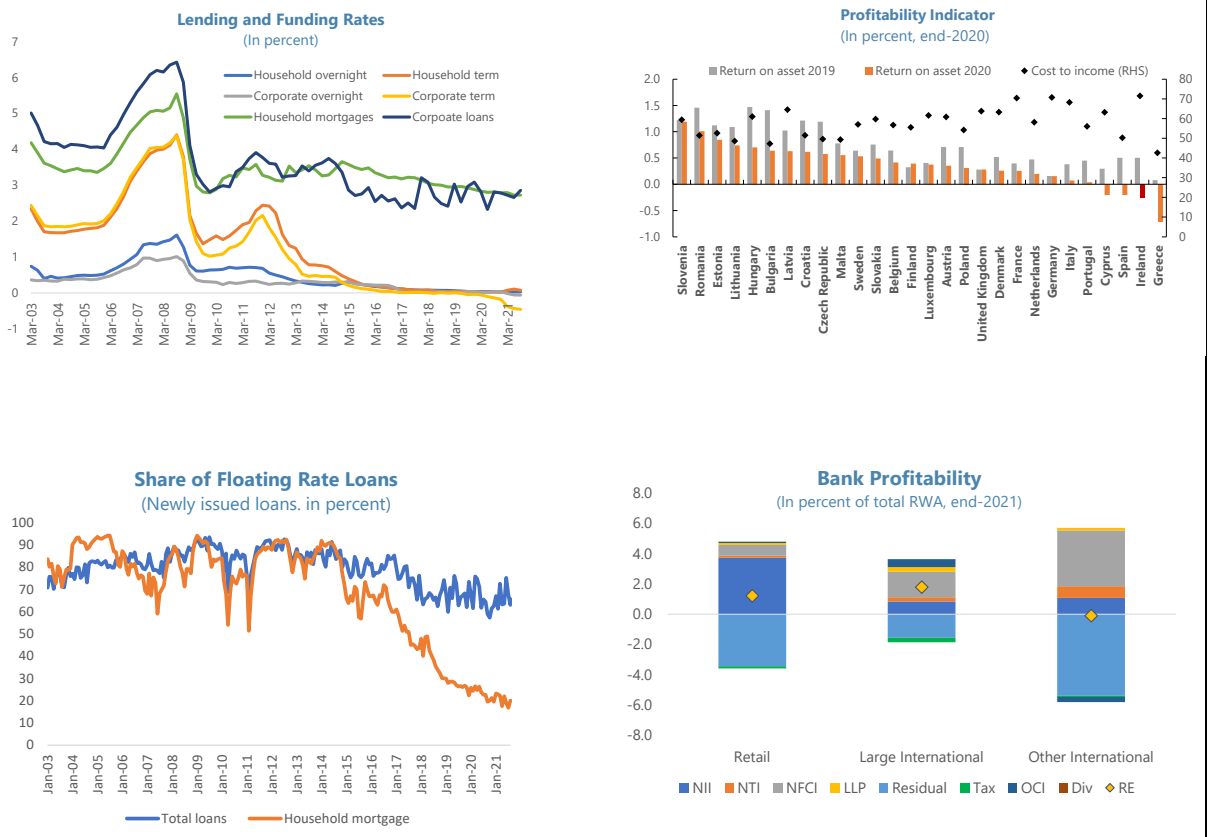



*Sources:* Banking and Payments Federation Ireland; EBA; IMF staff calculations.
1/ based on as of end-June 2020 values.
2/ Under IFRS 9, banks must model expected losses based on historical, current, and forward-looking information, including macroeconomic forecasts. Although it is not necessary for a credit event to occur before an expected credit loss is recognized, a missed payment is taken as an indication of increased risk, triggering a higher provision. At origination, the provision must cover expected loss resulting from possible default within 12 months (Stage 1). If thereafter the bank determines that a material increase in credit risk has occurred, the provision must also cover the lifetime expected loss on the loan (Stage 2). Finally, if credit risk is determined to have increased to the point where the loan is impaired (usually at more than 90 days past due), the provision must add coverage of future accrued interest at amortized cost (Stage 3).

**4. There are also intrinsic risks associated with bank business models.** The mission identified below some structural vulnerabilities which may expose Irish banks to long-term risks:

- *Subdued profitability and high-cost base of banks (Figure 4).* Sound liquidity position of the banks, to certain extent, mirrors the subdued bank lending and the resulting lower profitability. Banks have seen deterioration in their income generation capacity in the run up to the pandemic, primarily driven by low credit demand and prudent lending standards, constrained net interest margin in a low interest environment with rising share of fixed rate new mortgages and high operational costs (Figure 4). Difference in banks business models also contributes to the variation of profitability between groups of banks, with large international banks out-performing retail banks supported by their diverse business lines and income sources, such as those generated from large derivative holdings.

## Figure 4. Ireland: Bank Profitability



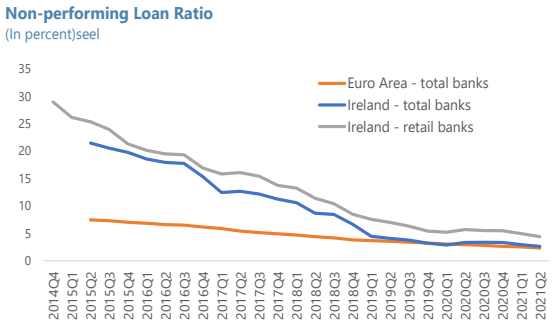

Sources: ECB, CBI and IMF staff calculations. For profitability indicator, data for U.K. is as of December 2019.
Note: NII = net interest income, NTI = net trading income, NFCI = net fees and commission income, LLP = loan loss provision, OCI = other comprehensive income, Div = dividends, RE = flow to retained earning.

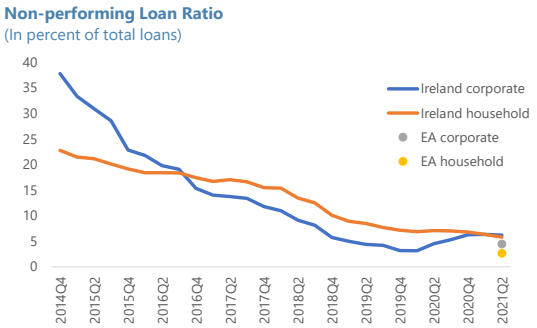
- *Problem assets and legacy portfolios (Figure 5).* The NPL ratio has declined significantly since the global financial crisis from a peak at 25 percent in 2014 to around 2.6 percent at mid-2021[14], driven by improved credit quality as well as NPL disposal in the form of direct sales and securitization. On the other hand, long-term NPL arrears, although declining since the GFC, remain a non-trivial portion of the retail banks' lending book (and a growing portion of non-bank lending books), with over 50 percent of the total NPL in arrears for more than 2 years, mostly in the household mortgage segment. This, combined with other factors such as higher loss-given defaulted modeled for the downturn, leads to persistently higher risk weight densities for the mortgage portfolios than other Euro Area countries.[15]

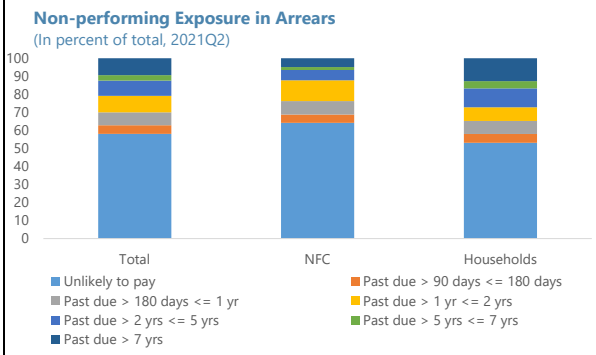
[14] The NPL ratio for retail banks is higher at 4.4 percent as of Q2 2021.

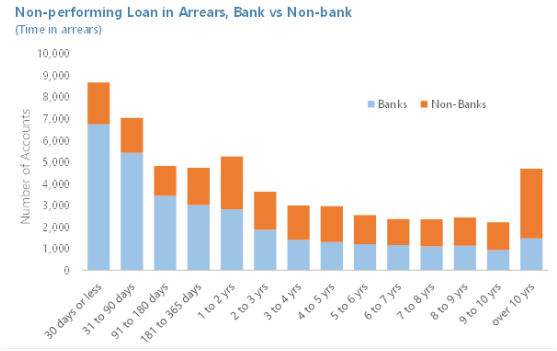
[15] Please refer to this Central Bank Financial Stability Note for more details on drivers of high risk weighted densities for the mortgage portfolios.

## Figure 5. Ireland: Credit Quality of Lending Portfolios



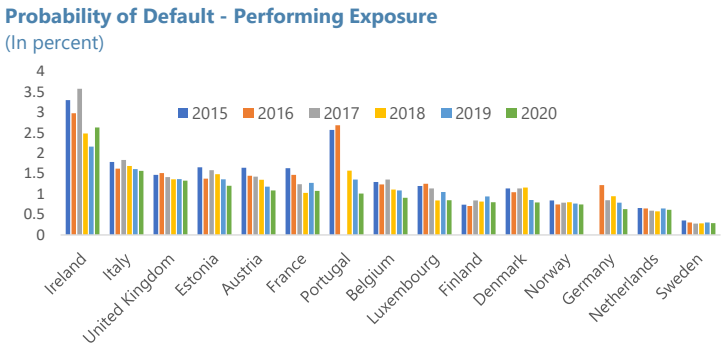
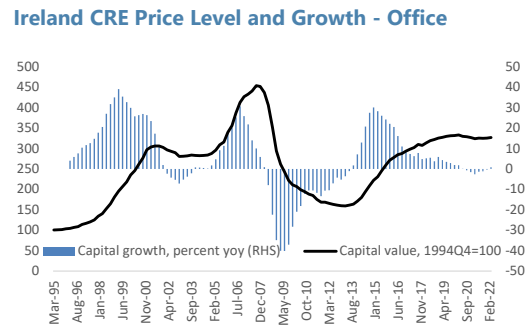



**Figure 5. Ireland: Credit Quality of Lending Portfolios** (Concluded)

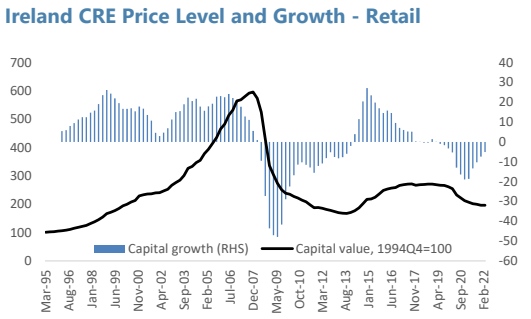

Sources: ECB and CBI and Banking Federation of Ireland.

- *Credit exposure to the CRE market and SMEs (Figure 6).* Among the sectors that were severely hit by the pandemic, Irish banks have meaningful exposure to the real estate activities sector, amounting to around €18 billion and €11 billion in total and domestic CRE market, or equivalently 20 and 30 percent out of total corporate and domestic corporate loans, respectively. Credit quality of the CRE segment also underperform the rest of the corporate segments, with the NPL ratio hovering around 12.2 percent, highest among the sectors classified according to NACE. Similarly, capital values for Irish CRE have weakened considerably since the pandemic, registering a decline of 6 percent at the trough, with the largest impact on retail space at 20 percent given its high sensitivity to the COVID-19 shock. In contrast, the mortgage segment, which constitutes about 40 percent of total bank lending, has seen strong residential housing price growth since the pandemic, reaching to 15 percent in March 2022, albeit with increased downside risks driven by tightened financial condition and household affordability challenges. Similar to the CRE market, SME lending constitutes about 35 percent of total corporate loans and its NPL ratio stands at 8.6 percent as of March 2021, higher than large corporate at 6.5 percent. Going forward, the gradual tapering of supportive policies and the possibility of a prolonged pandemic may exert additional downward pressure and further deteriorate the outlook of the CRE and SME market.

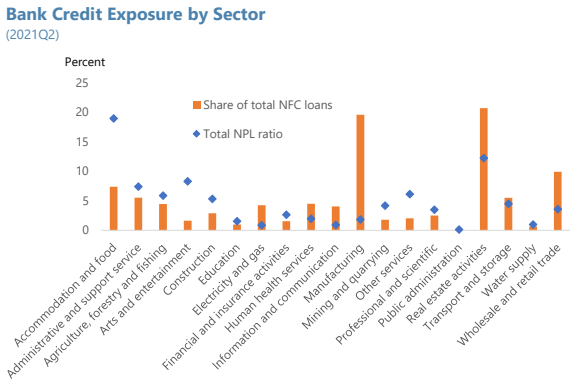
## Figure 6. Credit Quality of the CRE and SME Segments

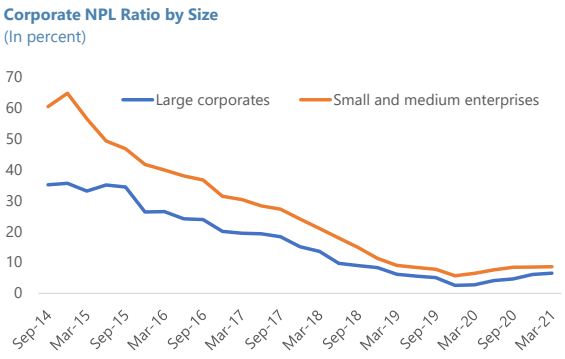



Source: MSCI.




Source: MSCI.




Sources: ECB, CBI and MSCI.

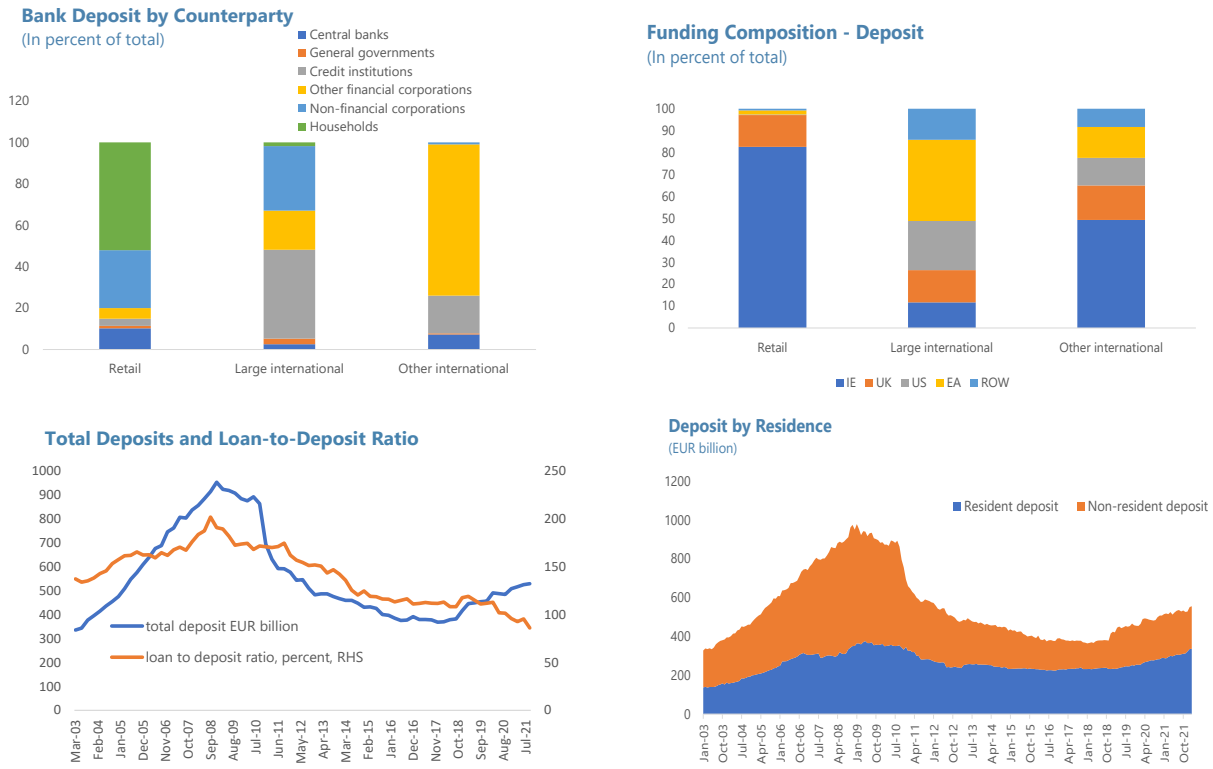
- *Coverage ratio.* The NPL coverage ratio of Irish banks is currently at around 34 percent, below the Euro Area average of 47 percent.[16] While the gap may be explained by the prevalence of collateralized loans and low arrear vintages relative to EU peers, an abrupt reversal in collateral value associated tighter financial conditions may nevertheless trigger a reassessment in the provisioning level on both new and existing NPLs, which could lead to reduction in bank capital.

- *High reliance on wholesale and non-resident funding of international banks (Figure 7).* Due to differences in market orientation, retail banks generally rely on funding from domestic retail deposits whereas international banks obtain bulk of their funding from either parent or large corporates via cross-border wholesale deposits. While funding structures vary, loan-to-deposit ratios are generally trending downwards, and liquidity buffers are high, underpinned by strong

[16] A cross country comparison on historical recovery rates also places Ireland on the lower tail of the distribution, at 11.8 and 21.8 percent for mortgage and CRE segments respectively. See report on the benchmarking of national loan enforcement framework here. According to CBI, A large portion of the sample were excluded in the analysis due to the elongated enforcement process and the significant portion of voluntary sale and surrender of properties, making the sample for analysis less representative of the Irish loan market. As a result, only 45 percent of Irish mortgage cases reported contributed to the benchmark, comparing an EU average of 84 percent.

inflows of consumer deposits. However, the high shares of wholesale funding and non-resident deposits[17] for international banks, which are generally considered more volatile, may pose risks to funding stability in the event of adverse domestic and global confidence shocks.

**Figure 7. Ireland: Bank Funding Conditions**




Note: Figures showing comparisons between banking segments are based only on the sample of banks used in the stress test. Loan to deposit ratio is reported by monetary financial institutions excluding central bank in Ireland.
Sources: ECB, CBI, Haver, and IMF staff calculations.

- *Off-balance sheet exposures.* Off-balance sheet exposures, including both credit lines and guarantees, amount to €108 billion (40 percent of total assets) for large international banks as of mid-2021, significantly higher than domestic retail banks at around €30 billion (10 percent of total assets). Some other international banks are more exposed to off-balance sheet credit risks than others due to their tailored business models to certain clients.[18] An unexpected conversion

[17] Please note that since 2009 Credit Union deposits are also included within the non-resident deposit category.

[18] For example, one of the LSIs acts as an acquiring bank within the payment system by earning fees and commissions on merchant transactions, and therefore may be exposed to significant credit risks from off-balance sheet exposures.

of these off-balance sheet exposures in a downside scenario may exert pressure on credit impairment through an expansion of risky exposures.

**5. Bank exposure to nonbank financial institutions (NBFIs), mostly comprised of financial vehicle corporations and special purpose vehicles (FVCs and SPVs), is concentrated in international banks with a cross-border focus.** The majority of the FVCs are domiciled in Ireland and Italy, with over 400 billion assets in each jurisdiction. Banks often use securitization by FVCs to offload loans and the associated credit risks from their balance sheets to the investors in the FVCs securities. Recently, however, they started to buy back a portion of the FVC securities or to provide direct sponsorship to the FVCs, thus retaining a portion of the risk associated with the securitized loans (NBFI Monitor, 2020).[19] These retained asset-backed securities could be used as eligible instruments to access various types of central bank liquidity facilities. SPVs are being used as investment vehicles, such as private equity, syndicated loans, distressed debt, etc. In addition, the international banks have substantial exposures to FVCs and SPVs via derivative transactions and settlements, and various type of short- and long-term asset receivables that could be associated with certain degree of counterparty risks. Other forms of linkages between banks and nonbank financial institutions include banks' investment in the property funds[20] and banks' wholesale deposits placed by NBFIs for transactional purposes, which is an important source of funding for the Irish banks (around 9 percent of total banking sector liabilities).

**6. Bank-sovereign nexus.** Bank-sovereign financial linkages in Ireland are created mostly via banks' government bond holdings and the government's holdings of bank equity. Domestic and foreign sovereign debt securities holdings account for about 2.4 and 4.2 percent of total banking sector assets as of mid-2021, lower than the average holdings by other Euro Area countries[21], with retail banks holding the majority of domestic sovereign bonds. The relatively longer duration sovereign bonds, currently at around 9 years, may expose banks to adverse market valuation amid sudden decompression of sovereign risk premium and tightened global financial conditions. State ownership[22] of three large retail banks which hold more than one-third of system assets may also form a two-way channel enabling the spillover of sovereign and banking stress.

**7. The banking system's exposure to climate risks is not insignificant** (Figure 8). Roughly 15 percent of bank NFC credit is to sectors with a high carbon footprint and more than 20 percent of loans are to sectors exposed to high physical hazards (largely floods), well above Euro area

[19] https://www.esrb.europa.eu/pub/pdf/reports/nbfi_monitor/esrb.202010_eunon-bankfinancialintermediationriskmonitor2020~89c25e1973.en.pdf

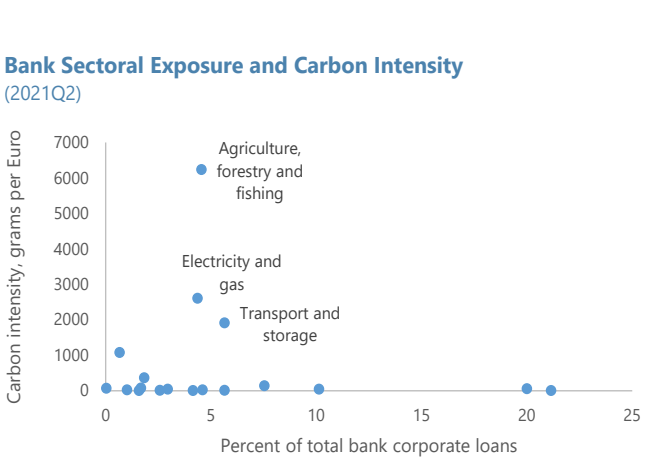
[20] Around €6.2bn (53 per cent of total) financing of property funds comes from banks, of which €3.2bn comes from Irish retail banks.

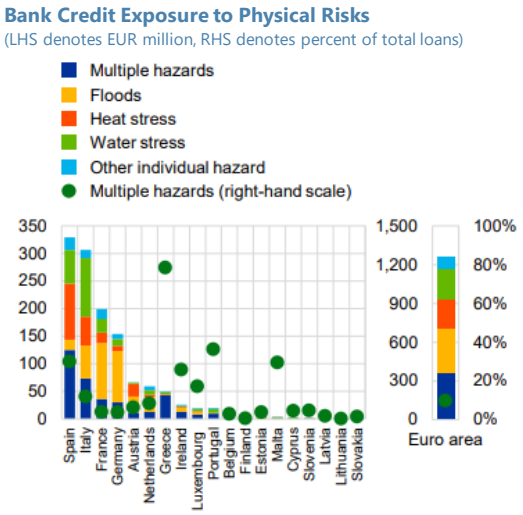
[21] For example, Italy and Spain holds about 12 and 7 percent of domestic sovereign securities out of total banking sector assets, higher than Euro Area average at around 4 percent. For more details, please see this ECB Financial Stability Review article.

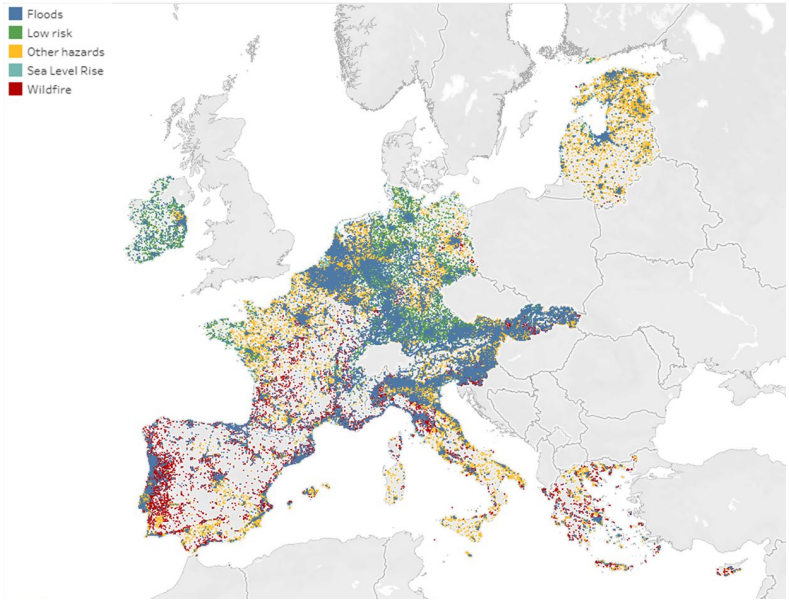
[22] Current state holding: AIB 70.97%; BOI 4.93%; PTSB 75% (Mar 2022).

average, suggesting heightened vulnerability of banks to carbon tax shocks and sea level rises. The government adopted an ambitious climate action plan in 2021. [23]

**Figure 8. Ireland: Bank Exposure to Climate Risks**




Sources: Eurostat, ECB, CBI, and IMF staff estimates.

[23] For details of the plan and Staff's assessment of the required policy efforts, see the Selected Issues Paper.

**8. The banking sector's both direct and indirect exposures to Russia appear to be limited.** [24] The following direct and indirect channels were identified:

*Direct channels*

- Irish banks' lending to Russian companies predominantly comes from the internationally focused banks and as of Q4 2021 stood at €1.1 billion, representing about 0.2 percent of total assets.
- No Irish banks had loans secured against collateral located in the Ukraine or Russia.

*Indirect channels*

- Real sector: Ireland has very limited trade exposure to Russia (around 0.4 percent of both goods exports and imports share) and Ukraine (0.1 percent).
- Energy sector: Ireland imports only 6.3 percent of its energy imports (coal, coke, and briquettes, petroleum fuels and gas) from Russia (49 percent from the United Kingdom, 15 percent from the United States, 6 percent, from Netherlands, 2.9 percent from Sweden).[25] The source of U.K. energy is also diversified, coming mostly from domestic production but also from Norway, the North Sea, parts of Europe, and the Middle East.[26] Only 5 percent comes directly from Russia.
- Household sector: The share of energy in final household expenditure is around 7 percent in Ireland, lower than the EU average. This can be partially explained by lower heating needs due to favorable weather conditions.[27]

Hence, both direct and indirect exposure of Irish banks to the Russia-Ukraine conflict is considered negligible at present. Further pressure from high global energy prices into domestic inflation and output has been incorporated into both the baseline and adverse scenario (Section 1B – Macroeconomic Scenarios).

**9. Against this backdrop, the objective of the FSAP risk analysis is to assess the capacity of the banking system to withstand severe but plausible macro-financial shocks.** The tests are meant to explore potential weaknesses in the financial system and the channels through which adverse shocks could propagate.

**10. The stress tests of the banking sector in the FSAP covered solvency, liquidity, contagion, and climate risks** (Figure 9).

- The solvency stress tests assessed the impact on banks of severe but plausible shocks to the economy in a top-down manner. The exercise used scenario-based stress test to assess impact

[24] See statistical release: https://www.centralbank.ie/docs/default-source/statistics/statistical-publications/direct-financial-links-to-russia-by-economic-sector-4-march-2022.pdf?sfvrsn=4

[25] Data refers to 2021. Source: CSO External Trade Statistics. See: https://data.cso.ie/table/TSA10

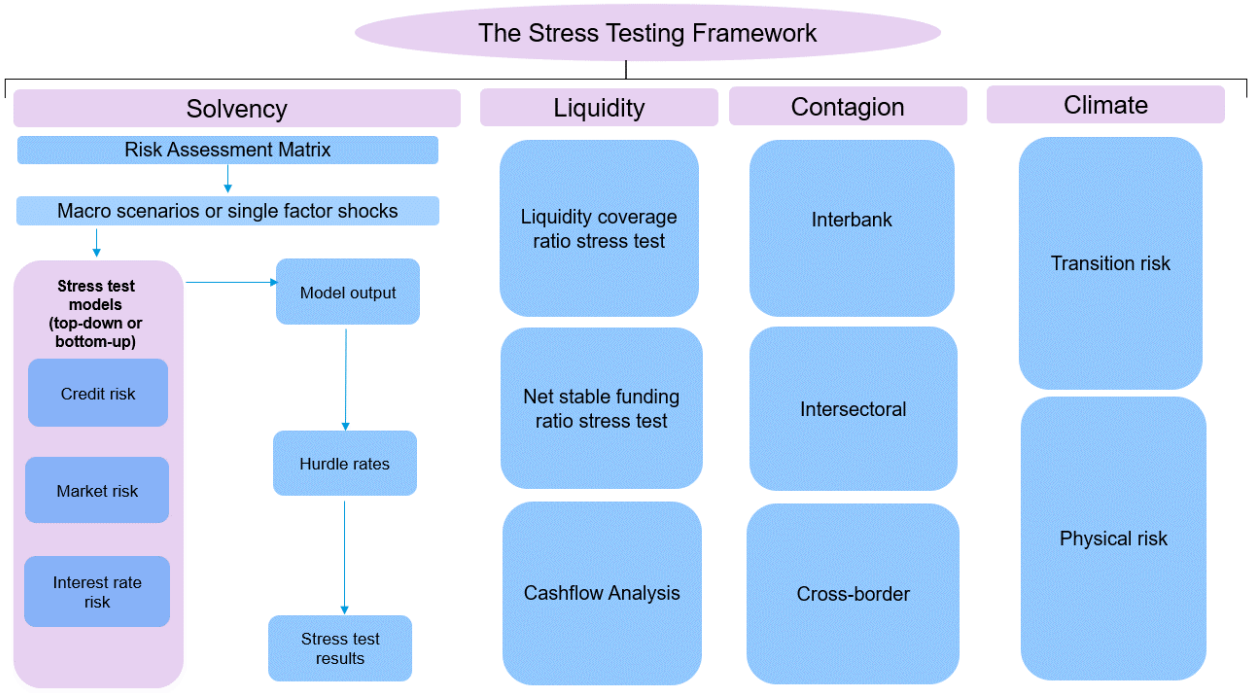
[26] For more details see here.

[27] For more details on the cross-country comparison on household energy expenditures, please see European Commission Staff working document here.

on retail and large international banks while applying a streamlined sensitivity test on other international banks on account of the high volatility of their income sources and risk drivers.

- The liquidity stress tests were conducted using several approaches. The regulatory based approaches include LCR, which focused on short-term liquidity mismatches, and NSFR, which focused on the longer-term structure of liquidity. A cash-flow based approach was also used to assess the liquidity resilience to large withdrawals of funding across multiple time horizons, using maturity ladders for cash flows.
- The contagion analysis covered both domestic and cross-border interbank exposures, as well as domestic and cross-border cross-sectoral interlinkages between banks and NBFIs such as FVCs, insurers, pension funds and investment funds, and used supervisory data.
- The climate risk stress tests establish a climate risk profile for Ireland and assess both transition and physical risks posed by climate change. The exercise used a single factor sensitivity analysis to study the impact on firms' probabilities of default (PDs) following an increase in carbon taxation. The analysis allowed for a sectoral level differentiation among firms. For physical risks, a scenario simulating the macroeconomic impact of a severe flooding event was adopted, which was translated into bank losses via satellite models.

**Figure 9. Ireland: Stress Testing Framework**




Source: IMF staff.

# TOP-DOWN SOLVENCY STRESS TEST OF BANKS

## A. Solvency Stress Tests of the Banking Sector

**11. The stress test covered 12 banking institutions, constituting around 80 percent of total banking system asset.** For the five retail and three large international banks, a scenario-based stress test was conducted, while sensitivity analysis was conducted for the four other international banks. The stress test used confidential supervisory data as of mid-2021 at the highest consolidation level within Ireland. Banking statistics on SIs were accessed during the ECB data room visits, whereas those on the LSIs were provided by the CBI.

## B. Macroeconomic Scenarios

**12. The FSAP identified the following key macrofinancial risks that could pose challenges for the banking sector if they materialized.** The adverse scenario is constructed on the joint realization of these risks (see the Risk Assessment Matrix):

- *Russia's invasion of Ukraine leads to escalation of sanctions and other disruptions*, which could lead to even higher commodity prices and tighter financial conditions. This, in turn, would put additional pressure on domestic inflation and hurt consumers, further stifling economic activity.
- *Outbreaks of lethal and highly contagious COVID-19 variants*, which could result in extended supply chain disruptions, a deterioration of fiscal balances, financial tightening, and an impact on growth.
- *De-anchoring of inflation expectations in the United States and/or advanced European economies* prompting central banks to tighten policies faster than anticipated, resulting in a sharp tightening of global financial conditions and spiking risk premia.
- *Geopolitical tensions and deglobalization*, which could cause, among other things, economic disruptions, a decline in global trade, and lower investor confidence.
- *Continued trade frictions and uncertainty related to the detailed implementation of post-Brexit arrangements,* which could cause increased costs for Irish businesses with close relationships with the United Kingdom leading to a slowdown in growth.

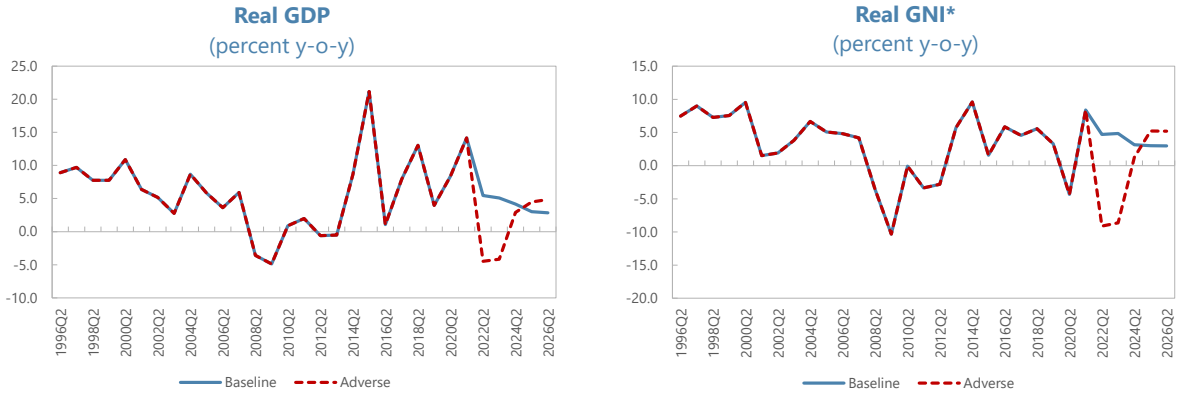
**13. The adverse scenario features significant contraction in growth, tightening global financial conditions and rising sovereign risk premia, and inflationary pressures.**[28,29] The main risk channels include credit risks, interest rate risks and market revaluation risks. The exercise uses data as of mid-2021 and features one baseline and one adverse scenario, spanning a five-year

[28] The scenario was calibrated using the IMF Global Macro-financial Model (GFM) documented in Vitek (2018). For more details on methodology and model assumptions see here.

[29] The scenario is different to that of the EBA 2021 Stress Test which was characterized by a lower-for-longer narrative (and did not include inflation risks). As such, comparisons between the results of the two exercises should be limited and warrant a more cautious approach.

horizon. The baseline scenario aligns with the WEO projection as of March 2022[30], while the adverse scenario is informed by both global and domestic risks that result in a shock to GDP and GNI* growth equivalent to 2.6 and 3.1 standard deviations, respectively, from their baselines.[31] Residential housing price is also in line with staff's house-price-at-risk estimation, which points to a cumulative decline of about 30 percent over a three-year horizon in the adverse scenario (Appendix II). More severely, the CRE price is calibrated to decline by about 40 percent over the same horizon based on multiple criteria, such as current cyclical position of the CRE price, historical relationship between CRE and residential housing price, as well as expert judgement on the structural changes since the GFC. The key variables under the scenarios are presented below (Figure 10).

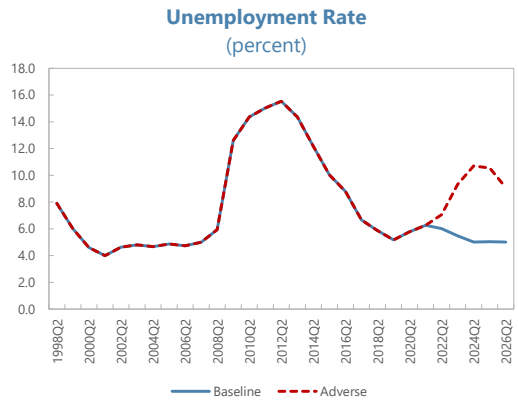
**Figure 10. Ireland: ST Macroeconomic Scenarios**

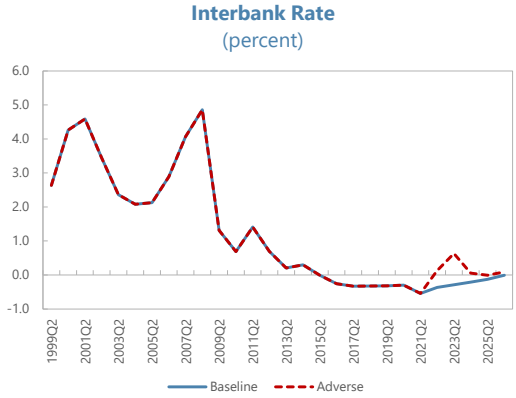


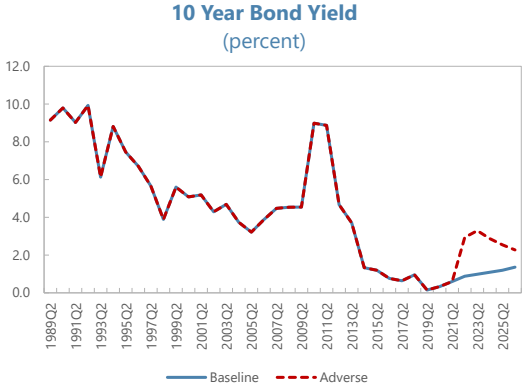

[30] The scenario incorporates baseline projection as of March 2022 and thus reflects staff's view on the impact of Russia-Ukraine conflict up to that point. An earlier cutoff date (mid-2021) for the stress test, though different from the cutoff date of the baseline projection, would not create large distortionary effects given the counterfactual nature of the analysis (e.g., the focus on shocks to the financial sector rather than providing an accurate prediction of the state of the financial sector going forward).

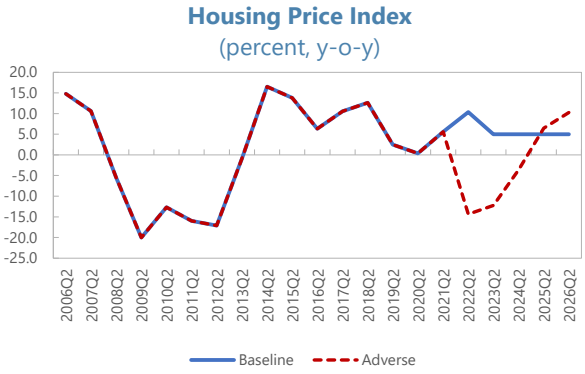
[31] When measuring against historical mean growth, shock to GDP and GNI* is equivalent to 2.1 and 2.4 standard deviations, respectively.

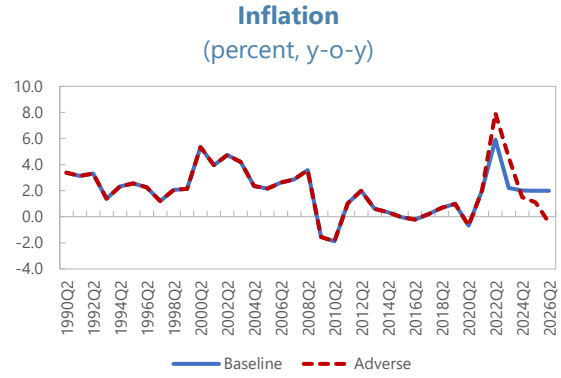
## Figure 10. Ireland: ST Macroeconomic Scenarios (Concluded)

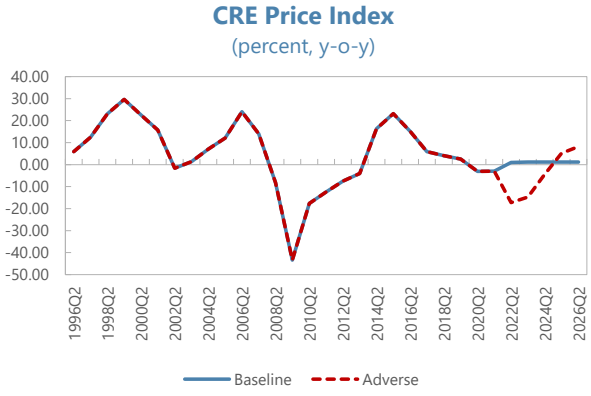



Sources: Haver Analytics, World Economic Outlook, and IMF staff estimates.

## C. Banking Sector Vulnerabilities

### Credit Risk

**14. Credit risk constitutes the largest risk factor for the banking system** (Figure 11). RWAs of credit risk account for 85 percent of total RWAs in the sample banks, in line with the banking system's asset composition. Retail banks use the IRB approach for most of their credit RWAs, at 60 percent, whereas for international banks the IRB share stands at 4 percent. Risk weight densities (RWD) has been historically high in Ireland, at an average of 51 percent since 2014 relative to the regional average at 37 percent, driven largely by the composition of assets in Irish banks, the level of roll out of IRB and legacy mortgage portfolios from the GFC. More recently, the Covid-19 shock, and the accompanying public supports has contributed to a notable decline in risk weighted densities, driven by strong growth of high-quality liquid assets which were funded by surging customer deposits.

**15. Banks' asset composition reflects their business models and market orientation** (Figure 11). The largest portion of assets are loans, representing 51 percent, followed by central banks reserves and non-interest earning assets. By sector, loans are mostly concentrated in households and corporates, followed by financial institutions and central banks and governments. Furthermore, asset composition differs notably between retail and international banks, with retail banks holding disproportionally large share of household (mostly in the form of mortgages) and corporate loans due to their domestic focus, whereas international banks hold a higher share of non-interest bearing assets (mainly in the form of reverse repo and derivative assets), and have the bulk of their credit exposure to banks and nonbank financial institutions, due to their exposures to cross-border banks and nonbank financial entities such as FVCs. This results in a more diversified and liquid asset profile for international banks than for retail banks.

**Figure 11. Ireland: Sample Bank Balance Sheet Decomposition**

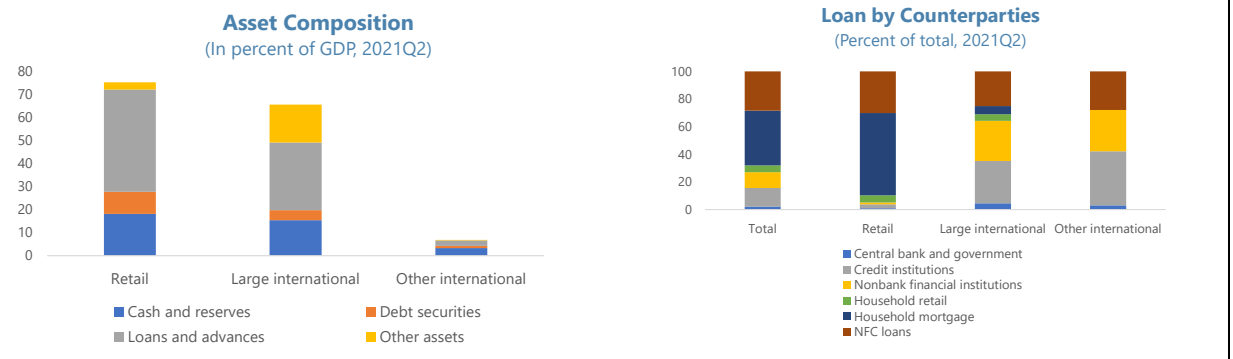
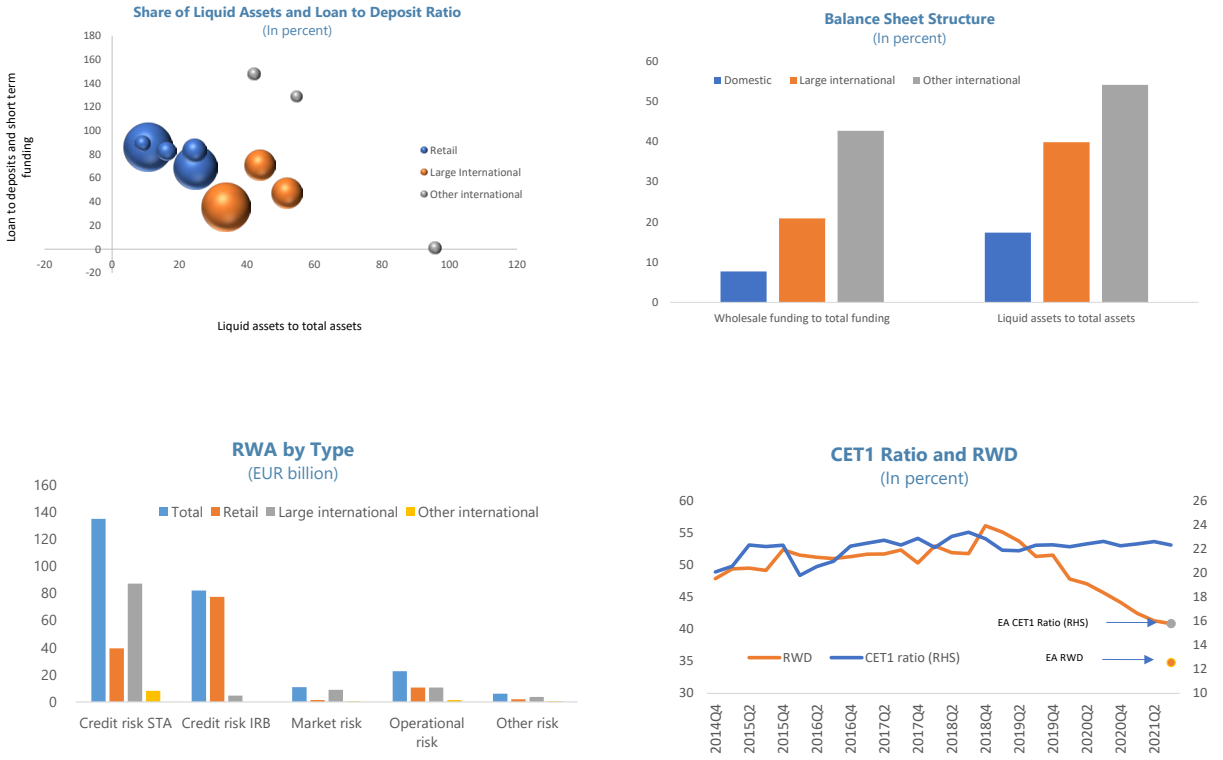


**Figure 11. Ireland: Sample Bank Balance Sheet Decomposition** (Concluded)

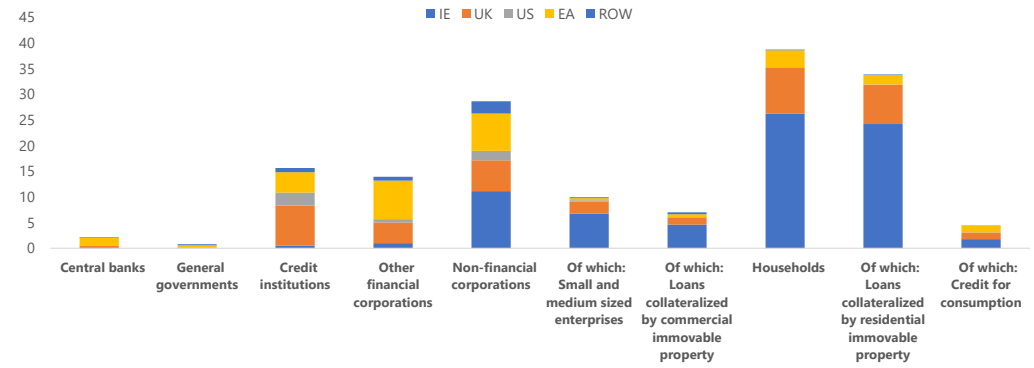



Sources: ECB, CBI, Fitch and IMF staff estimates.
Note: "CET1 Ratio" reflects traditional (non-fully loaded) measure of CET1. Figures showing comparisons between banking segments are based only on the sample of banks used in the stress test. CET1 ratio and RWD (Risk Weight Density) figures represent the entire Irish banking system and thus are different from the bank stress testing sample.

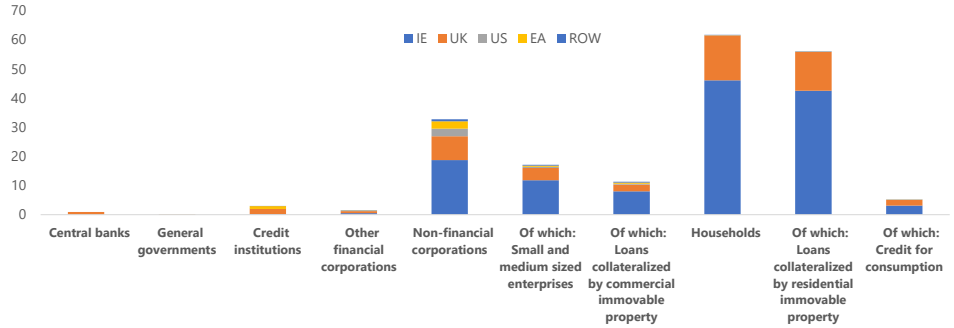
**16. Asset quality also varies across geographies and market segments and is subject to changes in regulatory definitions** (Figure 12). The cross-border focus of the international banks gives rise to a higher share of credit exposure to U.K., Euro Area, and U.S. retail banks, on the other hand, are highly exposed to the Irish market with some exposures in the U.K., explained by their market orientation toward domestic real sector and close ties with the U.K. economy. Credit quality also varies across market and segments, with exposures in the Irish and U.K. markets underperforming those in the rest of the world and corporate portfolios (particularly in the real estate and SME segments) bearing higher credit risks than other loan products. NPL ratios for nonbank financial institutions, although lower than rest of the segments, remain an area of uncertainty due to the inherently high-risk profile of FVCs and their dense interconnections with the large international banks. A recent revision in the definition of default and the reassessment of risks in the unlikely-to-pay loan category also contributed to the increase in NPLs across portfolios. Nonetheless, the recent declining trend of NPL ratios may reflect various forms of supportive policies, which are likely mitigating the full pass-through of the Covid-19 shock to the recognition in loan loss provisions.

## Figure 12. Ireland: Bank Credit Exposure and Quality by Geography and Segment

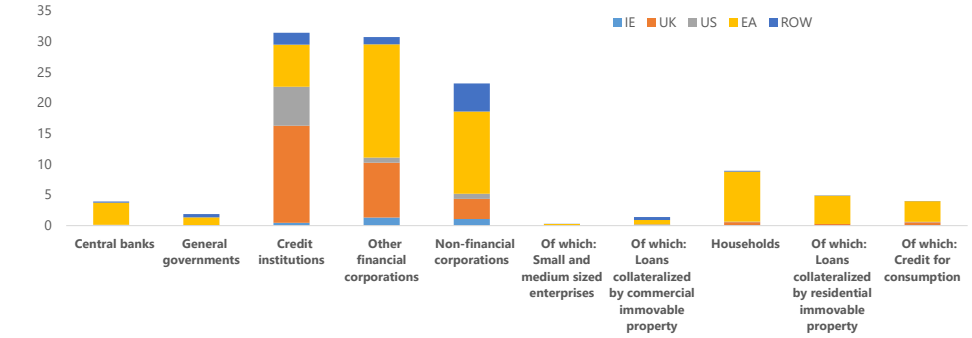
### Loan Composition - Total
(In percent of total loans)




### Loan Composition - Retail Bank
(In percent of total loans)

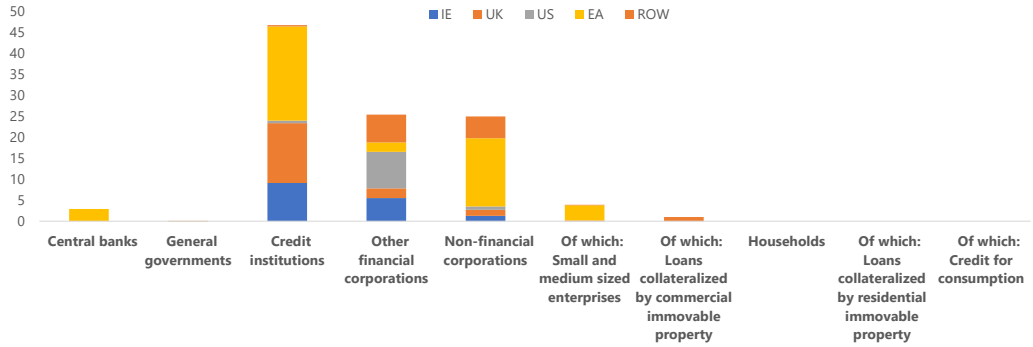



### Loan Composition - Large International Bank
(In percent of total loans)

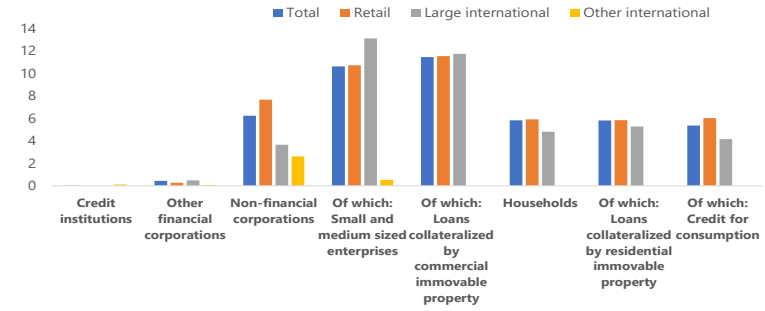


## Figure 12. Ireland: Bank Credit Exposure and Quality by Geography and Segment
(Concluded)

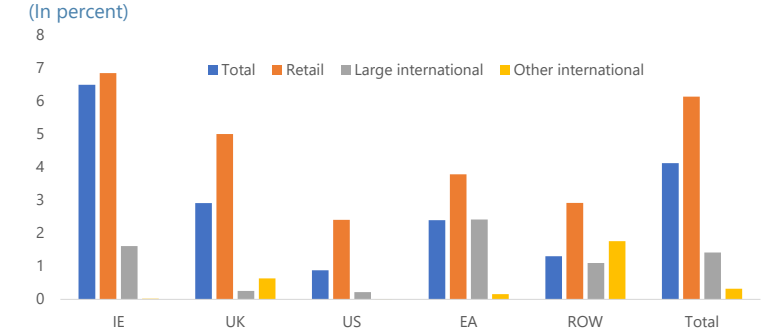
### Loan Composition - Other International Bank
(In percent of total loans)




### NPL Ratio by Segment
(In percent)



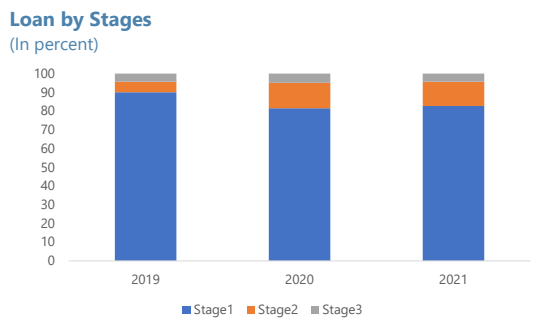

### NPL Ratio by Geography
(In percent)




Sources: ECB, CBI and IMF staff estimates.

**17. The global pandemic, coincided with Brexit, has resulted in a significant increase in credit risk** (Figure 13). Stage 2 assets on aggregate have doubled since the pandemic. Part of the increase in 2020 has reverted to stage 1 in early 2021, although the overall level remains elevated. An assessment of the impact on bank solvency in the event of a large transition from stage 2 to stage 3 is therefore warranted, given the delayed recognition of NPLs[32], the tapering of policy support, and limited policy space to counteract additional downside shocks in light of heightened global uncertainties.

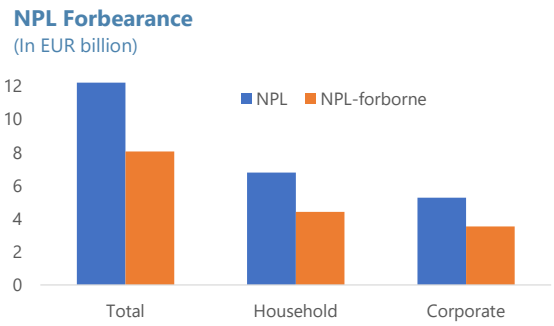
**Figure 13. Ireland: Loans by Stages**




Source: ECB, CBI and IMF staff estimate.
Note: Sample contains retail and large international banks.

**18. A significant portion of the NPLs has undergone forbearance process** (Figure 14). Although moratoria have expired for most of the Euro Area countries including Ireland, various types of forbearance measures have been offered to distressed borrowers, mostly at the discretion of banks, to prevent further rise in NPLs and to reduce existing stock of NPLs. As of mid-2021, 66 percent of the total non-performing loans has been re-negotiated and restructured with borrowers (65 percent for household NPLs and 67 percent for corporate NPLs). These measures, if used properly, can provide sufficient buffers to viable firms and households facing transitory liquidity difficulties, and in the meantime relieve stress on banks by bringing down the probability of default and the resulting level of loan loss provision. However, banks should make reasonable efforts to identify and distinguish viable borrowers from those that are non-viable, to avoid the delay in recognition of inevitable credit losses that can limit bank's lending and income generation capacity, which may further lead to systemic risks.

**Figure 14. Ireland: Loan Forbearance**



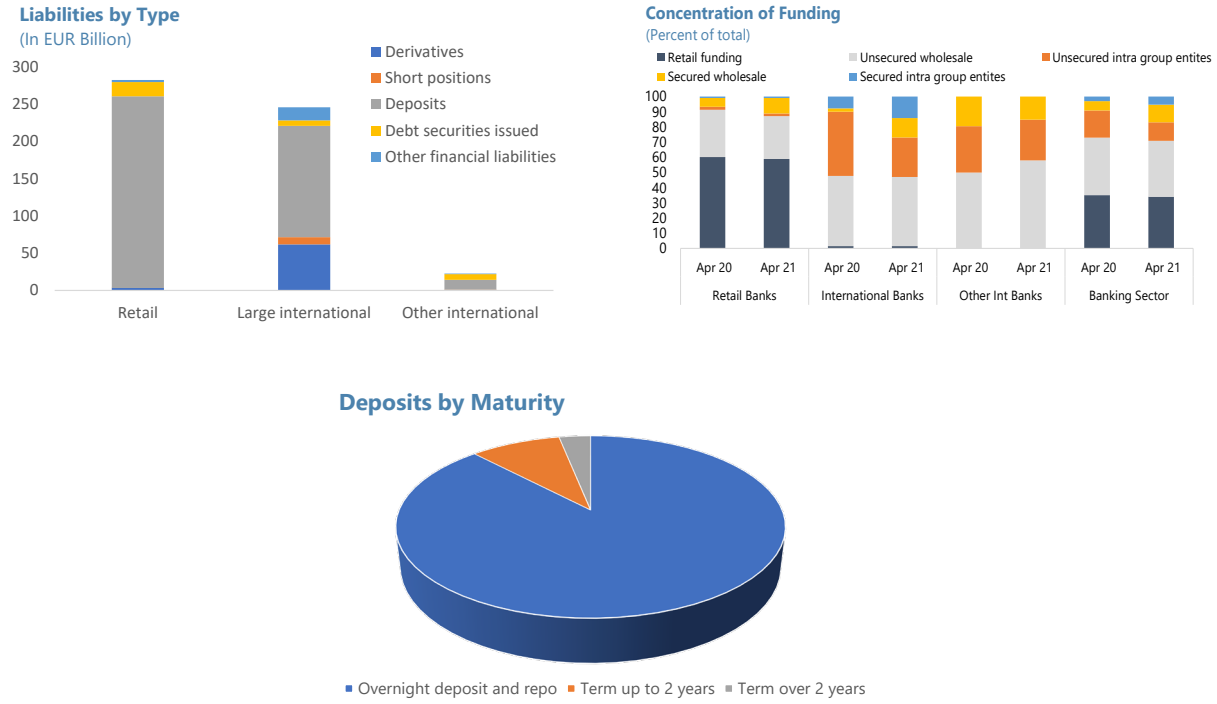

Source: ECB, CBI and IMF staff estimate.
Note: Sample contains retail and large international banks.

[32] Banks are also proactively working with distressed borrowers to restructure their loans, which may avert an outright default in the short term but may also push further the full recognition of NPLs into the medium- and long-term.

## Interest Rate Risk

**19. Bank assets comprise a mix of floating and fixed rate instruments.** As of September 2021, 65 percent of the newly issued loans were denominated in variable rates, with lower share for household mortgage (20 percent). Going forward, the large share of overnight and term deposit liabilities subject to short-term repricing (Figure 15), slower repricing on the asset side (especially for new mortgage loans with high share of fix rate issuance)[33], and further competition from nonbank lenders suppressing lending rates may enlarge the repricing gap to more than offset the benefit of having the adjustable-rate lending scheme.

**Figure 15. Ireland: Liability Composition**



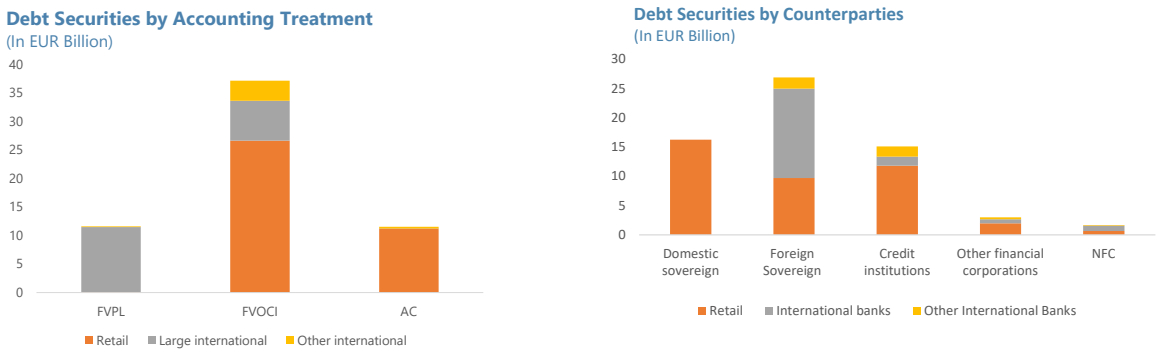

Sources: CBI and IMF staff estimates.

[33] On the other hand, the higher share of floating rate loans for segments other than household mortgages may translate into heightened credit risks in a stressful event.

## Market Risk

**20. Holdings of sovereign securities are moderate.** At 43 billion euros, or 7 percent of total banking assets (70 percent of total debt securities), banks' exposure to sovereign bonds is moderate and introduces linkages via the capital and liquidity channels. As of mid-2021, the share of foreign sovereign securities was the largest, representing on average 4.3 percent of total banking assets (43 percent of total debt securities) held by the banks, and were held mostly by international banks. Irish sovereign securities ranked the second and were held exclusively by retail banks given their domestic market orientation, followed by securities issued by credit institutions. A significant portion of the sovereign securities were placed in the fair value category (mostly through other comprehensive income) rather than the amortized cost category. Although most of the fair value holdings are used for liquidity purposes and therefore are swapped out against large valuation shocks,[34] the high concentration of sovereign debt in conjunction with relatively longer duration[35] may still expose banks to adverse market conditions under imperfect hedging and may adversely affect banks' solvency and liquidity position (Figure 16).

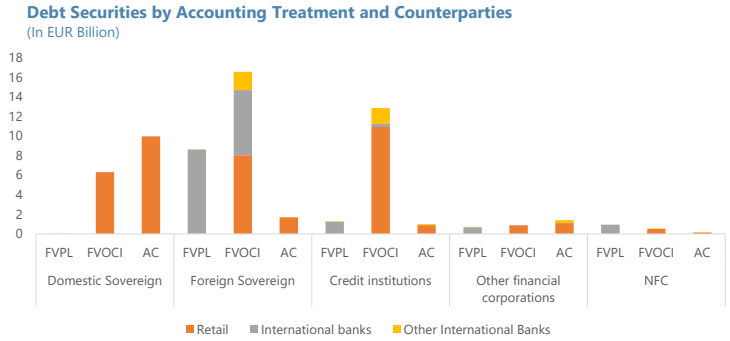
**Figure 16. Ireland: Sample Banks Securities Holdings**

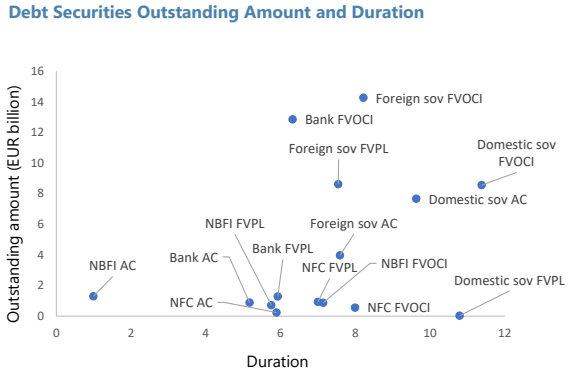



[34] According to Central bank of Ireland, banks hold most of the marketable securities in the banking books for liquidity purposes as HQLA eligible. These positions are held as FVOCI and swapped out, and the vast majority of the holdings retain less volatile CS01 risk. The generation of realized gains in these portfolios thus does not form a core part of any strategies in the banks, nor it is generally material. The unhedged portion of the debt securities represents about 12.3 percent of the total marketable securities.

[35] The weighted average duration for sovereign securities holdings of the retail banks in sample is 5 years, higher than holdings of bonds issued by banks, and corporates, at 3.4, and 4.7 years, respectively and lower than nonbank financial institutions at 5.8.

**Figure 16. Ireland: Sample Banks Securities Holdings** (Concluded)




Sources: ECB, CBI and IMF staff estimates.
Note: FVPL = fair value through profit and loss, FVOCI = fair value through other comprehensive income, AC=amortized cost.

## D. Methodology for Scenario-Based Solvency Stress Test

**21. The scenario-based solvency stress test followed a balance sheet approach and was based on IFRS9 accounting framework.** IFRS9 framework introduced in 2018 required the team to move away from incurred loss calculations (under the IAS39) to a forward-looking, accounting-based expected loss (i.e., provisions) calculations. As a result, the stress test adopted in its methodology the concept of asset stage classifications, the use of transition matrices, and the calculation of the life-time expected loss compliant with the new accounting standards.

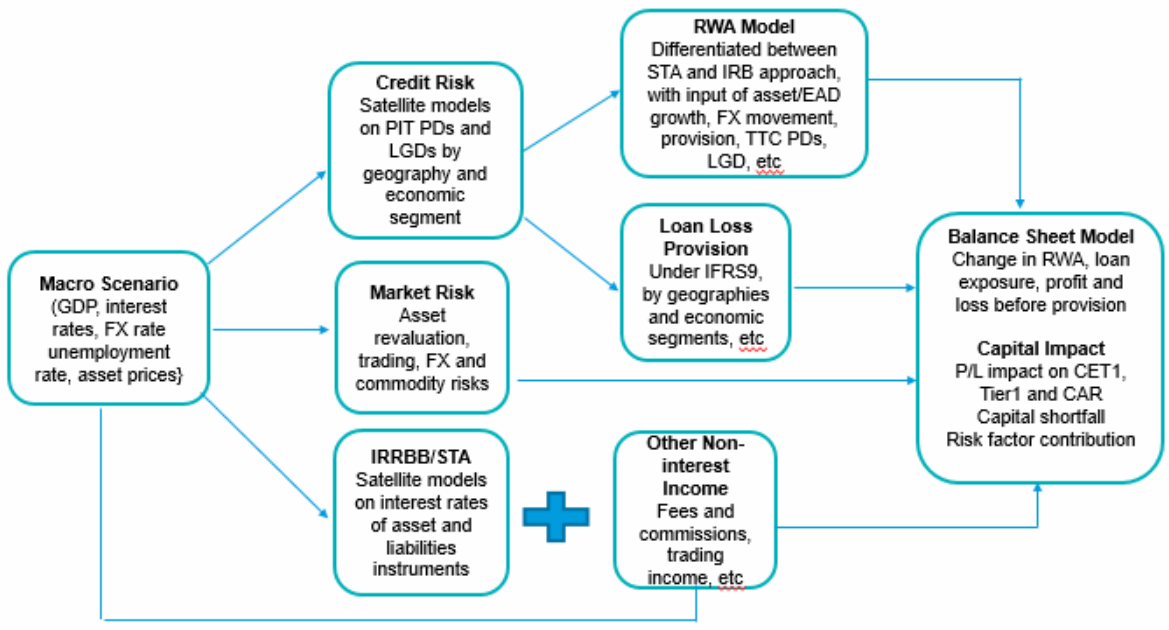
**22. The stress test used regulatory capital requirement calculations.** The performance of the eight sampled banks[36] was assessed based on total capital adequacy ratio (CAR), Tier 1 capital (T1), Common Equity Tier 1 (CET1) capital and leverage ratios. Under both scenarios, capital requirements include O-SII buffer, where applicable, and the baseline scenario is also subject to bank specific Pillar

[36] For the five retail and three large international banks, a scenario-based stress test was conducted, while sensitivity analysis was conducted for the four other international banks.

II requirements. Finally, banks are allowed to deplete their capital conservation buffers (CCBs) under the stress condition.

**23. The stress test adopted a solvency framework that covers a comprehensive set of risks** (Figure 17). It included credit risk associated with all exposures, market risks, sovereign risk, and interest rate risk in the banking book. By contrast, the derivatives book was not considered, due to lack of access to granular enough information to stress the derivatives portfolio in a meaningful way. Given the cross-border nature of the Irish banks, the team applied geographical segmentation to exposure classes. Key risk parameters were stressed for exposures in Ireland, United Kingdom, United States, rest of the Euro Area and rest of the world. Macro scenarios were translated into the evolution of PDs, LGDs and interest rates using a set of satellite models, and in the meantime indirectly affect the growth of balance sheet items, pre-provision net income and other base components. Shocked risk parameters drove Risk-Weighted Assets (RWAs) and provisions (via IFRS9 transition matrices), asset repricing and market valuation losses. The final step combines all P&L items and full balance sheet under evolution to obtain CET1, Tier 1 and total capital and leverage ratios over the stress testing horizon. Figure 17 summarizes key elements of the solvency framework.

**Figure 17. Ireland: Structure of Solvency Stress Testing Framework**




Source: IMF.

**24. A quasi-static approach was used for the growth of banks' balance sheet over the stress-test horizon.** Under this approach banks' asset allocations and the composition of their funding are assumed to remain the same, whereas the balance sheet growth is assumed to follow the weighted average GDP growth of all countries where the banks have a significant exposure. However, to prevent banks from deleveraging, a floor on the rate of change of balance sheets was

set at zero percent.[37] This constraint is binding in the adverse scenario. Other factors affecting balance sheet growth are the revaluation of assets and liabilities in accordance with foreign exchange movements and the conversion of a portion of off-balance sheet items (i.e., credit lines and guarantees) to on-balance sheet exposures.

**25. The implementation of IFRS9 bridges the assessment of credit losses under accounting and regulatory regime, hence emphasizing the need to harmonize the differences in their classification of asset/exposures.** Accounting classification is based on balance sheet exposures, distinguishes between loans and securities, while regulatory classification is based upon on- and off-balance sheet amounts of loans and securities combined. Granularity is also different: the accounting classification is based on sectors and does not distinguish between different types of borrowers/loans, like large corporates, small- and medium-enterprises (SMEs), mortgage loans and credit card loans. The FSAP team therefore mapped the accounting and regulatory portfolios using approximations and assuming similar risk characteristics (Table 3).

**Table 3. Ireland: PD Portfolio Mapping**

| Accounting (IFRS9) | Model |
|---|---|
| Loans and advances to central governments or central banks | PD central governments or central banks |
| Loans and advances to credit institutions | PD financial (proxied by Moody's Expected Default Frequency) |
| Loans and advances to other financial corporations | PD financial (proxied by Moody's Expected Default Frequency) |
| Loans to non-financial corporations - Ireland non-CRE | PD corporate - Ireland non-CRE |
| Loans to non-financial corporations - Ireland CRE | PD corporate - Ireland CRE |
| Loans to non-financial corporations - UK, U.S., Euro Area excl. Ireland, and rest of the world | PD corporate - UK, U.S., Euro Area, and rest of the world (proxied by Moody's Expected Default Frequency) |
| Loans to household retail (Decomposed from total household loans based on EADs) | PD household retail |
| Loans to household mortgage (Decomposed from total household loans based on EADs) | PD household mortgage |

Source: IMF.

**26. The evolution of default under stress in Ireland was estimated separately for five portfolio types, using the Bayesian Model Averaging (BMA) methodology** (Table 3 and Figure 18). Historical default rates (PDs) at the aggregate level were estimated for five main loan portfolios: corporate CRE, corporate non-CRE, household retail, household mortgage,[38] and financial

[37] The stress test also assumes no write-off of existing NPLs over the risk horizon.

[38] For household mortgage portfolios, a differentiation between U.K. and non-U.K. exposure was made by implementing an ad-hoc adjustment on the adverse PD shocks to the U.K. mortgage portfolios by reducing them to 50 percent of the original shock to reflect the lower historical default rates observed for U.K. mortgages.

institutions. Point-in-time PDs were projected using BMA models with macro variables as independent variables. The results were then used to shift the transition matrix of each type of loan portfolio held by individual banks.

**27. The PD proxy for exposures to central governments was extracted from sovereign yields using a Merton-based approach.**[39] The FSAP team used data from FINREP returns on the breakdown of financial assets by counterparty to calculate banks' exposures to general governments. It then applied a reduced-form structural model to extract PD estimates from the sovereign spreads projected in the scenario.[40] Using the credit spreads for sovereign exposure linked to the scenario $S^i_{t,T}$, time to maturity (T-t), and assuming an LGD of 45 percent, the implied risk-neutral PD is backed out as:

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

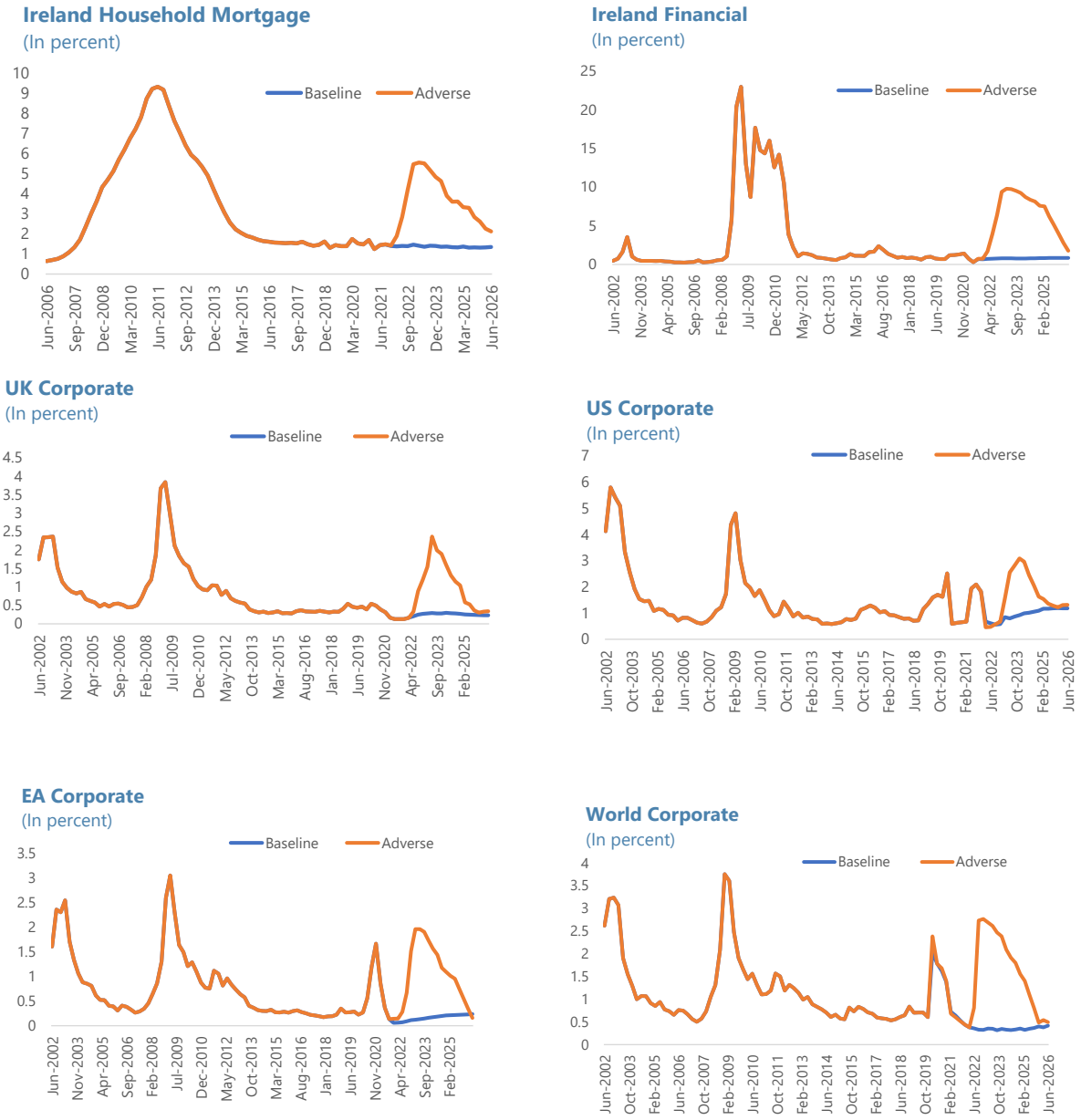
**28. The projection of default rates for corporate exposures outside Ireland were estimated using Moody's expected default frequency (EDF) for geographical areas that are significant for the sample banks.** Since the large international banks have significant loan exposures in countries outside Ireland, historical corporate PDs proxied by EDFs were analyzed for exposures in United Kingdom, United States, other Euro Area, and rest of the world. The estimated point-in-time PD shifts were applied to bank specific transition matrices, which were then used in conjunction with bank lending exposures for the calculation of loan loss provisions. PDs for financial institutions within Ireland were also sourced from Moody's.

**29. A logit transformation was applied before conducting BMA/OLS estimates to address the truncated nature of default rate distribution.** This transformation addresses biases and ensures that the projected rate is contained within the 0-1 bound once the logit forward path is applied to the forecast.

[39] Note that an increase in sovereign issuer risk is reflected in higher loan loss impairment charges on AC and other comprehensive income (OCI) portfolios as well as in lower regulatory capital from marked-to-market valuations through FVTPL (Fair value through profit and loss) and OCI portfolios.

[40] The approach assumes that the difference between a risk-free security and a risky security is the put option on the value of the assets which includes the loss induced by the stressed PD and LGD of the bond.

## Figure 18. Ireland: PD Projections
(In percent)




Sources: CBI, Moody's Analytics and IMF staff estimates.
Note: Due to data confidentiality agreement, PD series for household retail and corporate loans are not presented.

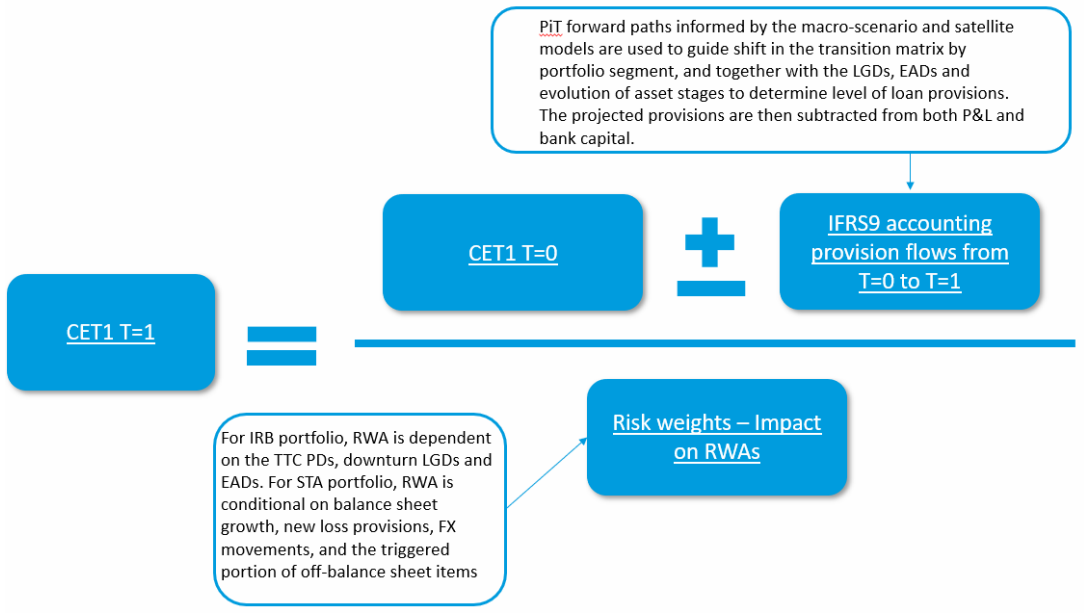
**30. Conditional PD forecasts were generated based on the estimated model parameters.** Given a stable macroeconomic outlook in the baseline, the PDs in most segments are projected to remain flat in the baseline scenario and to sharply increase in the adverse scenario. The impact under the adverse scenario displays idiosyncrasies across segments, with the impact on household retail, corporate (in particular, the CRE segment) and financial institutions (in particular NBFIs) more sizable than those on household mortgages. The magnitude of the projected PD shock under the adverse scenario for most segments, including those severely shocked, is milder relative to historical stress episodes explained by structural changes in the economy since the GFC.

**31. Real domestic output, unemployment rate, short-term and long-term interest rates as well as asset prices proved to be relevant for the buildup of credit risk.** This is reflected in the higher than prior posterior inclusion probability and the sizable, long-run multiplier estimates (i.e., coefficients for both the contemporaneous and lagged terms of the independent variables) for the sectoral PDs. The type and number of significant variables varies distinctly across segments, as manifested by the individual characteristics of their historical PDs.

**32. Point-in-time LGDs paths under the baseline and adverse scenario were projected using historical time series on coverage ratio for the total loan portfolio provided by the CBI**. The stressed coverage ratio under the adverse scenario was applied to household and corporate portfolios separately, taking into consideration their differences in the level and quality of collateralization at the starting point. The forward paths under the baseline and adverse scenario were then attached to the bank specific Point-in-time LGDs, with a floor imposed on the adverse scenario at the downturn LGDs. For banks under the standardized approach where LGD statistics are unavailable, the team used the LGDs for the IRB banks provided by the national authorities as a proxy.

**33. Credit risk affects banks' capital ratios both through loss provisions (numerator) and risk weights (denominator).** For exposures booked under both the STA and IRB approach, the calculation of loan loss provisions is consistent with the account standard (IFRS9) and depends on the evolution of loan exposures, stage transition matrices (guided by the stressed PiT PDs) and the PiT LGDs under stress. The capital requirement (RWAs) is subject to differences in regulatory approaches used by the bank. See Figure 19 for further explanation.

**Figure 19. Ireland: Use of PiT and TTC PDs for RWAs and Provisioning**




Source: IMF.

**34. To compute capital requirements, standardized (STA) and internal ratings-based (IRB) portfolios were differentiated.** For the standardized portfolios, RWAs can change due to the balance sheet growth ($g_t^c$), new flows of NPLs ($\Delta NPL_t$) and new provisions for credit losses ($Prov_t$), exchange rate movements ($\Delta FX_t^c$), and the triggered portion of off-balance sheet items ($UCL_{i,t-1}^{c,j}$).[41]

$$RWA_{i.t}^{c,j} = (RWA_{i\,t-1}^{c,j} - Prov_t)\left(1 + g_t^c + f_{rwa\_i}^c \Delta FX_t^c\right) + \Delta L_{i.t}^{c,j} UCL_{i.t-1}^{c,j} + \Delta NPL_t$$

For IRB portfolios, the bank specific regulatory credit risk parameters (TTC PDs, downturn LGDs, stressed EAD) were used for the derivation of RWAs under the baseline and adverse scenarios, with the weighted average through-the-cycle (TTC) PDs governed by the following formula:

$$\Delta TTC\_PD_t = (\Delta PiT\_PD_t) * 0.5$$

This reflects the assumption that adjustments to long-run average (TTC) PDs are based on the point-in-time (PiT) PDs of the most recent years as well as migration of exposures within the non-defaulted rating grades.

The change to EAD in the IRB portfolio is governed by:

[41] The triggered portion is assumed to be zero percent and 20 percent of the off-balance sheet items for baseline and adverse scenarios over a 5-year horizon, respectively.

$$EAD_{i,t}^{c,j} = EAD_{i,t-1}^{c,j} \cdot \left(1 + g_t^c + f_i^c \cdot \Delta FX_t^c\right) \cdot \left(1 - PD_{i,t-1}^{c,j}\right) + \Delta L_{i,t}^{c,j} \cdot UCL_{i,t-1}^{c,j}$$

where *i* denotes the bank, *j* denotes the portfolio, *c* denotes the country of exposure, $g_t^c$ is credit growth in country *c* (where demand effects are incorporated but supply effects are disallowed), $f_t^c$ is the fraction of foreign currency loans, $\Delta FX_t^c$ is the depreciation of the foreign currency relative to the euro, $\left(1 - PD_{i,t-1}^{j}\right)$ represents the non-defaulted portfolio, $\Delta L_{i,t}^{j}$ is the shock to triggered credit lines and guarantees, and $UCL_{i,t-1}^{j}$ is the amount of undrawn guarantees. While paths for credit growth and FX shocks were generated for each scenario, stressed credit conversion factors on undrawn credit lines and guarantees were informed by historical behavior of off-balance sheet migration during stress periods drawing on banks' Pillar III disclosures.

The projected RWAs are dependent on stressed credit risk parameters, correlation assumptions, and effective maturity for each exposure and are sectoral specific. In line with the Basel III framework, RWAs were computed after applying the scaling factor of 1.06 to credit RWAs and using a 1.25 multiplier to the correlation parameter of all exposures to financial institutions. Difference in granularity of RWAs calculation was recognized by applying original scaling factor, i.e., ratio of model calculated RWAs to reported RWAs at time T0.

**35. The assessment of interest rate risks can be decomposed into two main components: base effect and gains or losses under stress.** The base effect is defined as the changes of interest income or expense due to changes in the outstanding amount of interest earning assets or liabilities, in absence of interest rate shocks. It is computed as the product of the effective interest rate on each relevant balance sheet item and their outstanding amount under the stress horizons. Gains or losses due to interest rate shocks are treated as an add-on component which uses a gap-analysis to assess the cash-flow effects from a general increase in interest rates that affects banks' banking books. The impact is felt on interest income or funding cost through bank's cash-flow structure comprised of interest sensitive assets and liabilities and repricing buckets. Throughout the stress horizon, interest rate shocks were applied to the interest rate-sensitive assets and liabilities as the positions reach their time of repricing, from less-than-1-year to the 5-year buckets, consistent with the stress testing horizon. Funding risks are considered as part of the interest rate risk assessment which prevails in the repricing of the sensitive liabilities subject to rising funding rates, such as deposit rates or interest rate on debt securities. Projection of net interest income is computed as the sum of the base component and the gains and losses due to interest rate shocks.

**36. Interest payments were assumed to accrue only on performing exposures under both the baseline and adverse scenarios.** The interest revenue on performing exposures was calculated on the gross carrying amount. While accounting rules allow banks to accrue interest income on non-performing exposures with provisioning required on the more delinquent and uncollectible assets,

the stress test exercise took a more conservative approach which does not allow banks to project income on non-performing exposures.

**37. The assessment of interest rate risks for Ireland used as input the historical time series of aggregated interest rates as well as sensitive asset and liabilities reported in the IRRBB template.** The evolution of the cost of funding and lending rates were treated as a function of the macroeconomic variables projected in the scenarios. The projection used aggregate bank rates for new business (front-book) and were mapped into two main categories on the asset side (loans and debt securities) and three main categories on the liability side (overnight deposits, term deposits, and debt securities). On the asset side, the model adopted a more granular approach by further decomposing interest rates on loans and debt securities into various counterparties. Same interest rate on bank bonds were applied to the asset and liabilities side of the banking book. Shocks to interest rates on total assets and total liabilities were also computed by aggregating the sub-components given that one of the sample banks only reports total sensitive asset and liabilities in the IRRBB template (Table 4). The projected interest rate shocks were then applied to the corresponding categories of sensitive asset and liabilities in each bucket to derive gains or losses associated with interest rate movements.

**Table 4. Ireland: Interest Rate Portfolio Mapping**

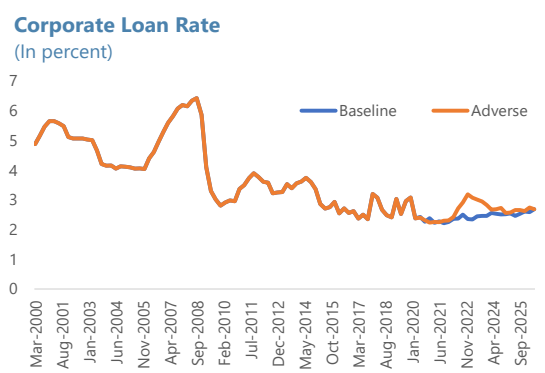
| IRRBB Template | Model |
|---|---|
| Assets - total | Assets - loans and debt securities |
| Assets - loans | Assets - corporate loans |
| | Assets - household retail loans |
| | Assets - household mortgage loans |
| Assets - debt securities | Assets - debt securities sovereign |
| | Assets - debt securities corporate |
| | Assets - debt securities financial |
| Liabilities - total | Liabilities - deposits and debt securities |
| Liabilities - overnight deposits | Liabilities - overnight deposits |
| Liabilities - term deposits | Liabilities - term deposits |
| Liabilities - debt securities | Liabilities - debt securities financial |

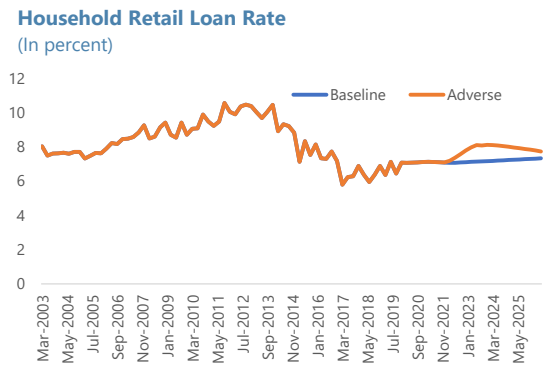
Source: IMF.

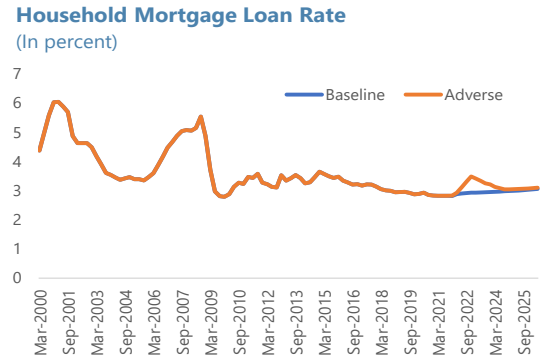
**38. Results from satellite models on aggregated interest rates reveals the significant role of short-term rate and long-term rates.** On the asset side, lending rates appear to be highly correlated with the short-term interest rate, which is consistent with the dominant share of floating rate loans in the banking book. On the liability side, the cost of overnight deposits is largely determined by the short-term rate while term deposits and bond interest rates appear to be driven by both short-term and long-term interest rates. The pass-through from Irish sovereign bond yield and short-term interest rate on funding rates appears to be large, particularly for the term deposit and corporate debt securities.

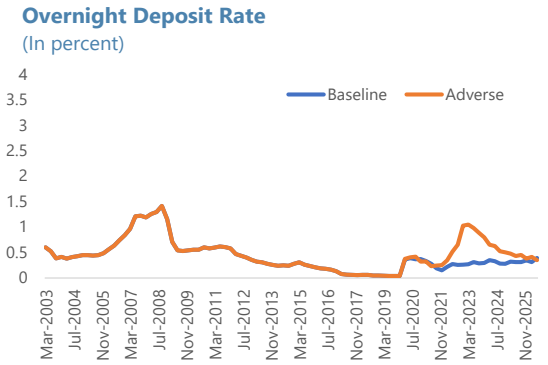
**39. The projected interest rates paths are broadly in line with banks' portfolio characteristics** (Figure 20). On the liability side, this is reflected by a more severe impact on the long-term and unsecured debt portfolios as opposed to highly liquid short-term funding. On the asset side, the increase on the lending rate appears to be moderate to reflect the constrain faced by the banks in increasing lending rates under stress. As a result, relative to the baseline, net interest margin declines in the adverse scenario by about 0.3 percentage point on average for the sample banks, relative to a historical net interest margin of the total banking sector at around one percent since 2008.

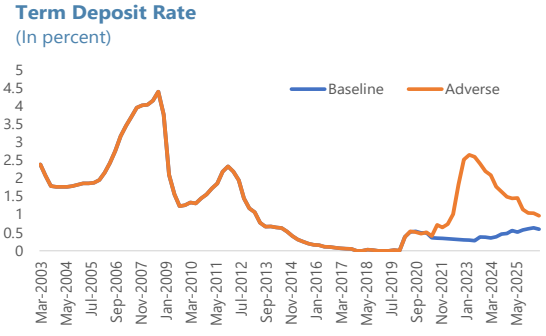
**Figure 20. Ireland: Interest Rate Estimation by Portfolio**
(In percent)



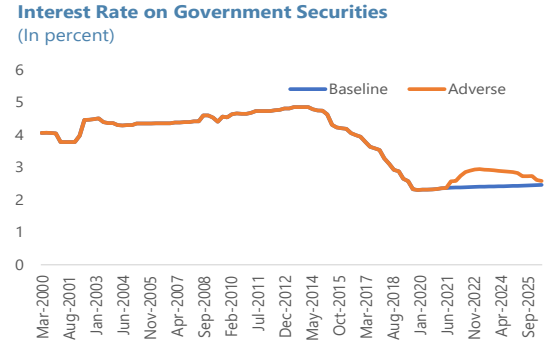
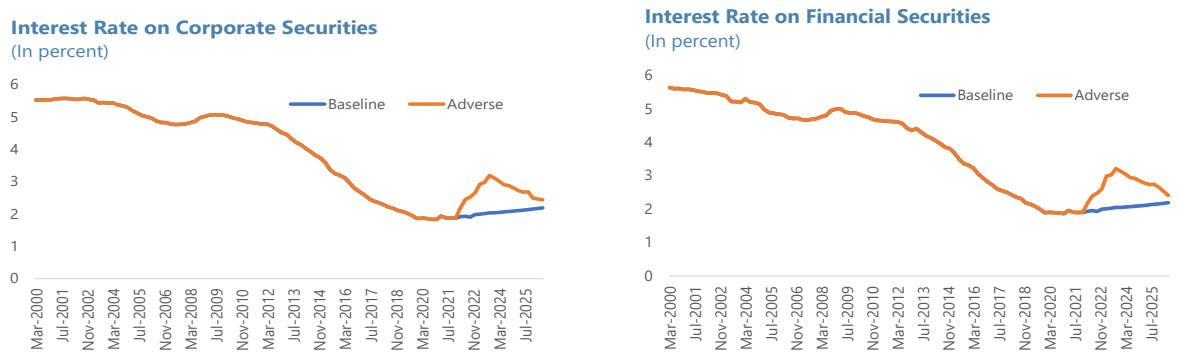



**Figure 20. Ireland: Interest Rate Estimation by Portfolio**
(Concluded)




Sources: ECB, Datastream, and IMF staff estimates.

**40. Securities-level data were used to measure gains or losses in the value of fixed income securities, due to changes in risk-free interest rates and credit spreads.** Unique securities holdings of types of securities by each bank were provided by national authorities and used to derive bank specific duration and yield. Gains and losses were calculated using the modified duration approach. The analysis covers the impact of the debt securities portfolio accounted in the fair value through profit and loss (FVTPL) and fair value through other comprehensive income (FVOCI). Rebalancing of the portfolio was not allowed throughout the horizon. For securities measured under Amortized Cost (AC), staff calculated loss provisions using the risk parameters of the AC lending portfolios as a proxy. Finally, to consider existing hedging strategies of the AC portfolios while also enabling imperfect hedging under stress, staff assumed 20 percent of the AC portfolios will be exposed to full valuation shock under the adverse scenario.

**41. Net income (profit and loss) was projected using all the risk factors in the stress test.** Net profits were mainly driven by the gains and losses from credit risks, market risks and interest rate risks. Gains or losses associated with other market positions, such as the currency net open position, can be affected by the evolution of these variables under the relevant scenario.[42] Any remaining items on the income statement were projected to grow in line with the size of the balance sheet. This included the projection of net fee and commission income and operational and administrative expenses. Under the adverse scenario, the growth in non-interest income and expenses is subject to a zero percent floor. Extraordinary income and loss were assumed not to recur during the projection period. The corporate income tax is factored in the profit and loss calculations, and it was set at banks' effective tax rate with a cap at 30 percent.

**42. For equities held with trading intent, the fair value impact follows the evolution of equity prices projected under both the baseline and adverse scenario,** while subject to a minimum threshold using the approach similar to EBA 2018 stress test methodology for exposures

[42] Other market risks are negligible in the case of Ireland.

held in the trading portfolio. The market impact from full revaluation of equity holdings is subject to the following constraint:

$$\Delta \text{Eq} \leq 1.5 * (-0.20\% * (Eq^{Long} + Eq^{Short}))$$

where the VaR scaling factor has been set to the upper bound of 1.5, and the trading position includes the fair value of long positions (assets) offset by the short positions (liabilities) in equity instruments in the trading book.[43]

**43. The distribution of profit is subject to the following assumed dividend policy.** Dividends are assumed to be paid out at a rate of 25 percent of current period net income after taxes by banks that are making profits (i.e., only if net income is positive) and in compliance with supervisory capital requirements. Banks are not allowed to issue new shares or make repurchases during the stress test horizon.

**44. The scenario-based solvency stress test confirmed Irish banking sector's resilience to severe macro-financial shocks, while revealing pockets of vulnerabilities as the economy exiting from the pandemic support** (Table 5).[44]

- **The baseline scenario confirmed banks strong capital position with further capital accumulation.** Both retail and large international banks would see their fully loaded capital ratio trending upwards, from 16.4 percent to 17.8 percent for retail banks and 19.9 percent to 27.9 percent for large international banks, with no banks falling below the hurdle rates.[45] The slower accumulation of capital for retail banks relative to large international banks reflects their low pre-provision income fettered by limited income generation capacity.

- **The adverse scenario confirms banks' resilience when facing severe yet plausible adverse shocks, with higher impact on retail banks.** Although the adverse scenario exerts significant impact on bank capital ratios, no banks would see their capital ratio failing below the hurdle rates, supported largely by the initial high capital position for both retail and large international banks, as well as the high pre-provision income[46] generation by the large international banks. On aggregate, CET1 ratio declines by about 6.7 percentage points for retail banks and 0.4 percentage point for large international banks by the 5th year. When looking at the trough,

[43] The gross position of the equities in the trading book (both long and short position) stands at 0.4 percent of the total asset or 5 percent of the total CET1 capital and thus is considered immaterial. Similarly, the net exposure is smaller and below 1 percent of both total asset and total CET1 capital.

[44] As the starting point is in the middle of the Covid pandemic period, the data are subject to a degree of variability, reflecting different approaches to provisioning by individual banks.

[45] Hurdle rates used are: (i) CET1: 4.5 percent plus O-SII buffer; (ii) Tier 1: 6.0 percent plus O-SII buffers; and (iii) CAR: 8 percent plus O-SII buffer. Capital conservation buffer is allowed to be used under the adverse scenario. There is currently no countercyclical capital buffer (CCyB) imposed on Irish banks. For more details see the Central Bank note.

[46] The pre-provision income refers to income before loan loss provisions and profit transfer to the parent entities. Profit transfers to the parent entities come from after-tax profits.

the capital depletion can reach to 7.2 and 2.3 percentage points for retail and large international banks, respectively. Retail banks experience higher capital depletion than large international banks due to lower initial capital position, larger holdings of domestic corporate portfolios with higher share of CRE loans, as well as lower pre-provision income to offset losses under stress. As a result, the distribution of ending CET1 ratios in retail banks is generally lower, ranging from 6 to 16 percent, relative to large international banks, from 12 to 27 percent. Within the retail banking group, two banks experience larger capital depletion than the rest of the banks. Credit risk provisioning is the largest contributor to the decline in capital ratios at the system level, amounting to about 7.4 percentage points, followed by interest rate risks (1 percentage point), risk weighted assets (0.6 percentage point) and market risks (0.4 percentage point).[47,48] Finally, the credit loss contribution also differs between banking groups, with corporate and NBFI recording the highest losses for retail banks and larger international banks, at 77 and 87 percent of total credit losses for each group, respectively.

[47] The impact from market revaluation risks considers banks' existing hedging strategy, as the majority of the holdings of the debt securities booked under the fair value categories (about 80 percent) are used for liquidity purpose and therefore are swapped out against large pricing volatilities.

[48] Dividend distribution also contributes to aggregated capital depletion by about 0.7 percentage point in the adverse scenario, primarily driven by profit generated by the large international banks.

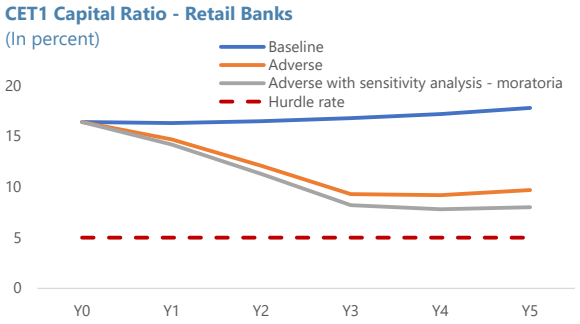
## Table 5. Ireland: Result of Scenario-Based Stress Test

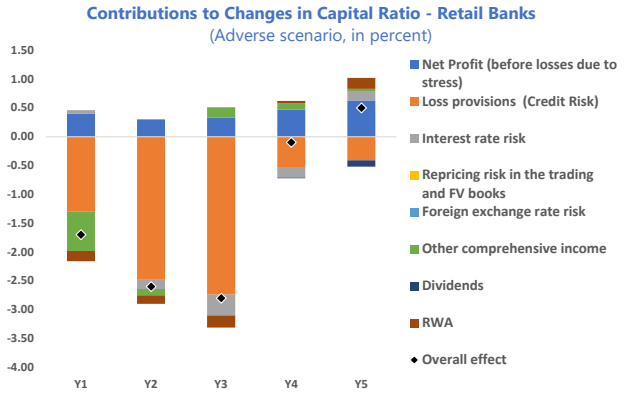
| | Scenario | Average CET1 ratio[1] (percent) All banks in group | Number of banks with CET1 ratio < 4.5% + OSII | Number of banks with T1 ratio < 6% + OSII | Number of banks with CAR < 8% + OSII | Asset share of undercapitalized banks (CAR < hurdle) (percent) | Max capital shortfall vis-à-vis CET1 capital thresholds (percent of GDP) | Average leverage ratio[2] (percent) All banks in group |
|---|---|---|---|---|---|---|---|---|
| Retail | 2021-Q2 | 16.4 | 0 | 0 | 0 | 0 | 0.0 | 7.9 |
| | Adverse, trough | 9.2 | | | | | | 4.6 |
| | Adverse, 2026-Q2 | 9.7 | 0 | 0 | 0 | 0 | 0.0 | 4.6 |
| | Adverse sensitivity analysis - Moratoria, 2026-Q2 | 8.0 | 1 | 1 | 0 | N/A | 0.2 | 4.0 |
| Large international | 2021-Q2 | 19.9 | 0 | 0 | 0 | 0 | 0.0 | 8.5 |
| | Adverse, trough | 17.6 | | | | | | 7.3 |
| | Adverse, 2026-Q2 | 19.5 | 0 | 0 | 0 | 0 | 0.0 | 7.5 |
| | Adverse sensitivity analysis - Moratoria, 2026-Q2 | 19.2 | 0 | 0 | 0 | 0 | 0.0 | 7.4 |
| Total | 2021-Q2 | 18.0 | 0 | 0 | 0 | 0 | 0.0 | 8.2 |
| | Adverse, trough | 13.2 | | | | | | 5.9 |
| | Adverse, 2026-Q2 | 14.5 | 0 | 0 | 0 | 0 | 0.0 | 6.0 |
| | Adverse sensitivity analysis - Moratoria, 2026-Q2 | 13.4 | 1 | 1 | 0 | N/A | 0.2 | 5.6 |

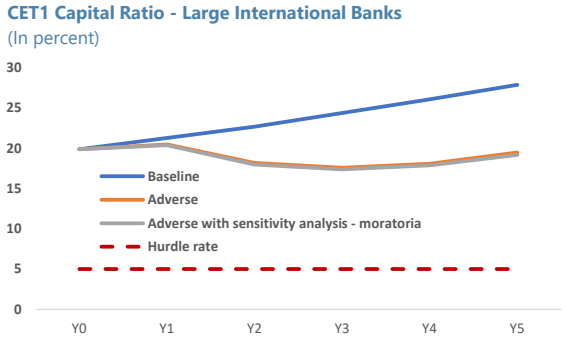
[1] CET1 ratio represents fully-loaded weighted average capital ratio. Tier 1 and total capital ratio represent ratios in absence of the IFRS9 transitional arrangement.

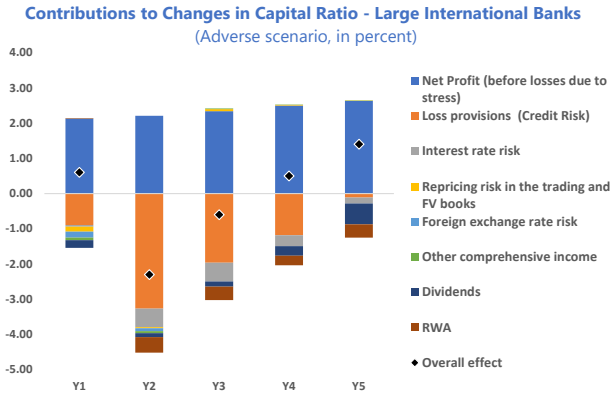
[2] Leverage ratio is proxied by Tier1 capital divided by total assets (non-risk weighted).

Note: Data represents stress testing sample which is a subset of the entire Irish banking sector.




Source: IMF staff.

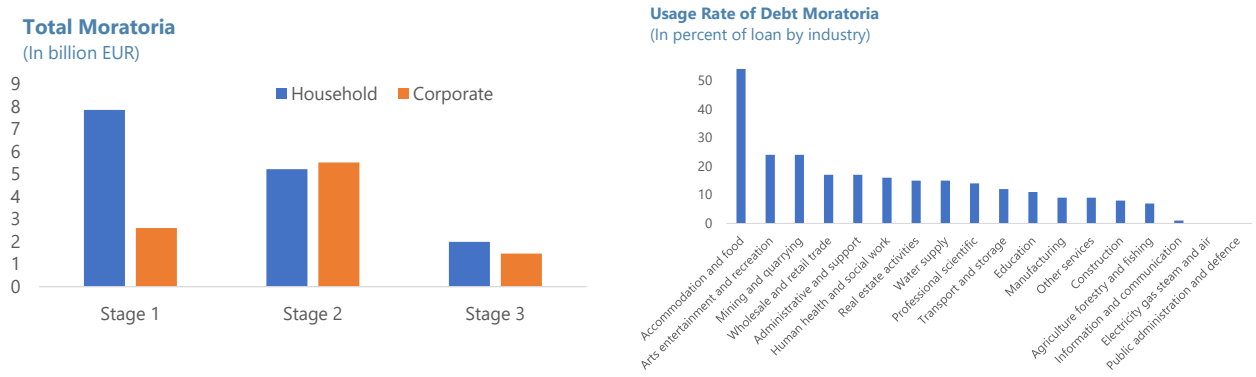
Note: Data correspond to the stress testing bank sample, which is a subset of the full banking sector. Hurdle rates in the figures are displayed as minimum CET1 ratio plus the average of the bank specific O-SII buffers.

## E. Sensitivity Analysis of Retail and Large International Banks

**45. Although loan payment moratoria have now largely expired, the initial take-up rate tended to be high in the riskier segments** (Figure 21). Additionally, households and businesses benefited from a significant and broad policy support package during the pandemic, largely in the form of direct income support, some of which continued until Spring 2022. The end of the policy support warrants close monitoring of loans as borrowers exit various support programs. In response to the COVID-19 pandemic, Irish retail banks have provided over €24 billion of payment breaks to both households and corporates, of which 99 percent have now expired. Although the majority have returned to full payments, a notable share of stage 2 and 3 assets previously under moratoria have been recorded. For instance, as of mid-2021, 40 percent of mortgages in stage 2 were previously under moratoria,[49] as opposed to corporate loans at 23 percent. Among the total, about 40 percent of mortgage balance with payment breaks had some forbearance history. Loans subject to public guarantees, however, is much lower, with the majority remaining in stage 3.

**46. Sectors severely impacted by the pandemic benefited the most from payment breaks** (Figure 21). It is evident that contact intensive sectors, such as hospitality, entertainment, and real estate activities, were hardly hit financially by the lockdown measures imposed due to the pandemic. Therefore, it is unsurprising that they are also showing high levels of usage of the payment breaks, with the take-up rate for accommodation and food registering at 54 percent, followed by entertainment and recreation (24 percent) and real estate activities (15 percent). This not only confirms the higher risk profile of corporate portfolios subject to payment breaks but also underscore the importance of monitoring and identifying any solvency and liquidity implications of these segments that could pose risks to the financial stability going forward.

**Figure 21. Ireland: Take-up of Bank-facing COVID-19 Support Measures**




Sources: CBI.
Note: Data as of May 2021, based on consolidated banking data for the Irish domestic banks.

[49] The share reflects payment breaks (numerator) and loans (denominator) granted in both Ireland and jurisdictions outside of Ireland.

**47. Against this backdrop, a streamlined sensitivity analysis was performed on top of the scenario-based stress test to gauge the impact of the end of payment breaks and broad policy support on bank capital positions.** The analysis assumes a further deterioration of the credit portfolios with expired moratoria under stage 1 and stage 2 category, by allowing partial flows of these exposures from high quality to low quality buckets in a smooth manner. The analysis was considered as an add-on component on top of the adverse scenario as the materialization of such additional flows is more likely when intersecting with a protracted economic downturn. Specifically, the additional flows are quantified as the following:

- 50 percent of the credit portfolios with expired moratoria under stage 2 category is assumed to flow to stage 3 category evenly across a 5-year horizon.
- 50 percent of the credit portfolios with expired moratoria under stage 1 category is assumed to flow to stage 2 category evenly across a 5-year horizon.

A partial flow of 50 percent was assumed to avoid potential double counting in the event that part of the for stage 1 and stage 2 assets would already face repayment difficulties due to the assumed macro-financial shocks in the adverse scenario. In addition, this assumption allows the remaining portion of loans to either stay within their current category or flow back to a higher quality category (e.g., from stage 2 to stage 1) as some borrowers may still be able to return to full repayment even being hit by both the initial Covid-19 shock and the additional adverse shock after the policy support ends.

**48. The results under these assumptions paint a slightly more adverse picture, warranting continued monitoring of credit quality as supportive policies fully unwind.** The additional credit impairment resulting from the lingering impact on portfolios that have previously benefitted from payment breaks brings additional 110 bps CET1 depletion to the adverse scenario, leading to one retail bank falling below the CET1 and Tier 1 hurdle rates, with the maximum capital shortfall against CET1 hurdle rate amounting to about 0.2 percent of GDP. These findings underline the importance of continued monitoring of portfolios that benefited from payment breaks and broader policy support to ensure banking sector resilience with the phase-out of supportive policies.

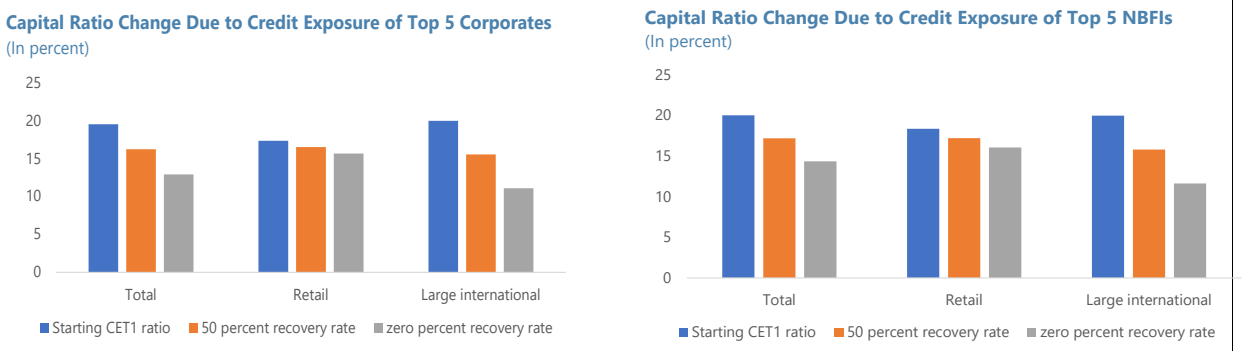
**49. The FSAP also assessed concentration risks of retail and large international banks using data as of mid-2021** (Figure 22). Concentration risk was tested by assessing the impact to bank's capital from the simultaneous default of their largest exposures. The test assessed banks' resilience under the assumption of a simultaneous hypothetical default of the five largest borrowers of each bank. The analysis also allows distinction of large exposure between non-financial corporations and nonbank financial institutions to address Irish international banks' specific vulnerabilities stemming from exposure to SPVs and FVCs. The results are as follows:

- Using a zero-recovery rate which is considered as a more stringent assumption, the simultaneous default of the five largest NFC borrowers would cause the aggregate CET1 ratio of sample banks to decline by 6.6 percentage points from 19.5 percent to 12.9 percent, with large international banks experiencing higher depletion (8.9 ppts) than retail banks (1.7 ppts). No

banks would see their CET1 ratio below the 4.5 percent threshold. The default of the five largest NBFIs shows milder impact, with CET ratio decline by 5.7 percentage points, with large international banks at 8.3 ppts relative to retail banks at 5.7 ppts.

- Using a provisioning rate of 50 percent, the simultaneous default of the five largest NFC borrowers would cause the aggregate CET1 ratio of sample banks to decline by 3.3 percentage points from 19.5 percent to 16.2 percent, with large international banks experiencing higher depletion (4.4 ppts) than retail banks (0.8 ppts). No banks would see their CET1 ratio below the 4.5 percent threshold. The default of the five largest NBFIs shows milder impact, with CET ratio decline by 2.8 percentage points, with large international banks at 4.2 ppts relative to retail banks at 1.2 ppts.

**Figure 22. Ireland: Concentration Analysis**
(Retail and large international banks)



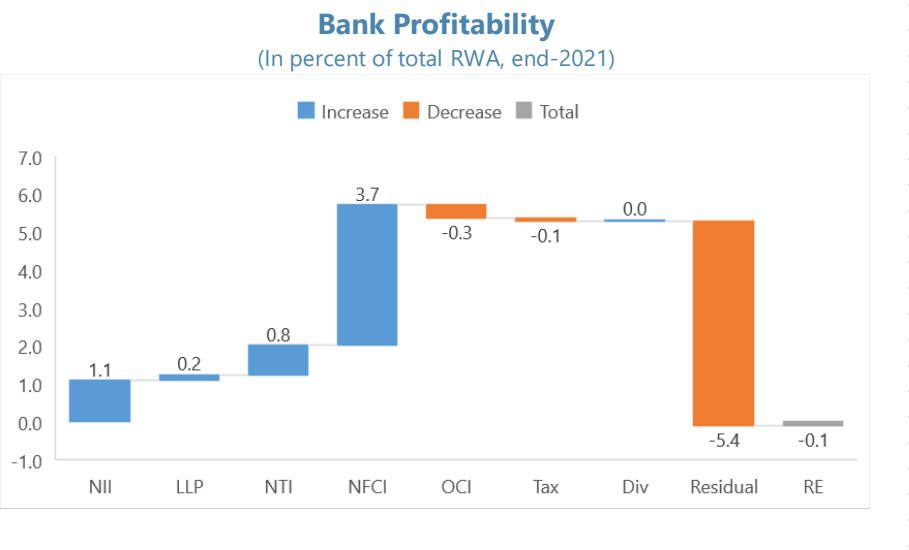

Sources: FINREP, COREP, IMF staff estimates.

## F. Sensitivity Analysis for Other International Banks

**50. Other international banks in Ireland (all LSIs) are identified as having diverse business models and sources of profitability.** In addition to their non-systemic size, their diverse business models motivated a streamlined and tailored stress testing approach based on sensitivity analysis of major P&L drivers. The analysis targeted 4 out of 9 foreign owned LSIs that have a wide EU presence and serve global clients. A few banks in this segment are in the process of business model transformation to enhance their competitiveness, relevance, and resilience following the pandemic and Brexit. The diverse and dynamic business models implies that banks can obtain income from various sources, ranging from reliance on fees and commission income from custodian services to inflow and outflows of trading income from derivative transactions, as well as gains or losses associated with off-balance sheet exposures. As of end-2021, net fees and commission constitutes 3.7 percent of the total RWAs, followed by net interest income (1.1 percent), net trading income (0.8 percent) and loan loss provisions (0.2 percent). The residual component, of which around 90 percent is administrative expenses (staff expenses and other overhead costs), is the largest cost driver, registering a -5.4 percent of total RWAs, followed by other comprehensive income

(-0.3 percent). Together, the compressed revenue and high cost-base have led to an overall loss and capital depletion of about 0.1 percentage point of RWA in 2021 (Figure 23).

**Figure 23. Ireland: LSI Profitability**




Source: ECB, CBI and IMF staff estimate.
Note: NIM = net interest margin, NTI = net trading income, NFCI = net fees and commission income, LLP = loan loss provision, OCI = other comprehensive income, Div = dividends, RE = flow to retained earning

**51. To better address vulnerabilities for each income source, a streamlined sensitivity analysis was performed on all P&L components.** Net profit was decomposed into five subcomponents, each representing an income or cost driver, which were then were transformed into corresponding P&L ratios as defined in Figure 24. Leveraging methodology adopted in the global banking stress test[50] and historical time series of each ratio between 2008 and 2020, the sensitivity analysis tests banks' capital adequacy by imposing a lower bound (10 percentile) of the historical distribution of net interest margins, net trading income ratios and net fees and commission income ratios, and an upper bound (90 percentile) of net loan loss ratios. A pre-defined ad-hoc conversion factor was set at 50 percent to convert off-balance sheet credit exposure onto balance sheet to simulate additional credit losses under stress.

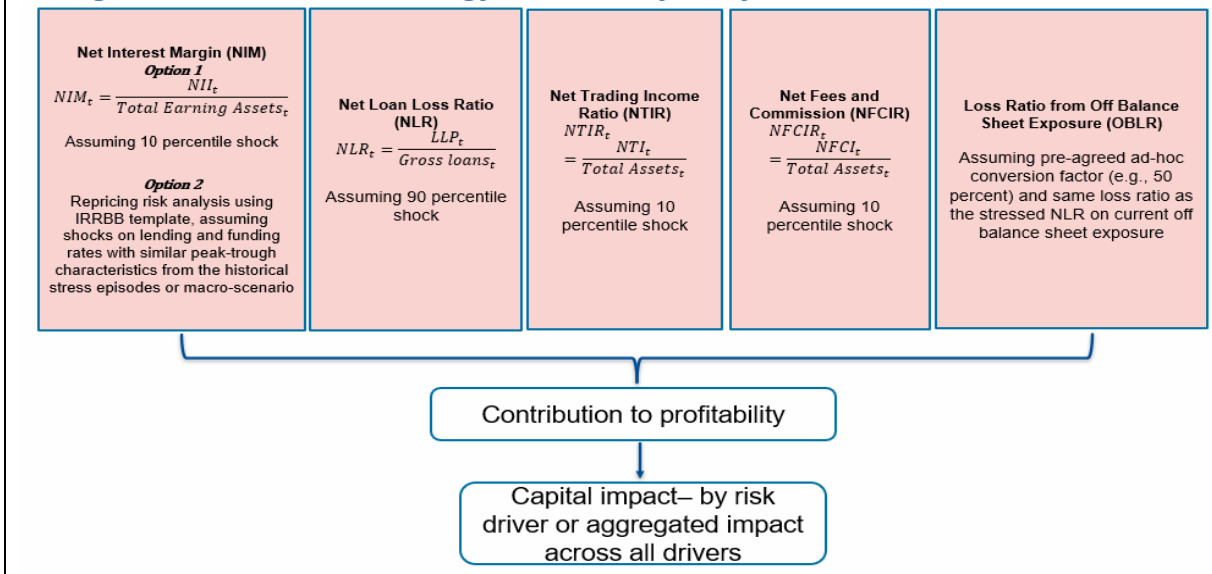
**52. The analysis was also complemented by a structural approach for assessing interest rate risks in the banking book.** In addition to directly shocking net interest margins, interest rate

[50] For details of the global banking stress test see the IMF Departmental Paper.

risks were also assessed using the maturity ladder approach specified in the scenario-based stress test. Total sensitive asset and liabilities subject to repricing were obtained from bank specific IRRBB templates provided by the CBI. Shocks to interest sensitive assets and liabilities were calibrated using historical time series of interest rates on total loans and liabilities and were selected at the 10th percentile of the change of historical interest rate spreads measured as aggregated lending rates minus funding rates, simulating a decompression of net interest margins. The final step multiplies the sensitive asset and liabilities and their corresponding rate shocks within each repricing bucket to derive losses associated with repricing risks.

**53. The sensitivity test using single factor shocks confirms diverse profitability drivers across other international banks** (Figure 25). On aggregate and relative to the baseline as of mid-2021, losses from net fees and commissions represents the largest loss contributor, registering a 3.1 percentage point decline in capital ratios, followed by credit risks (2.5 ppts), interest rate risks (0.9 ppts) as well as trading risks (0.6 ppts). Off-balance sheet exposure also contributes to a non-negligible amount of capital depletion of 0.5 ppts. Interest rate risks measured under the traditional structural approach recorded similar level of loss contribution of 1.4 ppts, broadly consistent with the outcome under ratio-based approach. The aggregated results mask a high degree of heterogeneity across banks, as the bank specific capital impact, when summing impact from all risk factors, can range from 2.3 to 27.3 percentage points relative to the baseline, signaling some bank specific vulnerabilities to downside risks. No bank, however, would see its capital ratio falling below the hurdle rates, defined as 4.5 CET1 ratio, thanks to their high initial CET1 buffers.[51]

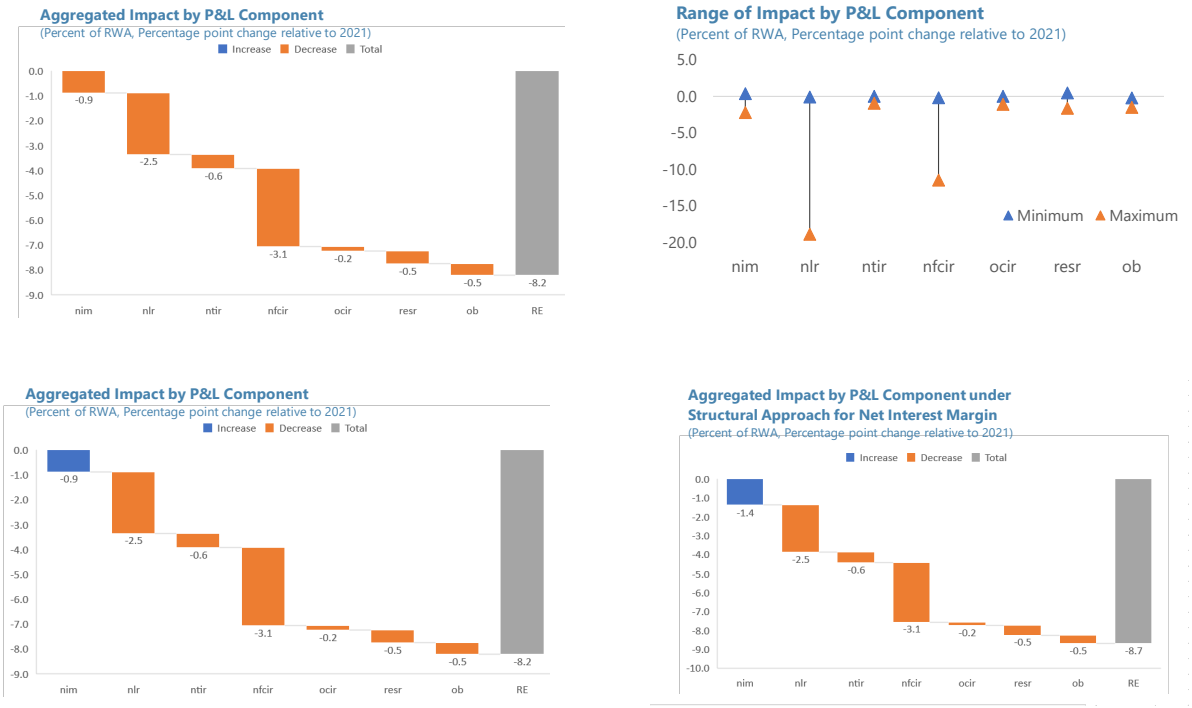
**Figure 24. Ireland: Methodology of Sensitivity Analysis for Other International Banks**




Note: The formulas use high-level denominators, such as gross loans and total assets, instead of performing loans and trading securities, to ensure data quality and maximize time coverage.

[51] Given the non-systemic nature of the other international banks, no banks in this group are subject to G-SII or O-SII buffers. Pillar II requirement is not considered under the stress conditions consistent with other bank segments analyzed above.

**Figure 25. Ireland: Result of Sensitivity-Based Stress Test for Other International Banks**




Source: CBI and IMF staff.
Note: nim=net interest margin, nlr=net loss ratio, ntir=net trading income ratio, nfcir=net fees and commission income ratio, ocir=other comprehensive income ratio, resr=remaining P&L ratio, ob=off-balance sheet exposure, RE=flow to retained earnings.

# BANK LIQUIDITY RISK ANALYSIS

## A. Introduction

**54. Three distinct liquidity stress tests were conducted to assess bank capacity to withstand large withdrawals of funding and market liquidity shocks.** The FSAP team performed LCR, cash-flow based, and NSFR stress test for five retail banks, three large international banks, and four other international banks. The LCR-based stress test measured bank ability to meet short-term liquidity needs in a 30-day horizon against the initial level of high-quality liquid assets (HQLA). The cash-flow based stress test leverages information on maturity profile over a 12-month horizon to investigate potential maturity mismatches and the assess the availability of bank counterbalancing capacity to offset net-cash outflows. The NSFR limit of 100 percent, which became binding in June 2021, was used on the NSFR stress test to gauge structural long-term refinancing and funding risks.

**55. The liquidity stress tests rely on multiple data sources.** The main LCR, NSFR and cash-flow based stress tests were based on COREP reports as of mid-2021. To complement the main

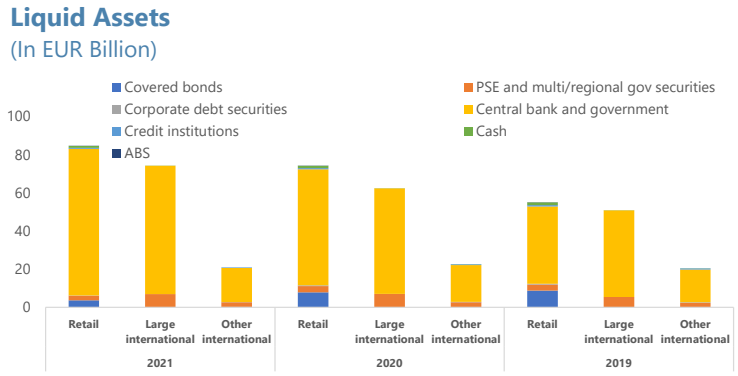
stress test, comparison on liquidity position between 2019 and 2021 was performed to assess the buildup of liquidity buffers since the pandemic. Data on resident and non-resident deposits was also taken from CBI supervisory templates to assess vulnerabilities arising from reliance on cross-border funding.

**56. The liquidity stress tests used different thresholds. The LCR and NSFR based stress test** used a 100 percent threshold, which is the minimum regulatory requirement as of mid-2021. The cash-flow based stress test used the amount of counterbalancing capacity as the threshold to assess the resilience of banks, with negative amounts indicating bank failure in the test.

## B. Liquid Assets and Funding Structure

**57. The initial position confirms that the banks' liquidity profiles are broadly comfortable.** Since the outset of the pandemic, public liquidity supports, either through outright liquidity injection via central bank liquidity facility or low-cost long-term financing to banks, have been the key instruments to improve liquidity position of the banks. Liquidity support to households and corporates, via lending schemes, direct grants, unemployment benefits and wage subsidies, have also indirectly contributed to the build-up of consumer deposits and bank liquidity buffers. Coupled with tightened lending standards and intensified risk aversion of banks amid the pandemic, the freshly injected liquidity has been mostly placed with the central bank as high-quality liquidity assets (HQLAs), thus significantly boosting liquidity indicators of the banking system (Figure 26). Loan-to-deposit ratio remains low at 86 percent, with large international banks at 89 percent, higher than domestic retail banks (75 percent).

**Figure 26. Ireland: Liquid Assets**



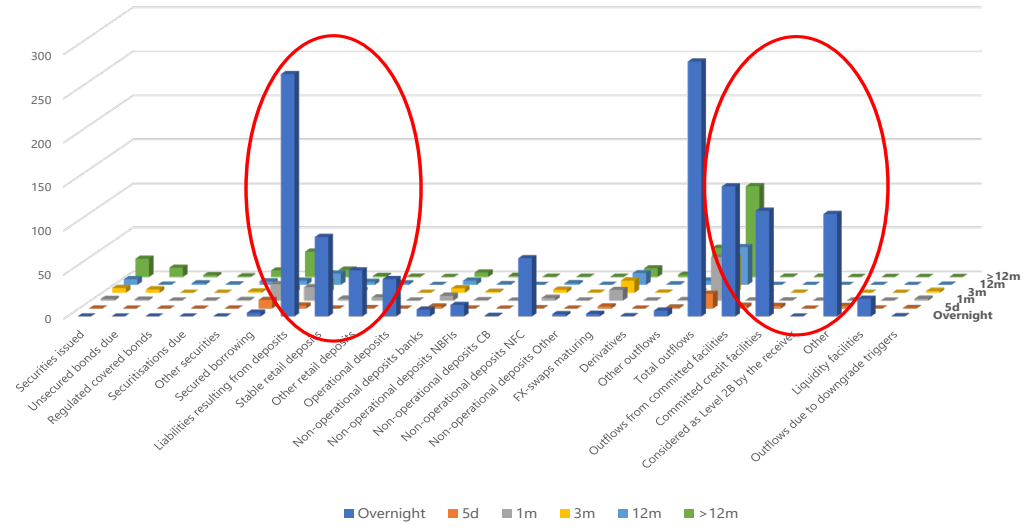

Source: ECB, CBI and IMF staff estimate.

**58. Maturity mismatches may expose banks to liquidity shortfalls in a sustained liquidity stress environment** (Figure 27).[52] On aggregate, banks obtain most of their funding through both wholesale and retail deposits, of which 77 percent were placed within the overnight bucket. On the asset side, over 50 percent of cash inflows would materialize beyond the first three months. This leads to a maturity mismatch characterized by a more frontloaded cash outflows and backloaded cash inflows, potentially leaving banks vulnerable to liquidity gaps under sustained liquidity stress over longer term. International banks, which rely more on non-resident deposits (88 percent of total deposits) and hold large amount of contingent liabilities (€108 billion or 40 percent of total contractual outflows within 12 months), can be particularly vulnerable to large deposit outflows and drawdown of credit lines. These observations underline the need of continued monitoring of banks' maturity structures and off-balance sheet exposures to promptly identify and address potential liquidity strains over the short- and long-term horizon.

[52] It is worth noting that banks' ability to push their mismatches out to beyond one month is not an unreasonable liquidity risk management approach.

## Figure 27. Ireland: Bank Contractual Cashflows and Funding Profile

**Maturity Bucket - Outflows**
(In EUR Billion)




**Maturity Bucket - Inflows**
(In EUR Billion)

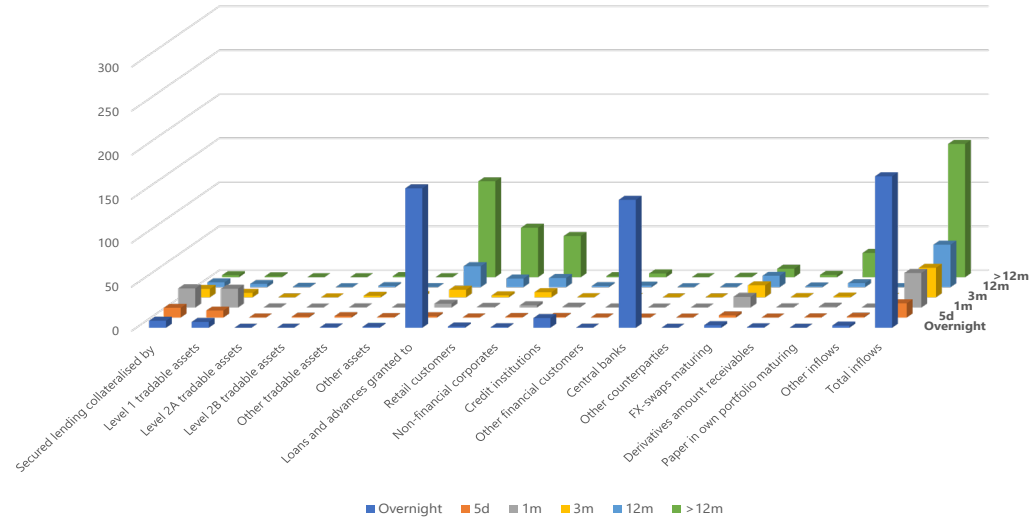
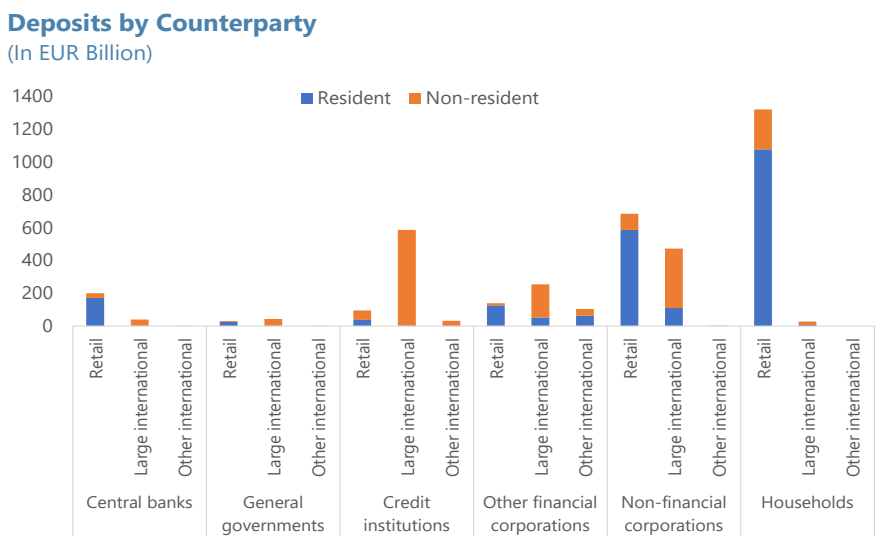


**Figure 27. Ireland: Bank Contractual Cashflows and Funding Profile** (Concluded)

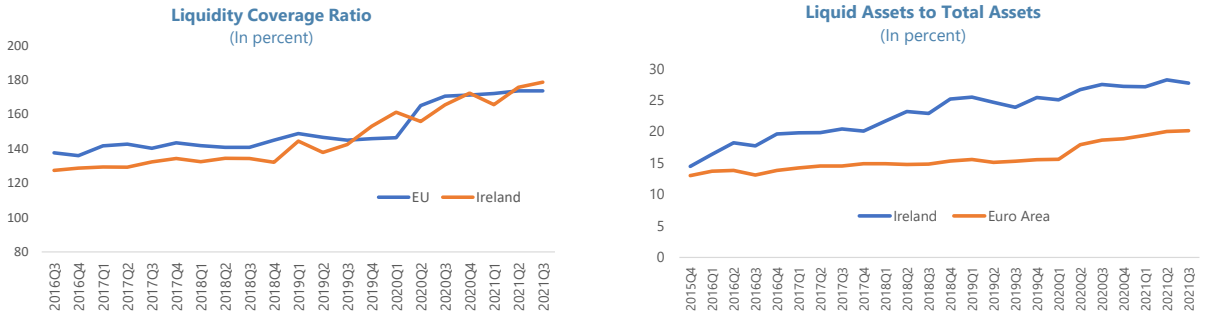



Sources: ECB, CBI and IMF staff estimate.

## C. LCR-based Liquidity Stress Test

**59. LCR for Irish banks has been significantly boosted since the outset of the global pandemic** (Figure 28). On aggregate, the LCR for Ireland has increased from 153 percent at end-2019 to 179 percent at mid-2021, buoyed by the high-quality liquidity buffers accumulated during the pandemic. Banks' total assets have also increased by about 17 percent since 2019. The balance sheet expansion, coupled with continued bank deleveraging, has led to a gradual pickup of the liquid assets to total assets ratio from 25 to 28 percent over the same period, and stands well above the regional euro area average at 20 percent as of mid-2021.

**Figure 28. Ireland: Liquidity Indicators**



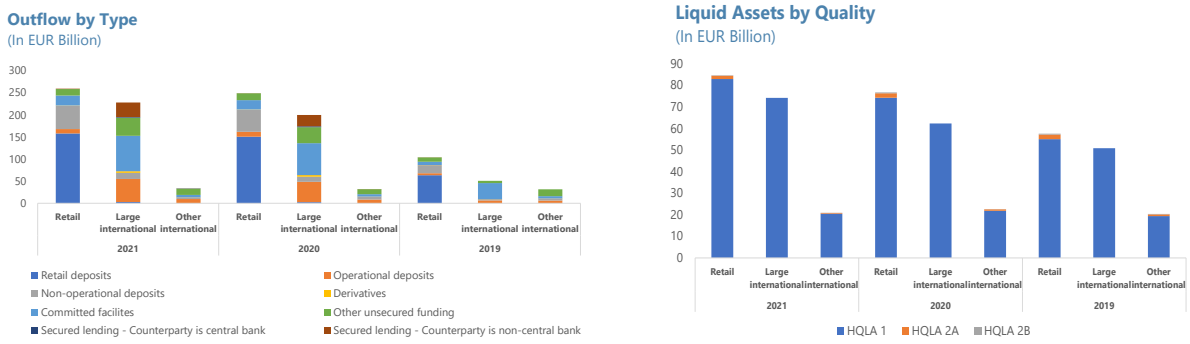

Sources: ECB.

Note: Data represents the entire Irish banking sector and thus different from the banking sample covered under the stress test.

**60. The funding profile of banks reflects their diverse business models and market orientation.** Retail deposits, which are more stable from an LCR perspective, accounts for 61 percent of retail banks' total funding. In contrast, international banks, which rely more on wholesale funding from intra-group and cross-border interbank transactions, hold a disproportionally higher share of deposits from credit facilities (35 percent), operational deposits (22 percent) and other unsecured funding (14 percent), with little reliance on retail deposits (1 percent). Since 2019, contractual outflows have increased notably for retail banks and large international banks, by €155 billion and €177 billion, while remaining broadly constant for other international banks (€2 billion). This can be explained by differences in funding sources. Since other international banks display higher reliance in on parent funding, the COVID liquidity support measures did not contribute to the expansion of their funding sources.

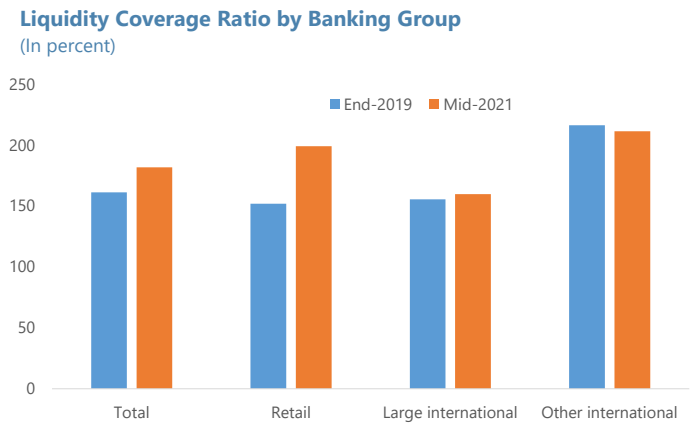
**61. The HQLA of all sample banks are concentrated in HQLA level 1, which indicates high levels of liquidity** (Figure 29).[53] HQLA level 1 comprised 99 percent of total HQLA. Central bank reserves and holdings of sovereign securities are the largest portion of HQLA, accounting for around 60 percent and 38 percent of total HQLA, respectively. While retail and large international banks experienced a sharp accumulation of HQLAs during the pandemic, other international banks have broadly maintained their level of liquid assets, resulting in a relatively more stable LCR during the pandemic.

**Figure 29. Ireland: LCR Component**




[53] The HQLA refers to unencumbered assets. The asset encumbrance ratio is at 15 percent as of mid-2021.

**Figure 29. Ireland: LCR Component** (Concluded)




Sources: ECB, CBI and IMF staff estimate.

**62. The LCR-based stress test was conducted on five retail banks, three large international banks and four other international banks, using four scenarios.**

- The standard LCR scenarios (baseline scenario, S1) applies the standard regulatory parameters as set out by the CRR.
- The retail stress scenario (scenario S2) applies higher run-off rates for retail related claims. The calibration of the run-off rates relies on historical information of deposit volatility in the Irish banking sector as well as parameters used in the past FSAPs within the Euro Area. Under this scenario, banks could use their liquid assets with no additional decline in the market value (the haircut follows the CRR parameters).
- The wholesale stress scenario (scenario S3) applies higher run-off rates for wholesale related claims. The calibration of the run-off rates relies on historical information of deposit volatility the Irish banking sector as well as parameters used in the past FSAPs within the Euro Area. Under this scenario, banks could use their liquid assets with no additional decline in the market value (the haircut follows the CRR parameters).
- The retail and wholesale stress scenario (scenario S4) combines scenario 2 and 3 and applies stressed run-off rates for both retail wholesale related claims, whichever is higher. However, in this scenario banks also face haircuts when liquidating assets to meet funding run-offs. The liquid assets haircuts draw on market value declines, which are also informed by the ECB valuation haircut when banks need to repo the liquid assets to the central bank.

Detailed stress parameters for the LCR stress test can be found in Table 6. Non-resident deposits are subject to higher shocks, via unstable wholesale deposits from financial institutions (both cross border banks and NBFIs) and nonfinancial corporations, at around 100 and 50 percent of outflow rates in the most severe scenario, respectively. The calibration the scenarios follows closely past

stress episodes drawing from historical time series, previous FSAP stress parameters and regional experience in liquidity outflows in the Euro Area, as well as IMF expert judgement.

**Table 6. Ireland: LCR Stress Test Parameters**

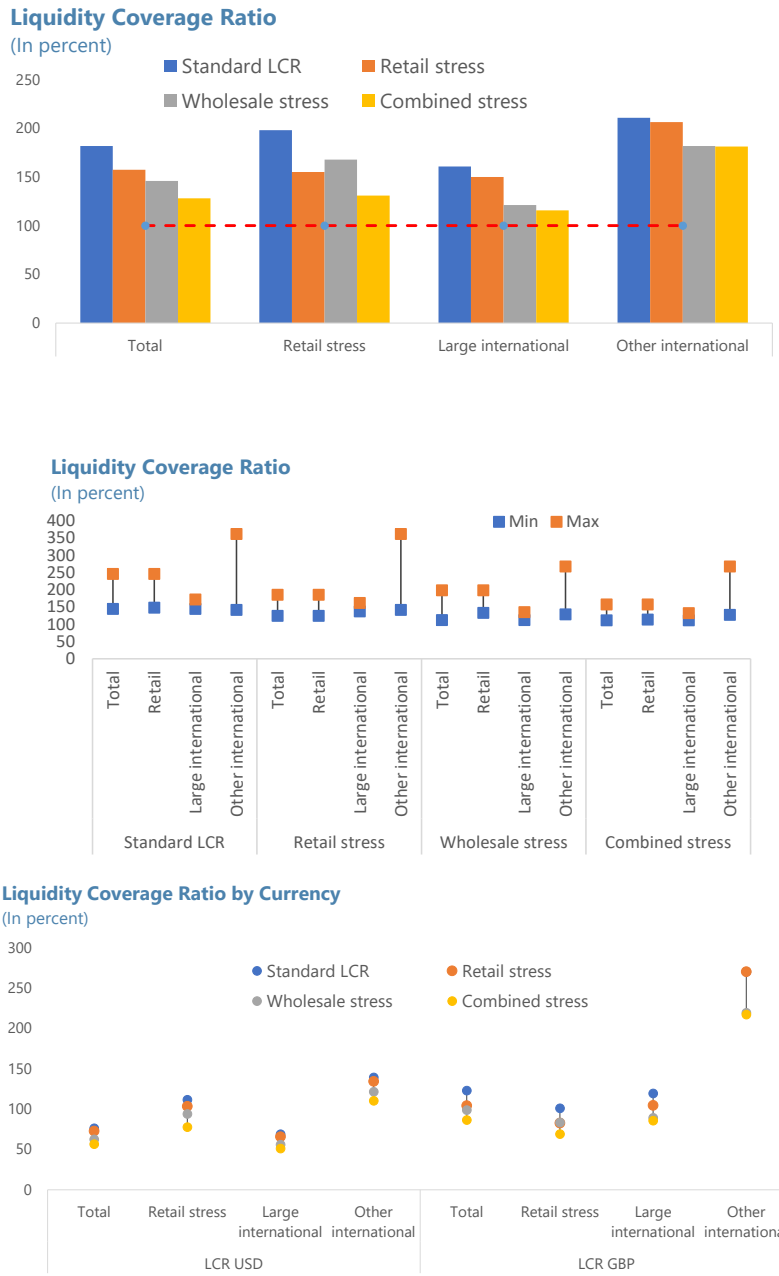
| Parameter | Position | Scenario | | | |
|---|---|---|---|---|---|
| | | Scenario S1 Regulatory LCR | Scenario S2 Retail run-off scenario | Scenario S3 Wholesale run-off scenario | Scenario S4 Combined run-off + price shock scenario |
| run-off rates | stable retail deposits | 5% | 10% | 5% | 10% |
| | other retail deposits | 10% | 20% | 10% | 20% |
| | opertaional deposits | 5-25% | 5-25% | 15-35% | 15-35% |
| | non-operational deposits | 20-40% | 20-40% | 30-50% | 30-50% |
| | commited facilities to retail customers | 5% | 10-15% | 5-10% | 10-15% |
| | commited facilities to corporate customers | 10-30% | 10-40% | 20-50% | 20-50% |
| change in liquidty assets weights | level 1 assets | no | no | no | -5/0% |
| | level 1 covered bonds | no | no | no | -20/-3% |
| | level 2A assets | no | no | no | -15/-5% |
| | level 2B assets | no | no | no | -25/-5% |

Source: IMF staff.

**63. Result of the regulatory (baseline) LCR-based stress test showed that Irish banks have ample liquidity buffers** (Figure 30). All sampled banks met the minimum threshold of 100 percent as of mid-2021. However, the large international banks appeared to have the lower standard LCR, at 161 percent, relative to retail banks and other international banks, at 198 and 211 percent, respectively. The weaker initial point may be explained by their higher volume of unsecured wholesale funding and contingent liabilities, thus leaving them potentially more vulnerable to adverse shocks. Other international banks enjoyed the highest standard LCR due to their persistently low level of contractual outflows relative to their holdings of HQLAs.

**64. The LCR-based stress test suggests that banks are resilient to adverse liquidity conditions** (Figure 30). On aggregate, domestic and international banks saw meaningful declines of the LCR ratio across stress scenarios, with retail banks experiencing larger impact under the retail scenario and international banks facing higher stress under the wholesale scenario. The lower initial level of LCR for large international banks brought this group closer to the threshold under stress. Other international banks experience less severe impact relative to other groups. Nonetheless, all banks are able to withstand the most severe shock within the 30-day window, underpinned by the high initial level of liquidity buffers built up since the pandemic.

## Figure 30. Ireland: Results of the LCR-Based Stress Test




Source: IMF staff.
Note: The LCR by currency calculations include off-balance sheet exposures which mainly consists of credit lines and FX-related derivative transactions. In line with EBA reporting instructions, inflows/outflows in the LCR of significant foreign currencies include principal exchange on FX derivative contract whereas the aggregate LCR reports FX derivative flows on a net basis. Such differences may contribute to a lower initial level of LCR for individual foreign currencies compared to the aggregate LCR.

**65. An LCR-based stress test was also conducted for several major foreign currencies.** Using same assumptions as the total currencies stress test, a separate LCR-based stress test was conducted on bank foreign currency positions, for U.S. dollar and Sterling separately. Banks are not required to meet a foreign currency LCR threshold, but the exercise was carried out in order to assess banks' liquidity resilience in a foreign currency-based stress scenario. Out of the total banking sample, seven banks report LCR in U.S. dollar while six banks report LCR in Sterling. Three banks (mostly retail banks) do not have significant positions in either currency, and therefore were not included in the exercise.

**66. The LCR-based stress tests for significant foreign currencies reveal pockets of vulnerabilities of banks to U.S. dollar and Sterling denominated outflows.** International banks, having a lower LCR starting point in U.S. dollars with two banks already below the 100 percent threshold as of mid-2021, experience higher stress than retail banks across all scenarios. The rate of the depletion, however, appears to be milder for international banks than for retail banks, suggesting the main driver comes from the weaker initial position of the former, possibly explained by non-trivial off-balance sheet exposure and reliance of funding of these international subsidiaries from their parents. Using similar assumptions and scenarios, and with one bank in each group already below the 100 percent threshold, the Sterling based LCR saw a lower starting point and a higher depletion rate for the retail banks across all stress scenarios, suggesting higher vulnerability of the retail banks to Sterling funding shocks and consistent with the evidence of concentrated lending and funding exposure of the retail banks to the U.K. market. These observations underscore the importance of continued monitoring of foreign currency liquidity conditions to promptly identify potential liquidity gaps over the short- and long-term horizon.

## D. Cashflow-based Liquidity Stress Test

**67. The cash-flow based analysis assesses the adequacy of banks' liquid asset to offset large cash inflow and outflow shocks over time.** The cash-flow based analysis focuses on net liquidity position, which is defined as the differences between cumulated net funding gap (sum of inflows minus outflows across maturity buckets) and cumulated counterbalancing capacity (sum of liquid assets across maturity buckets). If the net liquidity position became negative after utilizing the counterbalancing capacity, a liquidity shortfall would be recognized, and banks would not be able to meet further funding withdrawals.

**68. The analysis builds on maturity ladder data in the COREP report as of mid-2021.** The COREP C66.00 template reports contractual cash outflows and inflows based on 21 maturity buckets, from overnight to greater than 5 years. The template also provides details on the source of outflows and inflows with the identification of secured and unsecured funding, as well as initial stock and changes in the counterbalancing capacity over the maturity buckets.

**69. The maturity profile of banks reveals certain level of maturity mismatch**. About 66 percent of total outflows are projected to take place in less than 30 days, with the open maturity bucket holding about 53 percent of total outflows. Retail and corporate deposits (both operational and non-operational) are the main contributor for short-term funding. When including outflows

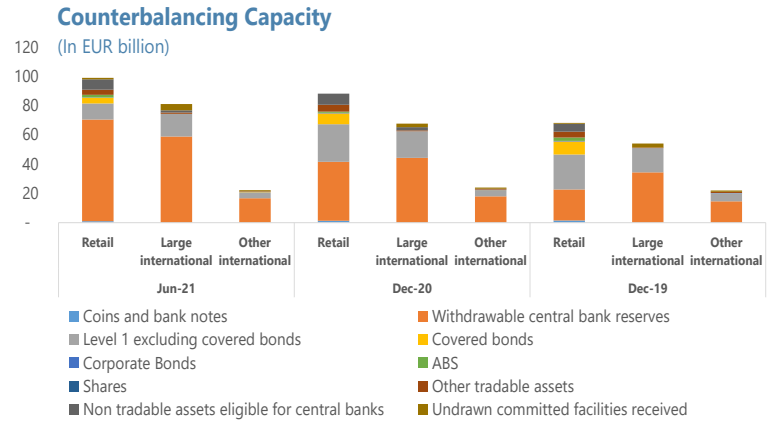
from committed facilities, the share of outflows increases to 73 percent for buckets below 30 days and to 63 percent for the open maturity bucket. For inflows, 50 percent of total inflows is concentrated in loans and advances with maturity longer than 30 days. This implies that banks will rely on the counterbalancing capacity to meet funding shocks for short-term periods. It is also important to note that:

- Around 75 percent of total corporate and retail loans have residual maturities more than 12 months.
- Among total retail and wholesale deposits of the sample banks, 44 percent are non-resident deposits, mostly concentrated in funding from credit institutions (94 percent) and nonbank financial institutions (51 percent) and dominated by international banks.

**70. Central bank reserves have significantly boosted banks' counterbalance capacity since the pandemic underpinned by unconventional public support** (Figure 31). Total cash reserves in the central bank, and marketable securities accounted for 73 percent and 19 percent of total counterbalancing capacity, respectively. Together, they would allow banks to obtain additional cash by either utilizing these reserves or selling liquid assets in the markets or through repo operations with the central bank. To preserve conservatism, upper bound from past Euro Area country FSAPs and ECB haircuts were used as benchmark to calibrate the haircut of the liquid assets.

**71. Outflow and inflow shocks were calibrated based on several working assumptions.** First, higher run-off rates for wholesale funding than retail funding were applied to reflect the first mover advantage of better informed and sophisticated depositors than retail depositors. Second, run-off rates on secured funding sources are lower than unsecured funding sources. Third, non-resident deposits were placed in components subject to higher outflow rate as they are typically treated as unsecured funding source from the stability perspective. Fourth, the inflow parameters are in principle 100 percent of contractual inflows, except for inflows from loans to retail and corporate customers (0 percent).[54] This replicates recent policy responses that allowed the postponement in repayment (debt moratoria) from distressed household and corporate borrowers amid the COVID-19 stress episodes and is consistent with the assumptions

**Figure 31. Ireland: Counterbalancing Capacity**



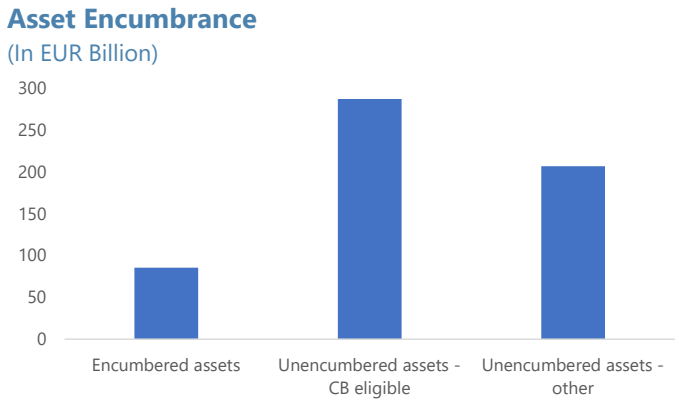

Source: ECB, CBI and IMF staff estimate.
Note: ABS denotes asset-backed securities.

[54] Inflows from loans are computed on performing loans only.

that banks are not allowed to deleverage (i.e., maturing loans are replaced by new loans) under stress testing scenarios.

**72. Low asset encumbrance ratio strengthens banks' liquidity buffers** (Figure 32). At only around 15 percent, the low asset encumbrance ratio could give banks flexibility to further tap wholesale funding market to strengthen their ability to fend of severe funding shocks. 60 percent of the total unencumbered assets, mostly in the form of government securities and equity instruments, are considered as central bank eligible instruments, confirming the high quality of the available pledgeable assets.

**Figure 32. Ireland: Asset Encumbrance**




Source: ECB, CBI and IMF staff estimate.
Note: Sample covers retail and large international banks.

**73. The cashflow liquidity stress test runs a set of embedded scenarios of increasing severity, for 5-days, 4-week, 3 months, and 12-month horizons.** Three stress scenarios with increasing severity (mild market stress, medium market stress and severe market stress) were applied to all three banking groups. Each of the stress scenarios is combined with two different approaches to the counterbalancing capacity.

- Full CBC: fully endogenous liquidity supply by the central bank as long as banks have unencumbered eligible collateral.
- Full CBC with market haircuts: a full CBC is assumed, but market-specific haircuts and bank-specific market price effects are imposed on elements of the CBC.

Detailed stress parameters for the cashflow based stress test can be found in Table 7. Non-resident deposits are subject to higher shocks, via unstable wholesale deposits from financial institutions (both cross-border banks and NBFIs) and nonfinancial corporations, at around 100 and 50 percent of outflow rates in the most severe scenario, respectively. The calibration the scenarios follows closely past stress episodes drawing from historical time series[55], previous FSAP stress parameters and regional experience in liquidity outflows in the Euro Area, as well as IMF expert judgement.

[55] For instance, wholesale deposits combining both operational and non-operational deposits, which are considered as more volatile than retail deposits, were given a higher run-off rate on average close to 50 percent in the most severe scenario, roughly consistent with the peak of the run-off rates of the wholesale deposits observed between 2003 to 2022, at 40 percent. In contrast, household retail deposits are more stable with a maximum runoff at 6 percent observed over the same period, also consistent with the shock parameters set for the stable retail deposit

(continued)

**Table 7. Ireland: Cash Flow Based Stress Test Parameters**

| Type | Item | Range of Run-off Factors (In Percent) across Mild, Medium and Severe Scenarios |
|---|---|---|
| Outflows | Unsecured bonds | 40-100% |
| | Regulated covered bonds | 25-70% |
| | Securitisations and others | 100% |
| | Repos across all asset classes | 100% |
| | Stable retail deposits | 2-10% |
| | Other retail deposits | 5-30% |
| | Operational deposits | 5-30% |
| | Non-operational corporate deposits & other | 20-100% |
| | Derivatives | 100% |
| | Committed facilities | 10-100% |
| | Outflows due to downgrade triggers | 0-100% |
| Inflows | Reverse repos across all asset classes | 100% |
| | Loan inflows from retail and corporates | 0% |
| | Loan inflows from central banks | 100% |
| | Loan inflows from banks and NBFIs | 30-100% |
| | Loan inflows from others | 0-30% |
| | Derivatives | 100% |
| **Type** | **Item** | **Haircut Based on Market Price** |
| Counterbalancing Capacity | Level 1 assets | 95% |
| | Level 1 covered bonds | 90% |
| | Level 2A assets | 85% |
| | Level 2B assets | 50-75% |
| | Other tradable assets | 50% |
| | Non tradable assets | 50% |

Source: IMF staff.
Note: Repos and reverse repo transaction involves inflow and outflow of underlying collateral to be added into existing CBCs, with potential haircut.

**74. Similar to the LCR stress test, the cashflow based stress test were also performed on major foreign currencies.** Using same assumptions as the total currencies stress test, a separate cashflow-based stress test was conducted on bank significant foreign currency positions, for U.S. dollar and Sterling separately, to assess bank capacity in meeting large foreign currency outflows. Out of the total banking sample, seven banks report maturity ladder template in U.S. dollar while six banks report in Sterling. Three banks (mostly retail banks) do not have significant positions in either currency and, therefore, are not included in the sample.

**75. The cashflow-based stress test suggests potential liquidity strains when stress liquidity conditions extend beyond 30-days, with international banks more susceptible to shocks even in the short term** (Figure 33). In general, banks can withstand mild and medium liquidity outflows

category, where most retail deposits were allocated. However, these shock parameters should be treated as a conservative upper bound and, as such, the direct comparison with history should be interpreted with caution due to significant structural changes of bank business models since the GFC.

with their existing counterbalancing capacities over the short-term. However, their liquidity position becomes weaker beyond three months. Additionally, international banks are more vulnerable to liquidity strains even in the short-term due to their larger share of wholesale funding and off-balance sheet exposures.[56] Specifically, under a 5-day stress horizon, decline in CBCs as a share of total assets can range from 7 percent in the mild scenario to 22 percent in the most severe scenario, with higher impact on large international banks, ranging from 8 to 25 percent of total assets. As a result, one large international bank would experience a funding gap within the 5-day horizon under the most severe scenario primarily driven by its high off-balance sheet exposure, albeit with a small liquidity shortfall relative to the total banking system assets (less than 1 percent). The depletion of CBCs increases as shocks persist into longer horizon, reaching up to 12 and 29 percent of total assets under the mild and severe scenario by the end of 12 months, with two retail, two large international and three other international banks experiencing shortfalls up to 4 percent of total sector assets in the most stressful condition. Liquidity shortfalls at the system level, however, appear to be manageable, with only large international banks registering a liquidity shortfall under the most severe scenario at 0.5 percent and 1.8 percent of total sector assets over the 3-month and 12-month horizon, respectively.

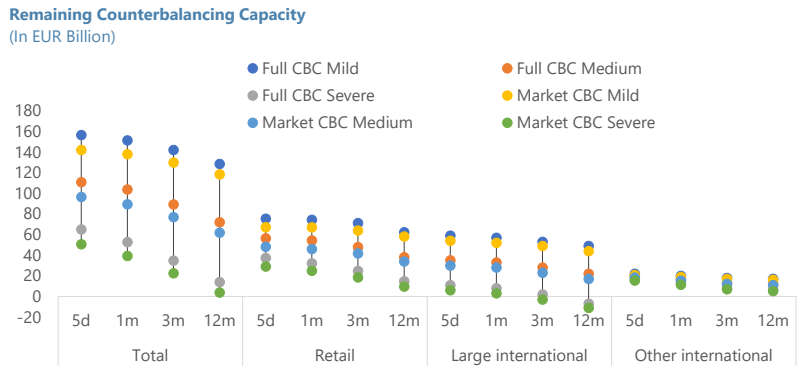
**76. The cash flow-based test echoes findings from the LCR-based stress test on vulnerabilities against foreign currency denominated liquidity shocks** (Figure 33).[57] International banks that rely on wholesale and non-resident parent funding are more vulnerable to dollar denominated funding stress, with net funding gap at the system level reaching to 2 percent of total sector assets under the most severe scenario over a 12-month horizon.[58] The funding gap associated with Sterling denominated outflows appear to be more moderate, peaking at only 0.1 percent of total system assets.

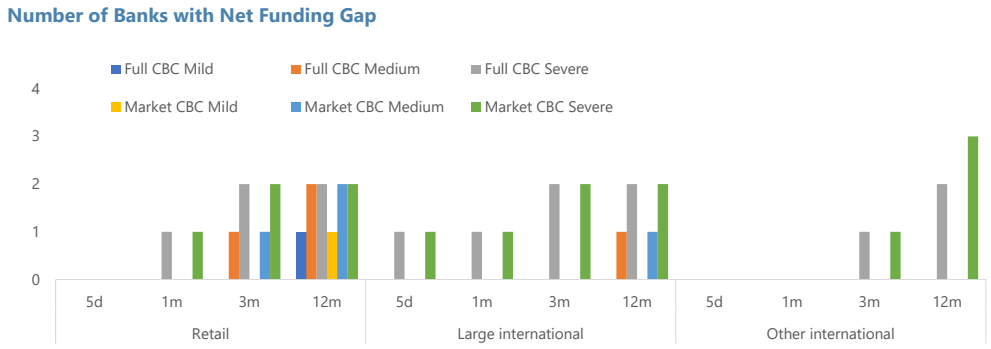
[56] One component of the off-balance sheet items includes the issuance of Insurance Letters of Credit ("ILOCs"), which is the key business line of the one of the large international banks and are similar to traditional trade finance letters of credit. It is approximately 80 percent collateralized on average and therefore is considered by the CBI as less unstable relative to the other components of committed facilities such as credit lines.

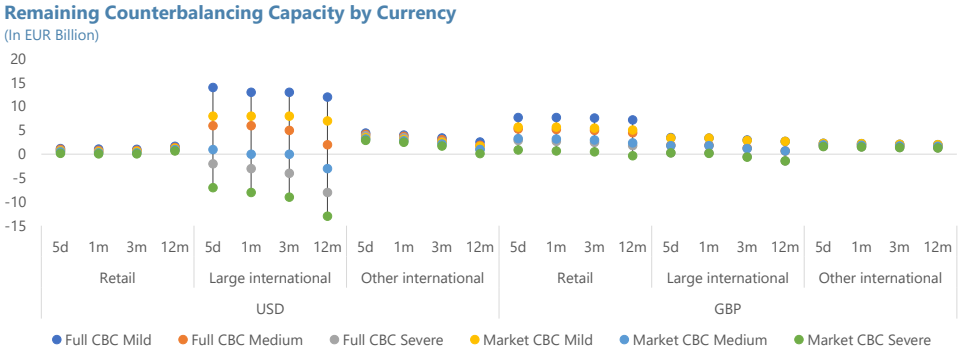
[57] LCR analysis focuses on short term (30 days horizon) whereas cashflow analysis focuses on potential liquidity gaps over the longer term (usually up to 12 months). Although a direct comparison is not feasible due to differences in granularity in the inflow/outflow/HQLA categories, risk horizon and stress testing parameters between the two exercises, they arrive at similar conclusions, such as lower liquidity capacity of large international banks due to large off-balance sheet exposures, as well as weak liquidity position of the banks in significant foreign currencies such as in the U.S. dollar over the one-month horizon.

[58] The liquidity gap identified in significant foreign currencies reflect partly non-structural off-balance sheet risks, such as the triggering of credit and liquidity lines as well as outflows associated with FX-related derivative transactions.

## Figure 33. Ireland: Results of the Cashflow-Based Stress Test



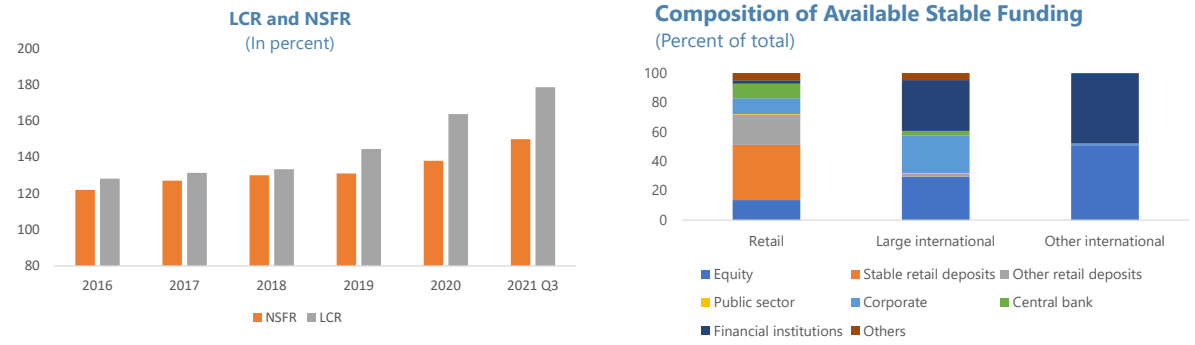




Source: IMF staff.

## E. NSFR-based Liquidity Stress Test

**77. Most banks are well above the NSFR limit** (Figure 34). As of mid-2021, the aggregate NSFR of sample banks stood at 150 percent, comfortably above the minimum requirement of 100 percent with no single bank below the threshold. A volume-based approach was considered in the NSFR-based stress test. The aggregate NSFR has been increasing since 2016 and continue trending upwards during the pandemic under the baseline scenario, supported by high share of retail deposits (mostly treated as stable funding under NSFR regulatory standards) for retail banks and high reliance of long-term corporate and interbank deposits for international banks. The high share of HQLA assets also reflects lower needs of available stable funding (ASF).

**Figure 34. Ireland: NSFR Development**



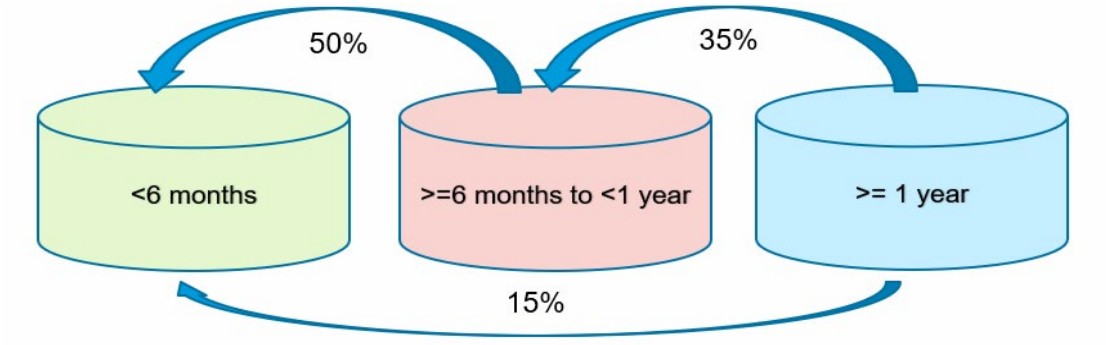

Source: ECB, CBI and IMF staff estimate.

**78. The NSFR stress test adopted a volume-based technique to simulate a migration from long-term to short-term funding.** The focus of stress test is to assess the risks associated with the overreliance on short-term unstable funding and excessive maturity transformation, and to test the resilience of the banks in managing funding risks over a long-term horizon by funding their activities with sufficiently stable sources of funding, in order to prevent systemic liquidity distress and promote funding stability. To this end, the exercise applied pre-defined migration rates from long-term to short-term funding for the following ASF instruments to simulate shocks on funding stability: retail deposits (stable and unstable), liabilities provided by other non-financial customers except central banks, liabilities provided by financial customers and central banks, funding from interdependent liabilities such as relevant credit and liquidity facilities, and other liabilities such as trade payables. Equity instruments were not stressed, assuming banks will not conduct stock transactions such as new issuances or repurchases.

**79. The stress test assumed part of the long-term funding sources would be replaced by short-term funding** (Figure 35). This would require a flow of funding from long-term to short-term maturity bucket, while also allowing a higher migration of funding that is already close to the short-term time bucket. Therefore, the stress test assumed 50 percent of the funding within six- to twelve-month bucket would flow to less than six-month bucket, 35 percent of the funding with more than one year maturity would migrate to the six- to twelve-month bucket, while applying a 15 percent

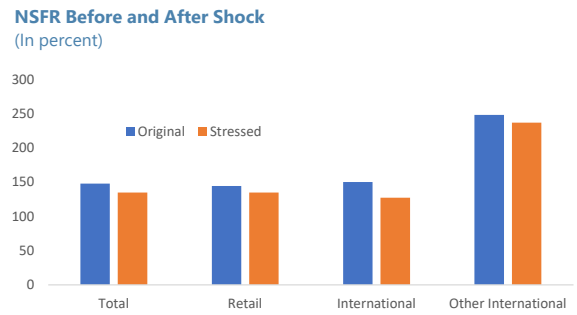
flow rate from over one-year bucket to the less than six-month bucket. The applicable required stable funding and ASF factor, on the other hand, were maintained under the stress scenario.

**Figure 35. Ireland: Methodology – NSFR Stress Test**




**80. The results of the NSFR stress test suggest most banks would be able to maintain a stable funding profile under stress** (Figure 36). The adverse scenario, which simulated a migration of ASF from long term to short term buckets, leads to only one retail bank finding its NSFR marginally below the 100 percent threshold. Comparison across banking groups shows a larger decline of NSFR for large international banks than for retail banks, while other international banks enjoy the highest level of stable funding both before and after the shock.

**Figure 36. Ireland: Results of the NSFR Stress Test**




Source: ECB, CBI and IMF staff estimate.

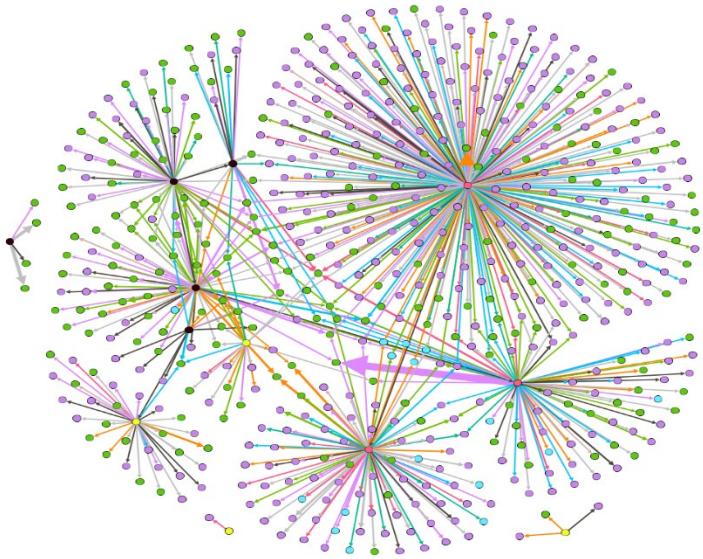
# BANK INTERCONNECTEDNESS ANALYSIS

## A. Interbank and Intersectoral Network

**81. The topology of interbank and bank-NBFI linkages reveals meaningful interconnections between large international banks, cross-border banks, and nonbank financial institutions** (Figure 37). While domestic interbank linkages appear to be limited, the network points to a high degree of connectivity between large international banks and NBFIs, accounting for 45 percent of the total exposures of the large international banks. Around 92 percent of these exposures are with foreign NBFIs (dominated by United Kingdom, France, and the United States) and over 80 percent are classified either as "financial service activities, except insurance and pension funds" or as "activities auxiliary to financial services," and the remaining portion belongs to insurance and pension funds. The finding confirms previous identification of high concentration of

international banks' exposure to foreign banks and NBFIs, suggesting potential for cascading effects and spillover from systemic events cross the border. Finally, both retail and large international banks in Ireland appear to have some meaningful relationship with the cross-border banks.[59] Nonetheless, data limitation curbed further investigation on subsequent transmission channels from the NBFIs, and whether they have close relationship with other systemic banks or nonbank investors that can have indirect linkages with the Irish banking system.

**Figure 37. Ireland: Interbank and Bank-NBFI Network**



Nodes

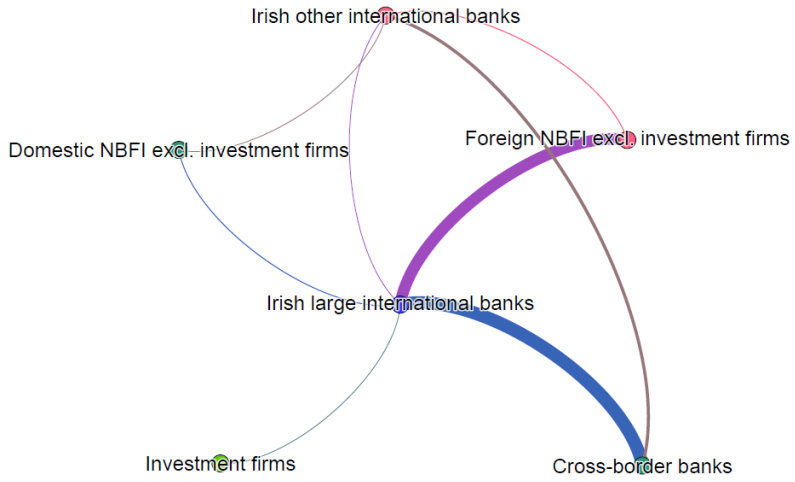
- Financial corporations other than credit institutions and investment firms
- Credit institutions
- Investment firms
- Retail
- OtherInternational
- International

Edges

- UNITED KINGDOM
- FRANCE
- GERMANY
- IRELAND
- UNITED STATES
- LUXEMBOURG
- NETHERLANDS
- SWITZERLAND
- SPAIN

[59] Due to data limitation, the network only covers large exposures of the sample banks. Article 392 of the Capital Requirements Regulation (CRR-575/2013) defines "large exposure" as an exposure, before the application of credit risk mitigation (CRM) measures and exemptions, equal or higher than 10 percent of a bank's eligible capital vis-à-vis an individual client or group of connected clients. The data includes intragroup exposures.

**Figure 37. Ireland: Interbank and Bank-NBFI Network** (Concluded)




Source: ECB, CBI and IMF staff estimate.
Note: Based on ECB large exposure template.

## B. Domestic Interbank Contagion

**82. The domestic interconnectedness analysis investigated channels of contagion between an institution and the rest of the financial system.** Given the concentrated nature of the Ireland banking system and potential interbank obligation between domestic banks, an adverse shock to large institutions could propagate to the rest of the banking system. In that context, domestic interbank contagion risks could prove to be important. An interbank contagion analysis, whereby the default of a single institution generates subsequent defaults among other banks, was implemented.

**83. The interconnectedness analysis relies on the network approach developed by Espinoza-Vega and Sole (2011).** This methodology is based on a matrix of bilateral bank-bank (for interbank contagion) or bank-NBFI (for bank-NBFI contagion) gross credit exposures of all domestic banks and domestic and foreign NBFLs in scope. Interbank and bank-NBFL exposures were assessed on both the asset and liability sides of the sample institutions' balance sheet. On the asset side, the analysis explored pure contagion whereby the default of a bank on its obligations triggers direct credit losses for other banks in the system. As the next step, the algorithm assumes fire sales as a result of funding shocks and reflecting the fact that the default of an institution also leads to liquidity squeeze for institutions funded by the defaulting bank. Banks affected by the default would need to replace a fraction of funding lost by selling other assets at a discount. The analysis thus explored potential for a "domino effect" whereby the initial default of a bank causes subsequent banks to default, either through a credit shock (asset side) and a funding shock (liability side). The exercise stops when there are no further failures, which is defined as 4.5 percent of the CET1 ratio.

**84. The output produces two main indices that quantify Irish domestic interbank linkages:**

- **Index of contagion (or index of outward spillover risks)**: the average loss of other banks due to the failure of a bank $i$. The index is computed as $Cont_i = 100 * \frac{1}{N-1}\sum_{j=1,j\neq i}^{N}\frac{L_{ji}}{K_j}$ , where $K_j$ is the capital of bank $j$ and $L_{ji}$ is the loss to bank $j$ due to the default of bank $i$.
- **Index of vulnerability (or index of inward spillover risks)**: the average loss of a bank $i$ due to the failure of all other banks. The index is computed as $Vuln_i = 100 * \frac{1}{N-1}\sum_{j=1,j\neq i}^{N}\frac{L_{ij}}{K_i}$ , where $K_i$ is the capital of bank $i$ and $L_{ij}$ is the loss to bank i due to the default of bank $j$.

**85. The domestic interbank exposure contains three retail banks, three large international banks, and two other international banks.** Two retail banks and two other international banks were excluded in the matrix as they do not report any interbank exposure. The matrix, which contains interbank loans and securities, is based on supervisory data (the large exposure dataset under the COREP template[60]) which covers each bank's interbank large assets and liabilities position vis-à-vis each other as of mid-2021. Data on off-balance sheet exposures and interbank equity and capital participation were not available and thus were not included in the analysis.

**86. The domestic interbank exposure, comprised of both loans and debt securities, are found to be small.** Total bilateral exposures represent 0.05 percent of the sample bank assets and 0.07 percent of GDP. Given the foreign market orientation of the large international banks, the majority of the domestic interbank assets and liabilities are vis-à-vis the retail banks, comprising 99 percent and 82 percent of total interbank assets and liabilities, respectively.

**87. On aggregate, retail banks are net lenders in the interbank market, while international banks are net borrowers.** Retail banks' main source of funding is household and corporate deposits (72 percent of total liabilities) while international banks obtain most of their funding from domestic and cross-border banks, NBFIs and corporates (57 percent of total liabilities). The differences in funding dependency makes retail banks the funding providers in the interbank market while international banks the net borrowers. As of mid-2021, banks which hold about 60 percent of total assets in the banking system are classified as net borrowers, with the remaining banks being net lenders.

**88. The result of the domestic interbank analysis suggests limited interbank exposures within Ireland, with retail banks playing a more prominent role in the network.** Although retail banks in general have a higher contagion and vulnerability index than international banks, the level of the index measured as losses in percent of capital appears to be small, at around 5 percent. This can be explained by both limited interconnections between banks, with little footprint of international banks in the domestic interbank market, and limited exposure identified through each

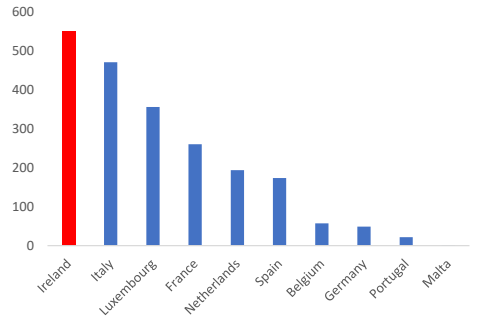
[60] Article 392 of the Capital Requirements Regulation (CRR-575/2013) defines "large exposure" as an exposure, before the application of credit risk mitigation (CRM) measures and exemptions, equal or higher than 10 percent of a bank's eligible capital vis-à-vis an individual client or group of connected clients.

bilateral pair. The results suggest that banks in general have sufficient capital to withstand domestic interbank shocks via their direct balance sheet exposures.

## C. Bank – NBFI Interconnectedness

**89. Furthermore, the interconnectedness analysis explores channels of contagion between banks and nonbank financial institutions (NBFIs), with a focus on other financial institutions (OFIs) mainly comprised of financial vehicle corporations (FVCs) and special purpose vehicles (SPVs).** OFIs consist of FVCs, SPVs and the OFI residual.[61] As of end-2020, the total assets of OFIs are large relative to the size of the economy at 400 percent of GDP. SPVs and FVCs are vehicles commonly used by various sectors, such as banks, investment funds as well as nonfinancial corporations, for financial transactions such as securitization. By regional comparison, Ireland represents the largest FVC market in the Euro Area, followed by Italy and Luxemburg (Figure 38). OFIs are closely linked with the Irish banking system mainly by obtaining funds from the large international banks, while providing meaningful amount of funding to other sectors in the economy such as the nonfinancial corporates. Specifically:

**Figure 38. Ireland: Total Assets of Financial Vehicle Corporation**
(In EUR billion, 2021Q3)




Sources: ECB.

- Irish bank assets and liabilities to OFIs account for 4 and 7 percent of total assets and liabilities, respectively, thus exposing banks to potential credit and funding risks.
- Within the Irish banking sector, large international banks have higher exposure to OFIs than retail banks, evidenced by their disproportionally higher credit exposure to nonbank financial institutions at 29 percent of their total credit exposure, relative to 1 percent for retail banks.
- At the same time, OFIs provide funding to NFCs and households at close to 10 and 32 percent of total loans to NFCs, playing a much larger funding role than the Irish banking sector (close to 6 percent of total NFC loans).

In light of the significant roles of OFIs in channeling funding and lending between banks and the rest of the economy, the extent to which the adverse shocks on OFIs could generate losses in the rest of the financial system, and especially in the banking sector, was assessed.

[61] OFI residual is calculated by subtracting all known non-bank sectors (money market funds, investment funds, insurance, pension funds, broker dealers, securitization vehicles) from the non-bank financial sector. For details, see the CBI note.

**90. The bank-NBFI network analysis encompasses same set of banks as the domestic interbank analysis, while including top ten nonbank financial institutions ranked by size of exposure.** The analysis was conducted under two approaches based on the large exposure dataset under COREP as of mid-2021: the first approach includes only Irish domiciled NBFIs, while the second approach includes both domestic and foreign NBFIs. Both approaches assessed banks' inward spillover, measured by vulnerability index, from other banks and NBFIs. A comparison of results between the two approaches could reveal important domestic and cross border spillover risks posed by nonbank financial institution on the entire or specific sub-segment of the Irish banking system. The assessment adopted the same modeling techniques as the domestic interbank analysis with the same assumptions, parameters, and propagation of shocks.

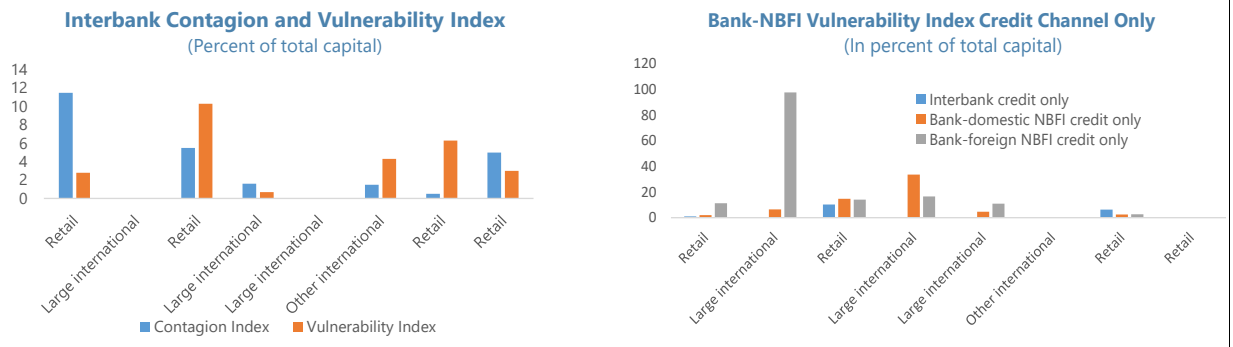
**91. OFIs represent the majority of the NBFI sample.** Under the first approach, OFIs account for seven firms out of the ten firms considered, and 89 percent of the total exposure. When including foreign NBFIs, the share of OFIs out of total exposure increases to 100 percent, reinforcing the dominant role of OFIs in the bank-NBFI network. Investment funds, however, are much less integrated with the banking sector and only account for 3 percent of the total exposure.

**92. Under the second approach where both domestic and foreign OFIs are considered, most large exposures come from the United States, United Kingdom, and France.** Within the top ten NBFIs selected worldwide, NBFIs from the United States, United Kingdom and France outrank domestic NBFIs and account for 33, 19, and 11 percent of the total exposure, respectively, suggesting relatively higher spillover risks originating from both the United States and Europe.

**93. Due to data limitations on the asset exposure of the NBFIs, the assessment considered mainly inward spillover risk (vulnerability index) via the credit channel on the Irish banks.** As a result, the vulnerability index reported for the Irish banks would capture credit impairment associated with the failure of all NBFIs in the network. This may lead to under-estimation of the impact due to limited information on the funding channel of the banks from the NBFIs. At the same time, by comparing the index level for each bank with and without the inclusion of NBFIs, the analysis can identify potential weak spots in the banking system, particularly driven by spillover risks originating from the NBFIs.

**94. The result of the bank-NBFI analysis points to significant linkages between large international banks and nonbank financial institutions, with the effect more pronounced when adding foreign NBFIs** (Figure 39). Under the first approach, relative to the network without the NBFIs, the vulnerability index via the credit channel rises sharply for the large international banks when including the domestic NBFIs, from almost 0 to 15 percent of total capital on average, whereas the increases for retail banks is rather marginal, from 4.4 to 4.8 percent of total capital. Under the second approach where both domestic and foreign NBFIs are considered, the increase of both indices is even higher for large international banks, reaching up to almost 100 percent of capital for one large international bank, suggesting deeper integration of this banking group with the rest of the world. These observations underline the importance of analyzing the riskiness of banks-NBFI linkages and their direct and indirect impact on the banking sector, with a larger focus on international banks.

**Figure 39. Ireland: Interconnectedness Analysis**




Source: ECB, CBI, and IMF staff.

## D. Cross-border Interbank Contagion

**95. The cross-border contagion analysis aimed at assessing Ireland banking systems' linkages with foreign banks and resilience to external shocks.** With foreign banks representing a meaningful portion of the Irish banking system, cross-border exposures could be relevant, including via parent bank funding. On the other hand, stresses abroad could impair banks' asset in Ireland, through Irish banks' claims on foreign entities (via deposits or interbank lending).

**96. The cross-border interbank analysis provides supporting evidence of limited integration of Irish retail banks into the global network** (Figure 40). Based on the Bank for International Settlements (BIS), consolidated banking statistics as of 2021Q3, Irish domestic banks' foreign asset claims and liabilities have declined significantly since the GFC, from $234 to $15 billion and $358 to $31 billion, respectively.[62,63] As a result, both inward and outward spillover risks for the Irish retail banks are well contained. Top asset exposures of the Irish domestic banks on the asset side include United Kingdom (25 percent) and France (23 percent), and on the liabilities side include France (35 percent), Switzerland (11 percent), United States (10 percent), and United Kingdom (7 percent). The BIS locational data, which includes foreign subsidiaries and is on an unconsolidated basis, points to similar downward trend, albeit with a higher level of exposure relative to the

[62] Irish banks' net cross-border position can be positive or negative depending on the consolidation level reported within the BIS statistics. For example, when using consolidated banking statistics where foreign subsidiaries are consolidated outside of Ireland, Irish banks would be seen as net borrowers with the rest of the world, whereas under the locational basis it is reported as a net lender given the inclusion of the foreign subsidiaries as domestic entities. See the BIS explanatory note.

[63] CBI internal estimates of the interbank exposure on a locational basis, which covers five main retail banks as well as foreign subsidiaries included in the international financial services center banks, points to a net lending position of the Irish banks towards cross-border banks, consistent with the net position reported in the BIS locational statistics.

consolidated data, driven by higher cross-border linkages of the international banks partly via intragroup exposures.

**97. When expanding the network to include exposures to all sectors, Irish banks' large exposure to the private sector, especially in the U.K. market, makes them more vulnerable to credit shocks in the global network** (Figure 40). Based on the BIS consolidated banking statistics, total nonfinancial private sector, composed of households and corporates, accounts for 60 percent of the total cross-border claims of Irish banks, with United Kingdom ranking the first (69 percent) followed by the United States (9 percent), France (7 percent), Spain (4 percent), Netherlands (2 percent), and Germany (2 percent). This is consistent with the findings of high concentration of the U.K. credit portfolios identified through the lending composition of the Irish retail banks. On the liability side, the composition varied notably, with nonbank financial institutions dominating the total claims of foreign banks on Ireland domestic economy at 52 percent, possibly reflecting high level of foreign investment on investment fund and other financial institutions such as FVCs and SPVs and underscoring the potential risks via the bank-NBFI channel. In terms of country ranking, United States outranked United Kingdom as the largest foreign investor with a total exposure of 116 billion, or equivalently 32 percent of total foreign claims, followed by United Kingdom (21 percent), France (16 percent), Germany (9 percent), Spain (7 percent), Italy (5 percent) and Belgium (4 percent).

**Figure 40. Ireland: Cross-Border Interconnectedness**

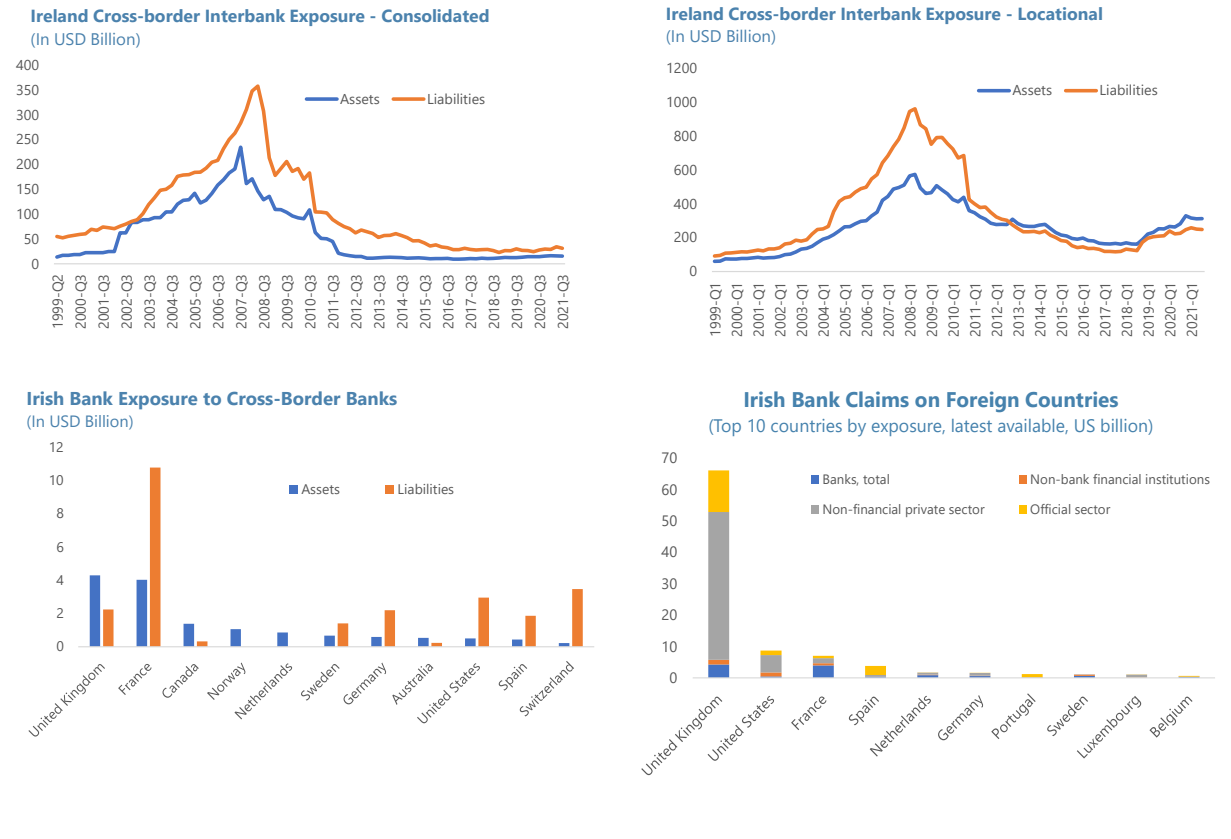
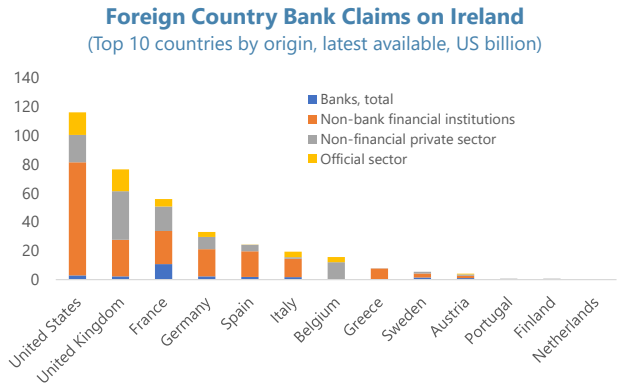


**Figure 40. Ireland: Cross-Border Interconnectedness** (Concluded)




Source: BIS and IMF staff estimate.
Note: Country bilateral exposures reflect BIS consolidated banking statistics.

**98. The cross-border contagion analysis assessed the extent to which the Irish banking sector is vulnerable to shocks from banking systems abroad.** The exercise considers in total 29 banking sectors, most of which operate within Europe and have direct linkages with Ireland. The analysis relies on BIS consolidated banking statistics as of Q3 2021 and simulates combination of credit and funding shocks, assuming a 30 percent loss on asset claims in case of the default of a counterparty, a 65 percent roll-over of funding (i.e., 35 percent decline in interbank funding), and a 30 percent haircut on assets that may be forced to be liquidated due to loss of funding. Although both credit and funding shock are present in the same scenario, the results allow decomposition of bank losses, hence impacts on bank capital, due to each type of shock.

**99. Both inward and outward spillover risks appear to be muted for Irish banks** (Figure 41). A comparison between contagion and vulnerability index further reveals that although Irish banking sector ranks lower in terms of the level of contagion and vulnerability index than the rest of its counterparties, the sector itself however has a higher score of vulnerability than contagion, at 0.2 and 0.1 respectively.

**100. The close financial relationship between the Irish banks and the European and the U.S. banks points to higher inward spillover risks from France, United Kingdom, and the United States.** (Figure 41). The capital losses on Irish banks due to both credit and funding shocks originating from the top EU countries and the United States is significantly higher than the rest of the countries, with France, United Kingdom, and the United States top the list and representing a loss of 2.2, 1.1, and 0.5 percent of capital. In relative terms, loss contribution via funding channel from France is higher than credit channel, whereas the opposite is observed for the U.K. market, signaling non-negligible credit exposure of Irish domestic banks to the U.K. banks.

## Figure 41. Ireland: Result for Cross-Border Interbank Contagion Analysis

(Credit and funding channels, interbank exposure)

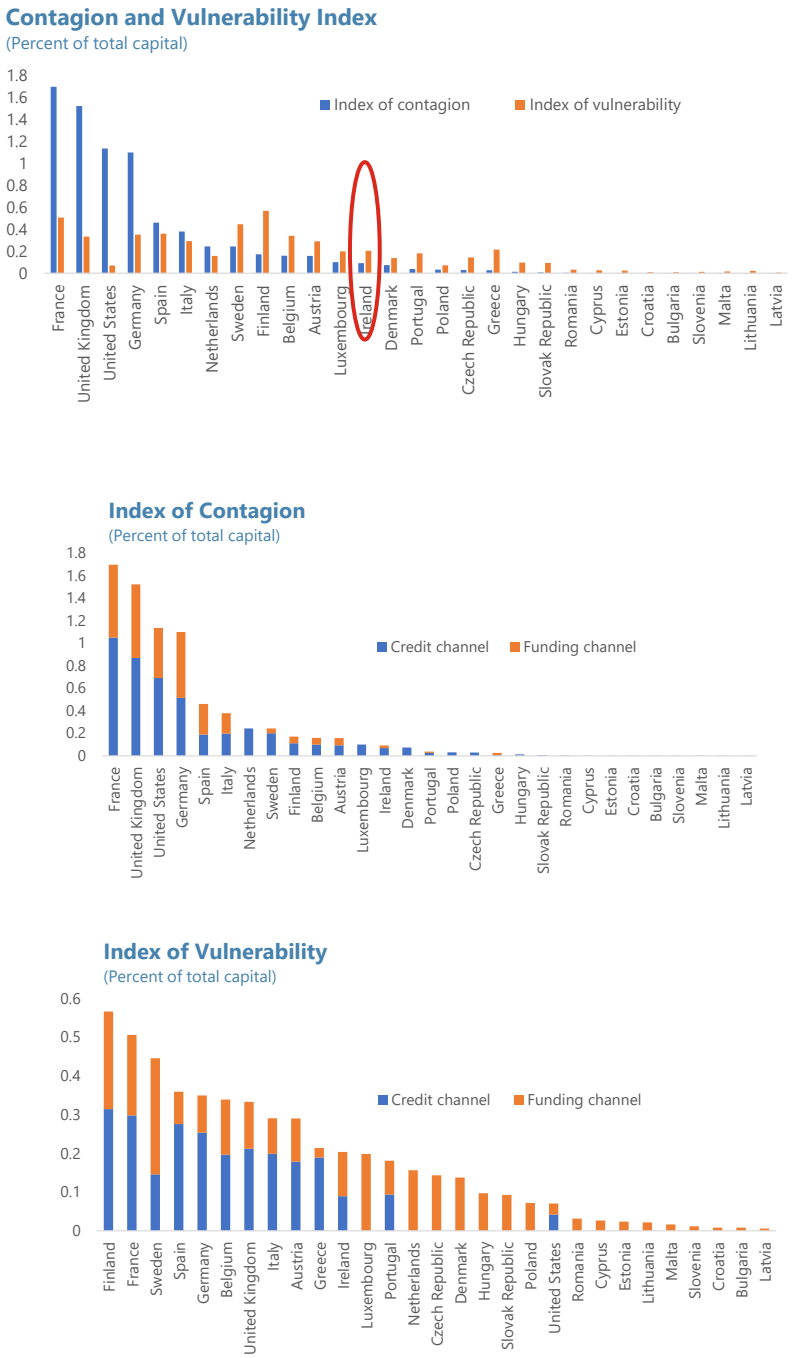
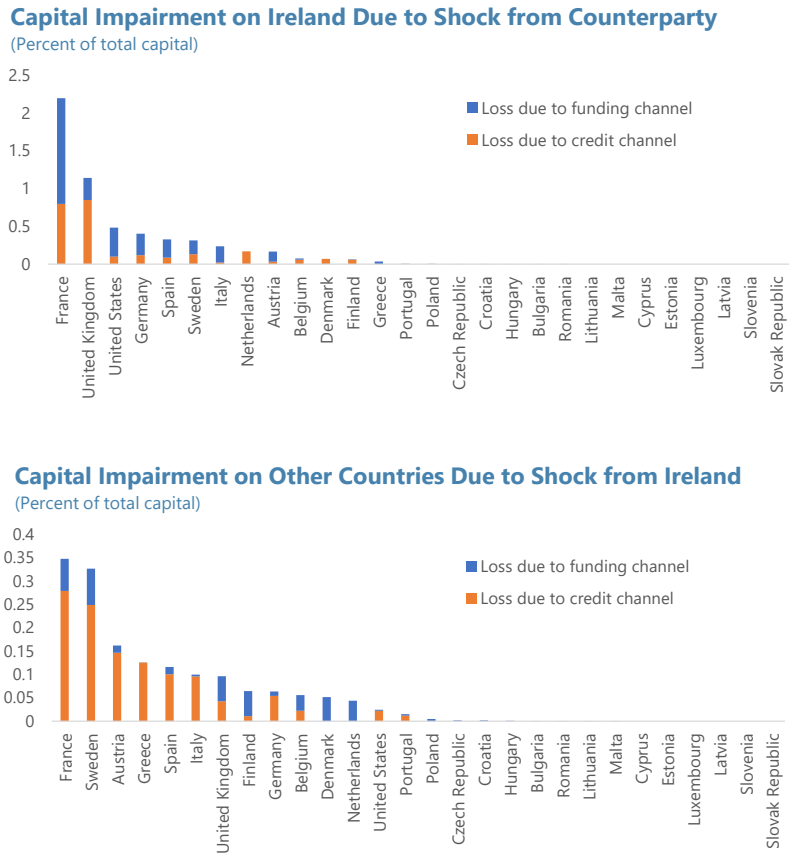


**Figure 41. Ireland: Result for Cross-Border Interbank Contagion Analysis**
(Concluded)




Sources: BIS and IMF staff calculations.
Note: All estimates are based on BIS consolidated banking statistics.

# BANK CLIMATE STRESS TEST ANALYSIS

## A. Ireland Exposure to Climate Risks

**101. Irish authorities are strongly committed to progressively raise carbon tax to reduce greenhouse gas emissions.** Ireland's 2021 Climate Act commits the country to net-zero greenhouse gas (GHG) emissions by no later than 2050, and to more than halving emissions by 2030. The government has introduced an incremental charge on carbon tax, from €33.5 to €100 per ton of $CO_2$ emissions by 2030[64], while recycling the revenue to mitigate the effects of potentially higher energy bills, finance climate-related investment and ensure a just transition. While the increase of taxes may have immediate adverse effect on profitability of carbon intensive firms, the long-term benefit of the

[64] The carbon tax was introduced in 2010 and is currently at €41/ton (slightly different start date and timing of increases for different fuels). For more details see the summary here.

improved energy efficiency and reallocation of resources are expected to more than offset the short-term losses and enhance the sustainability and resilience of the economy against climate change.

**102. In the meanwhile, significant climate change-related physical risks in Ireland posed by rising sea levels (and their uneven impact across the country) has made discussions on effective climate policies more pressing.**[65] Some of these risks from extreme events, like floods, storms, landslides, and heatwaves, as well as long-term, progressive shifts include:

- Severe coastal flooding due to rising sea levels, which make it more likely that storm surges and spring high tides coincide in the near future. An average sea level rise of between 0.5 to 1 meter, in combination with storm surge events, could result in as much as 1,000km2 of coastal lands around Ireland being inundated by the sea if no protective measures are undertaken.

- Growing weather variability, including more frequent extreme rainfall, which could increase the severity of river flooding and exacerbate the water overflow in combination with storm surges, and a re-emergence of droughts adversely affecting the crop cycle.

**103. The Irish banking system's direct exposure to climate risks is not insignificant.** Roughly 15 percent of bank NFC loans are to sectors with a high carbon footprint and more than 20 percent of loans are to sectors exposed to high physical hazards, dominated by floods, well above Euro Area average, suggesting heightened vulnerability of banks to both carbon tax shocks and sea level rises.

## B. Transition Risk Sensitivity-based Stress Test

**104. The transition risk analysis is motivated by growing interests in assessing financial stability implications of transition to a low carbon economy.** Climate policy actions, such as an increase in carbon prices, are expected to hit firms with high carbon footprints and impair credit quality of the banks that extend loans to these entities. The analysis attempts to quantify the impact on corporate PDs and the associated impact on bank capital by using a single factor sensitivity analysis assuming an increase of carbon tax from €33.5 to €100 per ton of $CO_2$ emission.[66] A schematic overview of the methodology is provided in figure 42.

**105. The exercise covers 1,400 firms, constituting around 68 percent of total corporate sector debt.** The analysis relies on four sets of statistics: firm level balance sheet data, firm level PD statistics, industry level carbon intensity and finally banking sector corporate loan exposure and NPLs by industry. The balance sheet data was sourced from Capital IQ and covered 1995 to 2020, while firm specific PDs was proxied by Moody's expected default frequency and sourced from Moody's analytics at the firm level, covering 1999 to 2020. The two datasets were used jointly to

[65] Please see Selected Issues Paper AIV 2021 "Considerations for climate change mitigation in Ireland"

[66] The analysis also follows the general approach developed by Norway and U.K. FSAP, with additional features added for Ireland FSAP. For details from the Norway and US FSAP analysis, see here and here.

assess relationship between firms' PDs and balance sheet health and make prediction of PDs under various scenarios, using 2020 as the starting point. Carbon intensity statistics based on greenhouse gas emissions were obtained from Eurostat on the industry level and used to compute firm level cost associated the carbon tax shock. Finally, data on corporate loans and NPLs by industry classified under NACE Rev.2 were obtained from regulatory reporting templates to translate PDs into losses on bank capital.

**106. The analysis is enriched by allowing firm level behavioral responses when facing immediate rise in carbon tax and production costs.** The additional feature allows firms to pass the entire carbon tax shock to ending consumers, while also allowing market demand to respond negatively to rising prices, based on empirical analysis of the demand elasticity of energy intensive products. These two off-setting effects jointly determine the revenue of each firm and subsequently their PDs. The estimate of elasticity relies on the Carbon Pricing Assessment Tool development by the IMF Fiscal Affair Department[67], which indicates a homogenous short-run price elasticity of -0.3 across all carbon producing industries. As a result, consumer demand is assumed to be relatively inelastic to changing prices, which could mitigate the immediate financial impact on firms. The analysis, however, does not consider other behavioral/transitional responses, such as energy efficiency improvements, which are assumed to take place only over the long term.

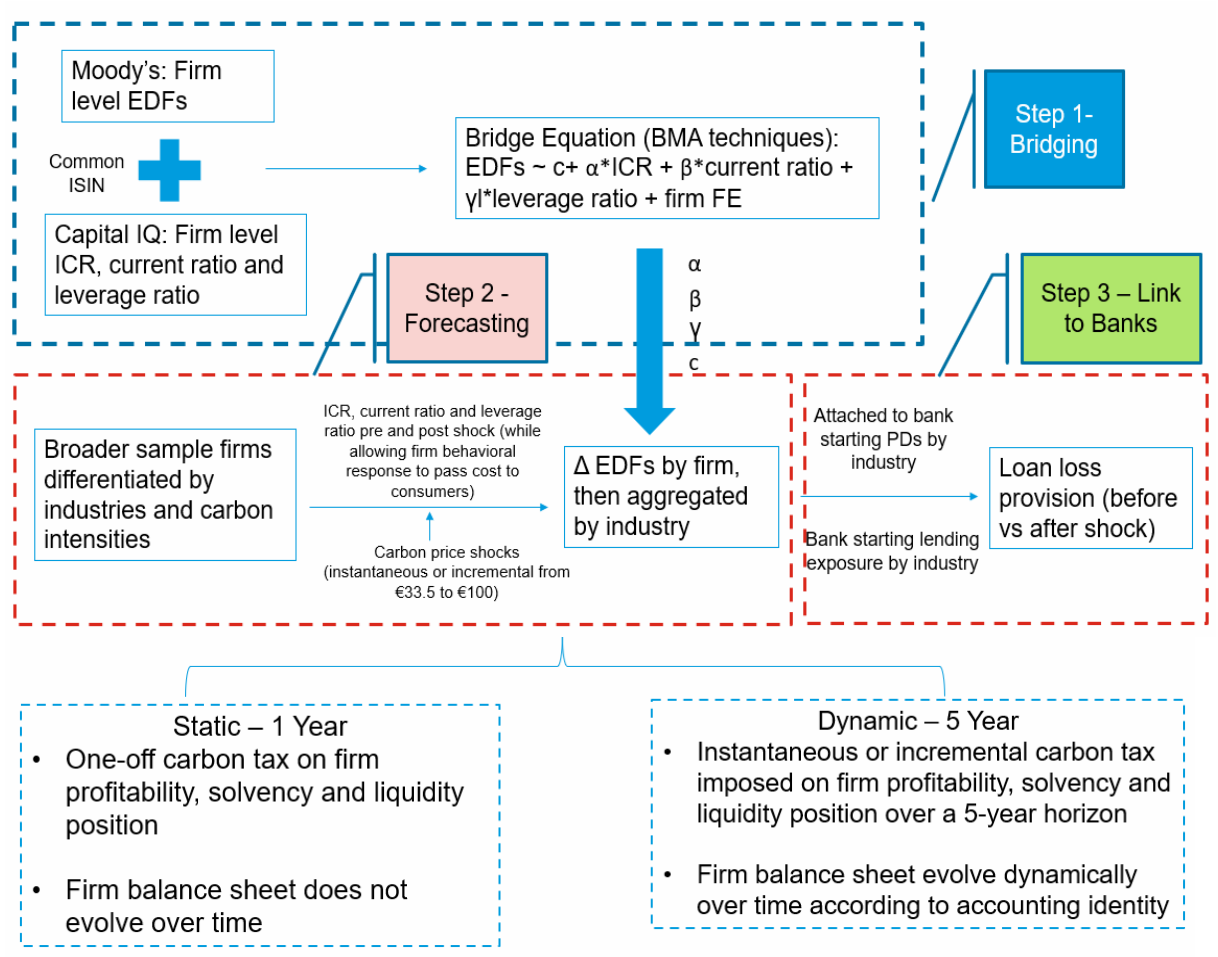
**107. The analysis also allows both static and dynamic projection of firm balance sheets.** In addition to assess corporate PDs associated with an instantaneous carbon tax shock over a one-year window, the analysis also extends the risk horizon to five years under either an instantaneous (e.g., immediate increase from €33.5 to €100 in the first year) or incremental (linear increase from €33.5 to €100 over a 5-year horizon) carbon tax shock, consistent with the bank solvency stress test, while allowing firm balance sheet to evolve dynamically based on a pre-defined accounting principle. The dynamic feature is expected to reveal important non-linear effect on firms' solvency and liquidity condition and thus their financial viability, due to a sustained high level of carbon tax levy. Considering all the additional enhancements, the results would present impact on bank corporate PD by industries and bank capital according to the following four scenarios:

- An instantaneous carbon tax shock from €33.5 to €100 per ton of CO2 emission over 1-year to 5-year horizon, assuming no firm behavioral response,
- An incremental carbon tax shock from €33.5 to €100 per ton of CO2 emission over 1-year to 5-year horizon, assuming no firm behavioral response,

[67] Carbon Pricing Assessment Tool (CPAT) was developed by IMF and World Bank staff and evolved from an earlier IMF tool used, for example, in IMF (2019a and b). For descriptions of the model and its parameterization, see IMF (2019b Appendix III; and Parry, Mylonas and Vernon 2021) and for further underlying rationale see Heine and Black (2019). It is a streamlined spreadsheet-based model which projects, on a country-by-country basis for 175 countries, fossil fuel CO2 emissions and the emissions, fiscal, economic, energy price, and distributional burden of carbon pricing and other commonly used mitigation instruments. CPAT is parameterized so that emissions projections, and the responsiveness of fuel use to pricing, are consistent with the broader climate/energy modelling literature.

- An instantaneous carbon tax shock from €33.5 to €100 per ton of CO2 emission over 1-year to 5-year horizon, assuming firm behavioral response to pass entire cost to consumers,
- An incremental carbon tax shock from €33.5 to €100 per ton of CO2 emission over 1-year to 5-year horizon, assuming firm behavioral response to pass entire cost to consumers.

**Figure 42. Ireland: Methodology – Transition Risks**




Source: IMF.

**108. The projection of firm level PDs follows three steps:**

- *The first step* is to derive a bridge equation that estimate the relationship of firm PDs in logit form with three firm level balance sheet indicators reflecting viability, liquidity, and solvency condition: interest coverage ratio (ICR), current ratio and leverage ratio (henceforth "vulnerability indicators"). Since PDs can be obtained only for publicly listed firms, a subset of Irish firms was included in this step. The estimation is done by using a unique model averaging technique with sign constraints to perform a fixed effects panel regression. The summary statistics of the regression

output is provided in table 8. Using this bridge model, coefficients of ICR, current ratio and leverage ratio (all contemporaneous explanatory variables) on firm PDs (dependent variables) can be obtained and incorporated into the PD projections in the next step.

**Table 8. Ireland: Estimation of Expected Default Frequency for Irish Firms**
(Dependent variable: logit form of probability of default proxied by Expected Default Frequency. RHS variables measured in fraction)

| Variables | Estimated Effect on Expected Default Frequency in Logit Form |
|---|---|
| Interest coverage ratio | -0.01* |
| Leverage ratio | 1.69* |
| Current ratio | -0.01 |
| (Intercept) | -7.39* |
| Individial firm with fixed effects | Yes |
| R-square | 0.38 |

Source: IMF World Economic Outlook, Capital IQ, Moody's Analytics, and IMF staff calculations.
Note: * denote p value less than 0.1.

- *The second step* applies the estimated coefficients from the previous step to an extended firm sample covering both publicly and non-publicly listed firms, to project firm level PDs under the four carbon tax scenarios. This is done by first projecting the vulnerability indicators at the firm level under each scenario, using firm specific balance sheet information and carbon emissions. Then the projected vulnerability indicators were multiplied by the estimated coefficients to derive the PDs before and after shock. This step also enables the dynamic projection under which the balance sheet and profit components can be dynamically determined using the following accounting identity (Table 9). For simplicity, the forward-looking projections assume constant economic conditions and firm characteristics such that no shifts in business models, energy usage and technological advancement to lower carbon emission is considered in the analysis.

**Table 9. Ireland: Projection of Corporate Balance Sheet and Vulnerability Indicators**

| Vulnerability Indicators | Projection Formula based on Accounting Identity |
|---|---|
| Interest Coverage Ratio (ICR) | (1) $ICR_t = \frac{EBIT_t - Carbon\ tax_t}{Interest\ expense_t}$<br>(2) $EBIT_t = EBIT_{t-1}$<br>(3) $Interest\ expense_t = \frac{Interst\ expense_0}{Total\ debt_0} * Total\ debt_{t-1}$ |

**Table 9. Ireland: Projection of Corporate Balance Sheet and Vulnerability Indicators** (Concluded)

| | |
|---|---|
| Leverage | (4) $Leverage_t = Total\ debt_t / Total\ assets_t$<br>(5) $Cash\ and\ equivalents_t = \max(0, Cash\ and\ equivalents_{t-1} + EBIT_t - Carbon\ tax_t - Interest\ expense_t)$<br>(6) $Total\ debt_t = Total\ debt_{t-1} - \min(0, Cash\ and\ equivalents_{t-1} + EBIT_t - Carbon\ tax_t - Interest\ expense_t)$<br>(7) $Total\ assets_t = Total\ assets_{t-1} + Cash\ and\ equivalents_t - Cash\ and\ equivalents_{t-1}$ |
| Current Ratio | (8) $Current\ ratio_t = \frac{Current\ assets_t}{Current\ liabilities_t}$<br>(9) $Current\ assets_t = Current\ assets_{t-1} - Cash\ and\ equivalents_t - Cash\ and\ equivalents_{t-1}$<br>(10) $Current\ liabilities_t = Current\ liabilities_{t-1} - \min(0, Cash\ and\ equivalents_{t-1} + EBIT_t - Carbon\ tax_t - Interest\ expense_t) * 0.5$<br>Note: 50 percent of additional borrowing assumed in the form of short-term debt. |

- *The final step* involves linking PDs from the corporate database to the banking sector corporate credit exposure and deriving the impact on bank loan loss provisions and capital. In this step, firm level PD projection is aggregated at the industry level from the corporate database using total debt as weights. The changes of the aggregated PDs were then attached to the starting point of the PDs of the bank portfolios by industry to compute the impact of the additional loan loss provisions on bank capital. Bank PDs by industry is proxied using new NPL flows in 2020 which was computed as the changes in the NPL stock between 2019 and 2020 assuming an average write-off rate of 30 percent. LGD is assumed to be homogenous across industries at 30 percent. Intuitively, the relative composition of the corporate portfolio on green and brown segments would determine the size of the impact, as banks hold non-negligible carbon intensive portfolios (Figure 8).

**109. The regression output suggests that interest coverage ratio and firm leverage dominate the evolution of firm PDs** (Table 8). This is reflected in the high P values and sizable coefficient estimates of ICR and leverage ratios for firms included in the regression sample. Intuitively, lower interest coverage ratio and higher leverage ratios are expected to drive up firms' PDs.[68] It is also worth noting that the high dominance of leverage ratios can be explained by construction, as leverage ratios are key input into the derivation of the market based EDF indicator.

**110. The projections of PDs under carbon tax shocks suggest that transition risks could be material for Irish firms over the medium term** (Figure 43). Energy intensive sectors, such as

[68] Note that PD here refers to probability of default in logit form.

agriculture, electricity and gas, and transportation, saw largest PD increases over a five-year horizon across all scenarios. While under instantaneous shock with no firm behavioral response the impact can be significant for these sectors, a full passthrough of carbon price shock to ending consumers can partially alleviate financial burden on firms and improve their credit quality. Furthermore, firms that undergo instantaneous carbon charges reach to significantly higher PDs by the fifth year than those subject to incremental charges, suggesting a benefit of having phase-in policies which formulate gradual increases in carbon tax. The higher increase in PDs as stress persists into the longer horizon also confirms important non-linear effects of carbon tax on corporate financial health under the assumption of constant carbon emissions. This dynamic highlights the importance of a speedy transitioning to greener technology to improve energy efficiency and ensure business viability for carbon-intensive segments.

**Figure 43. Ireland: PDs Impact under Carbon Tax Shock**

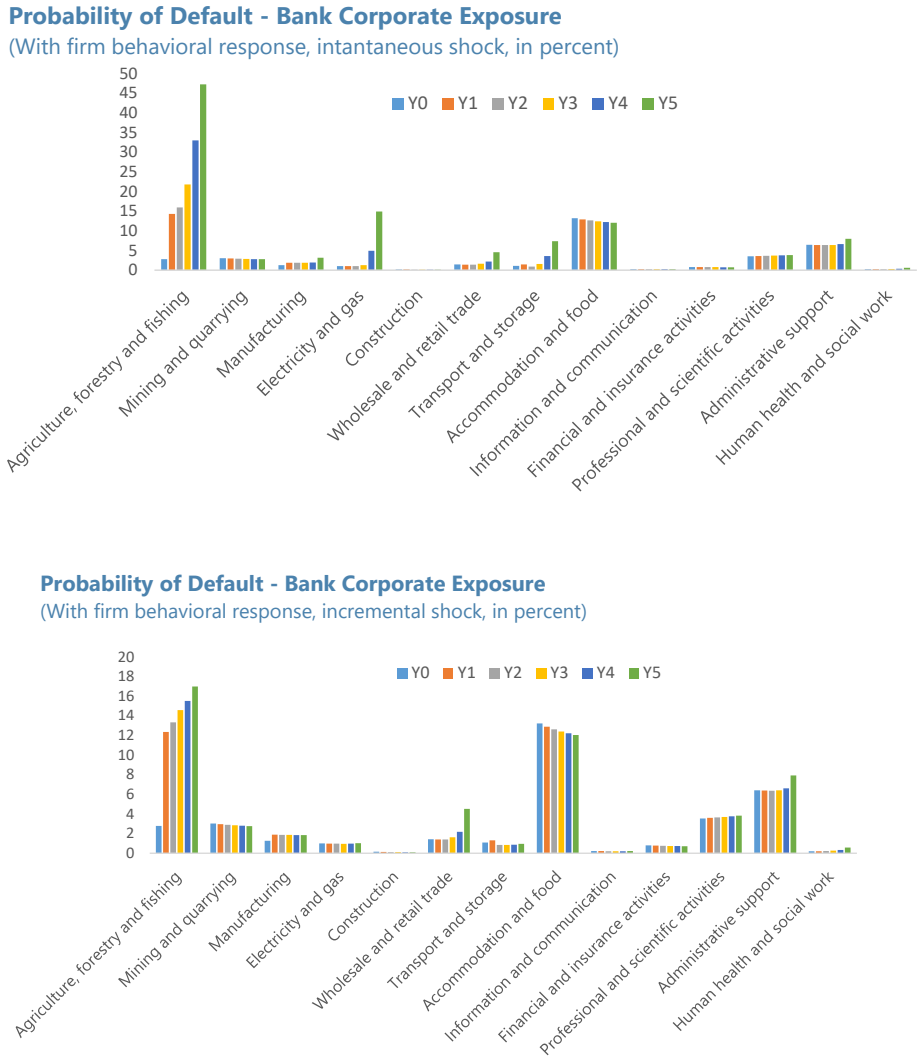
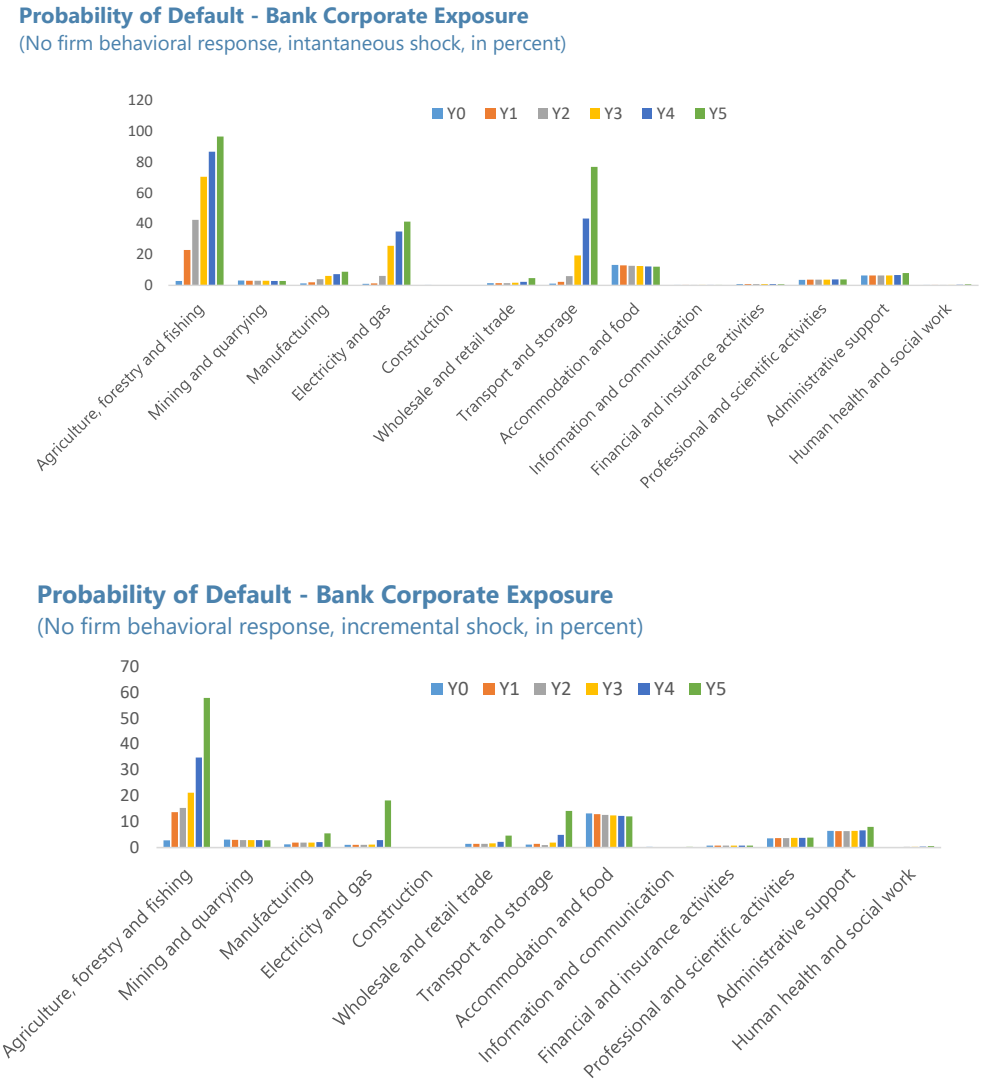


**Figure 43. Ireland: PDs Impact under Carbon Tax Shock** (Concluded)

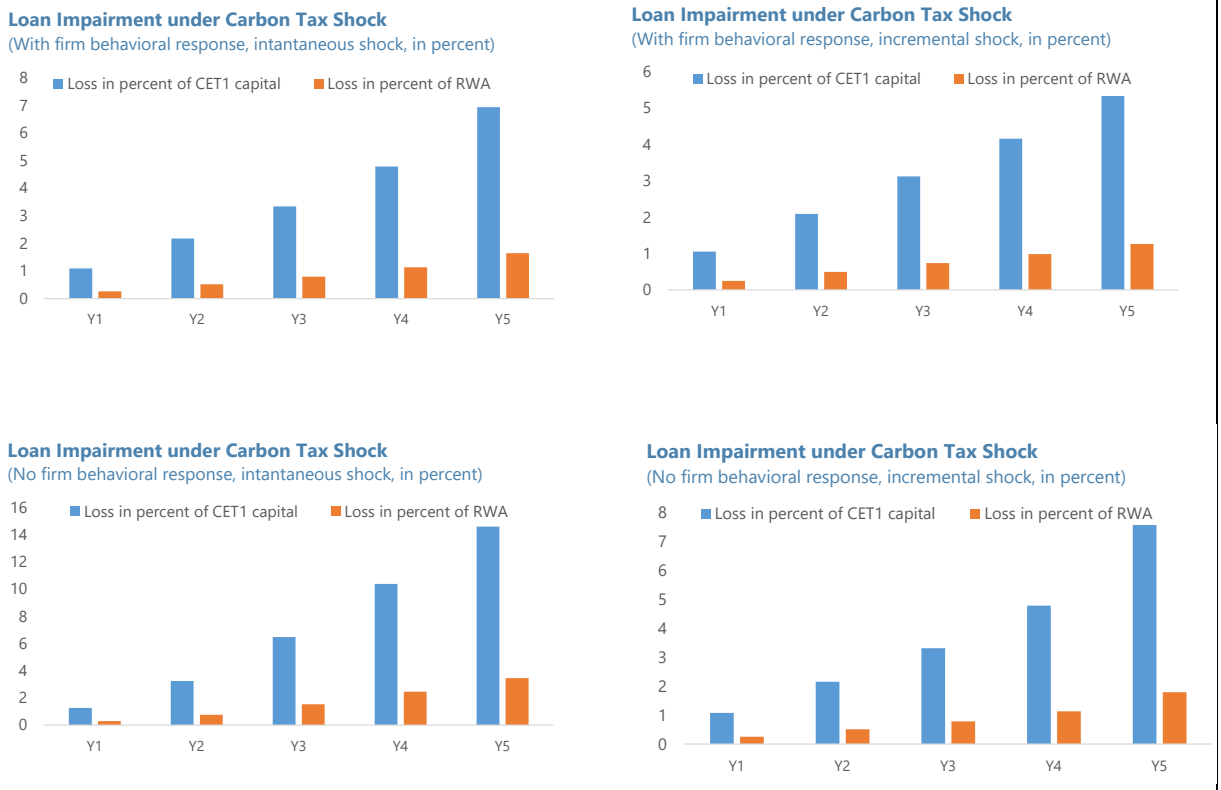



Source: Eurostat, Capital IQ, Moody's Analytics, and IMF staff calculations.
Note: All figures represent annual probability of default (n0n-logit and non-cumulative).

**111. Likewise, the spillover impact from corporate to the banking sector should not be overlooked** (Figure 44). While the immediate impact on the banking sectors appears to be contained, the cumulative capital impairment over the medium term can reach to almost 3.5 percentage points of CET1 capital (or 15 percent of existing CET1 stock) under the most severe scenario with instantaneous carbon tax shock and no firm behavioral response, which may curtail bank resilience to sustained transition shocks in absence of preemptive monitoring of carbon

intensive credit portfolios.[69] These observations underline the importance of advancing monitoring toolkit, including developing relevant modeling approaches, to properly assess the impact on banking sector of material climate risks.

**Figure 44. Ireland: Bank Capital Impact under Carbon Tax Shock**




Source: IMF staff estimates.

**112. Nonetheless, the results should be taken with caution due to several important caveats.** First, the absence of scenario consistent dynamic projections that incorporate redistribution of tax receipt to offset the initial impact coupled with firms' technological transformation that mitigate their carbon footprint over time may overestimate the negative impact of the carbon tax on firms' financial health and credit worthiness. Second, given that the dataset used in the analysis covers almost exclusively large publicly listed firms, the estimated impact may not be fully representative of the entire corporate sector which encompasses a significant portion of small and medium size enterprises (mostly non-listed). Third, the analysis does not differentiate banks into

[69] The calculation of capital impairment under carbon tax shock does not consider pre-provision income made in the baseline over the risk horizon and thus the overall capital depletion should not be seen as akin to a traditional solvency stress test.

retail banks that are more sensitive to domestic carbon tax shocks and international banks that are foreign-oriented and thus less susceptible to domestic policies, and therefore may mask important heterogeneity within the banking sector. Fourth, the analysis does not consider public subsidies towards certain segments post carbon tax levy, such as the agriculture sector, to mitigate immediate financial difficulties. Fifth, different metrics of carbon intensities, such as those measured under greenhouse gas emissions versus carbon emissions, can also make a difference in terms of impact on PDs, especially on the agricultural sector which emits mostly greenhouse gas in the form of methane and nitrous oxide (CO2 equivalent) rather than CO2. Finally, if data permits, the analysis can benefit from considering also indirect tax effect via scope 2 and 3 emission, as well as carbon border adjustment as it can be an important pressure point for an open economy such as Ireland.

**113. Finally, the projected PDs were used to evaluate market losses associated with the holdings of debt securities on bank balance sheets.** The market losses can be computed using the modified duration approach where shocks to corporate bond spreads are proxied by the simulated corporate PDs under the Merton approach as the following:

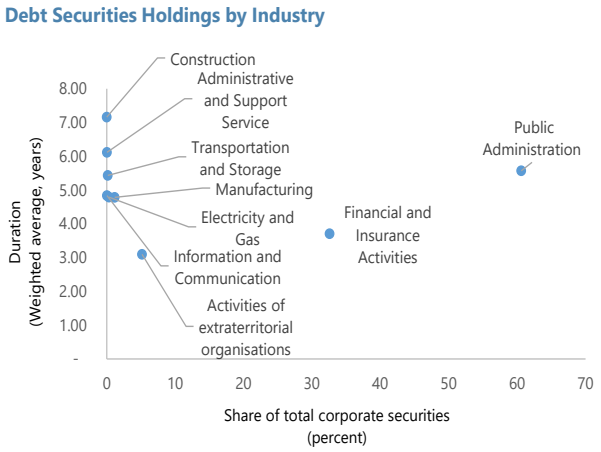
$$PD^{i}_{t,T} = \frac{1 - exp^{-S^{i}_{t,T^{*}}(T-t)}}{LGD^{i}_{t}}$$

Where the LGD is set to be homogenous at 30 percent. Subsequently, the revaluation losses can be derived according to the modified duration approach as:

$$\Delta P^{i}_{t} = -\frac{D^{i}}{\left(1+r^{i}_{t}+S^{j}_{t}\right)} * \Delta B^{i}_{t} * \Delta S^{i}_{t}$$

Where D represents the duration of the debt securities, B represents the initial bond yield, and S represents the corporate bond spread computed using the Merton formula and r represents risk-free rate. To achieve the same sectoral granularity under the credit loss estimation, information on duration and outstanding amount of bank debt securities were provided by the CBI under the same sectoral classification under NACE Rev.2.

**Figure 45. Ireland: Bank Exposure to Transition Risk**
(2021Q3)




Sources: CBI.

**114. The market valuation risk associated with the transition risk is found to be insignificant.** The cumulative losses over the medium term under various carbon tax shock scenarios peak at 0.04 percent of total CET1 capital, much less than what was observed under the credit risk analysis. Banks on aggregate are less exposed to securities issued by carbon intensive industries, currently at 0.5 percent of total holdings of corporate debt securities (Figure 45), which experience sharper decompression of corporate bond spread under various carbon tax shocks, at 5 percentage points on average, in contrast to 0.1 percentage points for "greener" industries in sample.

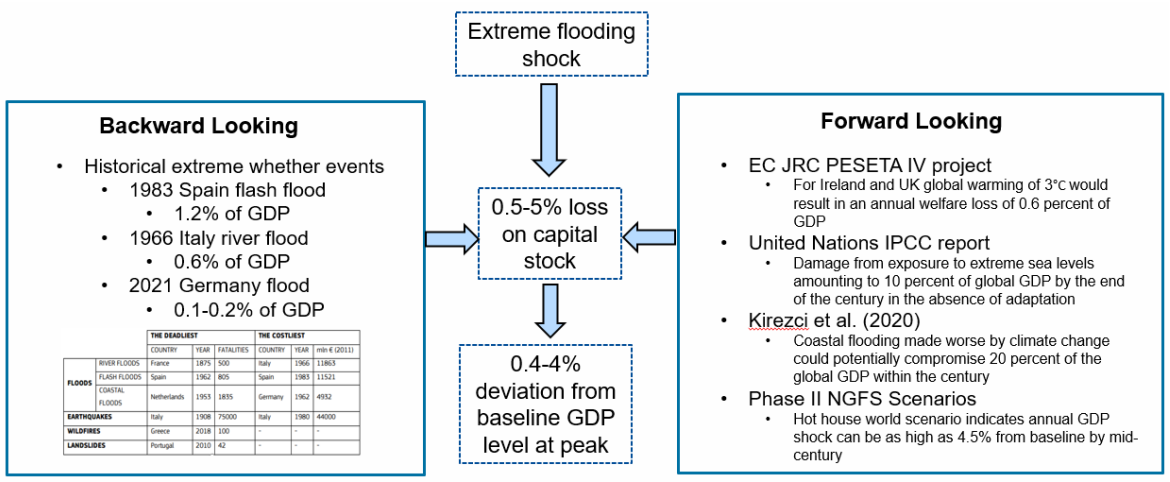
## C. Physical Risk Scenario-based Stress Test

**115. Against heightened flooding risks facing Ireland due to growing weather variability and sea level rise, a scenario-based stress test was conducted to gauge the financial implication for the banking sector of a severe flooding event.** The scenario-based stress test attempts to quantify the extreme flooding event into the impact on a set of macroeconomic variables, which can be then translated to bank capital impact, mainly via credit and market risk channel. Distinct from earlier studies which formulate long-term views of climate risks to the mid-century, the scenario-based stress test frontloads long-term impact of the physical hazards into 5-year horizon, thus ensuring conservativeness in the severity of the scenario while achieving alignment with the risk horizon typically used in the bank solvency stress test.

**116. A multi-pronged approach was used to assess potential damages associated with the severe flooding event** (Figure 46). The exercise relies on both backward and forward-looking approach in setting a range of damage rates, measured as percentage of total capital stock in the Irish economy, resulting from the extreme flooding event. Under the backward-looking approach,

actual damage rates from historical extreme flooding events across Europe was used to set the lower bound of the shock. On the other hand, the forward-looking approach draws predictions from recent publications on potential physical damages due to coastal flooding over the long term to calibrate the upper bound of the shock. A complete list of references and methodology in shock calibration can be found in Appendix V. As a result, the damage rates over a 5-year horizon are expected to range from 0.5 to 5 percent of total capital stock.

**Figure 46. Ireland: Shock Calibration – Physical Risks**




Source: IMF.

**117. As the next step, the damage rates were further translated into output loss according to the production function.** The historical elasticity between total capital stock and GDP were estimated using a standard OLS regression which specifies the following:

$$ln(Y)_t - \ln(Y)_{t-1} = \ln(A)_t - \ln(A)_{t-1} + \beta * (\ln(K)_t - \ln(K)_{t-1}) + (1-\beta) * (\ln(L)_t - \ln(L)_{t-1})$$

Where Y denotes output, K denotes total capital stock and L denotes labor. The coefficient on total capital stock, corresponding to the elasticity between capital and GDP, is estimated to be 0.83. Therefore, the shock to GDP in response to the total capital loss is valued between 0.4 to 4 percent, relative to the baseline scenario, over the 5-year horizon.

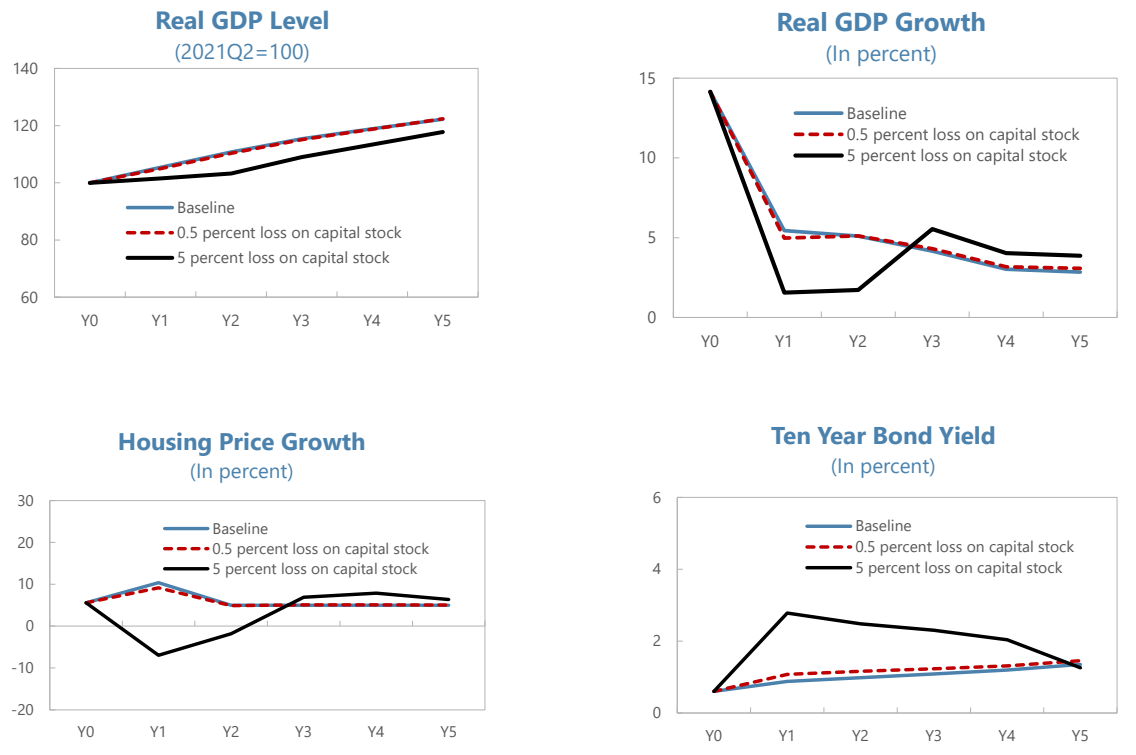
**118. The scenario calibration relies on the GFM modeling, the same technique adopted in generating the macro-financial scenario under the bank solvency stress test.** The model calibration is governed by the following scenario narratives reflective of the macroeconomic impact associated with a severe flooding event, while benchmarking GDP shock at the trough against the estimated output loss above:

- Shock to the capital stock, resulting in drop in labor productivity, with subsequent recovery via investment

- Lower capital leads to smaller future wealth and in turn implies a drop in private consumption and demand in labor and thus rate of employment
- Drop in housing price due to curtailed income and saving and falling expectation in housing market led by flooding damage
- Rise in sovereign risk premium due to higher fiscal cost associated with the recovery.

The key macroeconomic variables simulated under the scenario is presented in Figure 47.

**Figure 47. Ireland: Physical Risk - Macroeconomic Scenario**



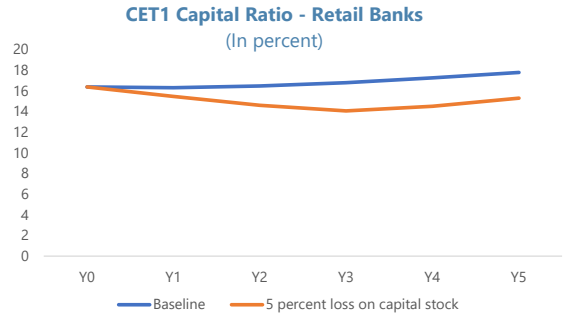

Source: IMF staff estimates.

**119. The transmission from the macroeconomic shock to bank capital impact is mainly through credit and market risk channels.** Same as the methodology adopted in generating credit and market losses under the scenario-based bank solvency stress test, the exercise studied potential credit loss associated with the severe flooding event according to IFRS9 accounting standards, while market losses were assessed via the modified duration approach. However, different from previous studies where the impacts under the physical shock was treated an add-on component to the adverse scenario of the bank solvency stress test, the exercise considered the severe flooding event

as a standalone scenario independent of the adverse scenario, given the uncertainty of the materialization of such physical shock at any given period.

**120. The result of the physical risk analysis identifies important linkages between domestic physical hazards and retail banks' financial health going forward** (Figure 48). The result focuses on the upper bound of the scenario (5 percent loss of capital stock) and exclusively on retail banks given the minimal impact of the lower bound of the shock as well as the high domestic relevance of the physical scenario. This means international banks will experience minimal losses due to their small holdings of domestic portfolios and hence minimal exposure to Ireland specific physical shocks. Under such scope, the severe flooding event triggers some non-trivial depletion of retail banks' CET1 capital (around 240 bps) before going back to be close to the pre-shock level, prompting enhanced monitoring of banking sector exposure to climate sensitive segments and precautionary action (e.g., ensure loans are secured with high quality collateral or insured against physical damages) to mitigate climate-related risks to financial stability.

**Figure 48. Ireland: Result of the Physical Risk Analysis**
(2021Q2)

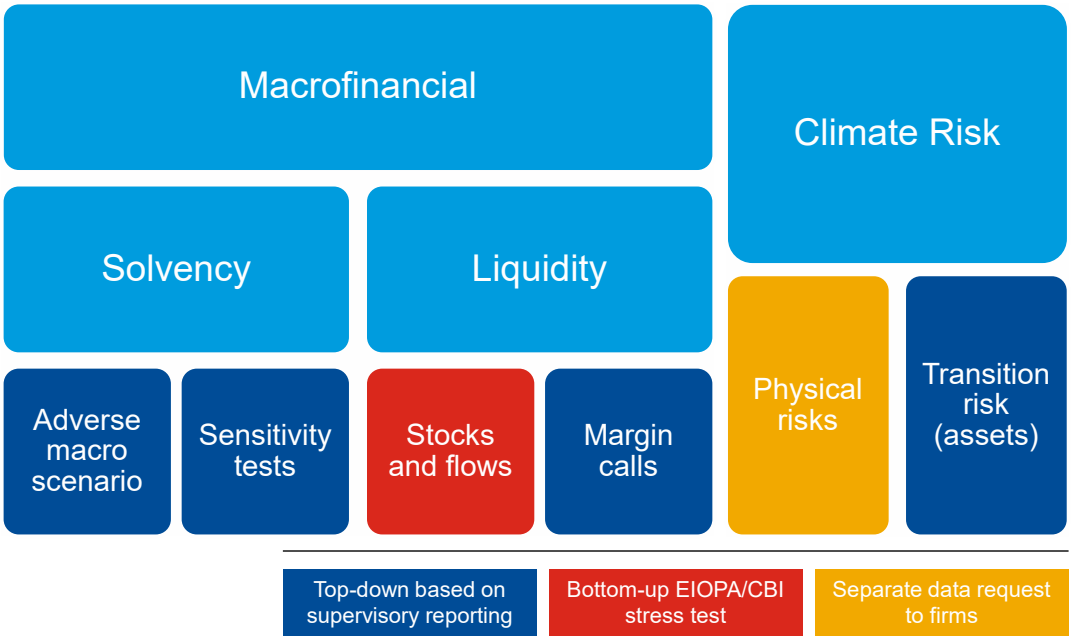



Sources: CBI.

# INSURANCE SECTOR SOLVENCY STRESS TEST

**121. The FSAP conducted solvency and liquidity STs as well as a climate risk analysis in the insurance sector, covering up to 25 (re)insurers** (Figure 49). The top-down solvency ST used the macrofinancial scenario also used in the banking ST, with some granularity added for the market shocks. Sensitivity analyses, e.g., interest rate and currency shocks and the default of the largest banking counterparty, were utilized to complement the solvency analysis. The liquidity ST builds on the scenario of the 2021 EIOPA stress test, which was rolled out by the Central Bank to a cross-section of insurers and reinsurers. In addition, the mission tested the impact of variation margin calls for interest rate swaps. The climate risk analysis covered a bottom-up exercise on natural disaster risks and parametric increases in the severity and frequency of weather-related loss events. Transition risk was analyzed with a top-down approach assuming a change in market sentiment towards certain investment exposures.

**Figure 49. Ireland: Components of Insurance Risk Analysis**




Source: IMF staff.

## A. Scope and Sample of the Solvency Stress Test

**122. A top-down (TD) solvency stress test was performed for 25 large insurers, on a solo-entity basis.**[70] With ten life insurers, eight non-life insurers and seven reinsurers, the stress test reached a representative market coverage of at least 70 percent in all three sub-sectors, based on gross written premiums. The participants' aggregated balance sheet assets amount to €369 billion, of which €270 billion can be attributed to primary insurers which undertake predominantly life business.

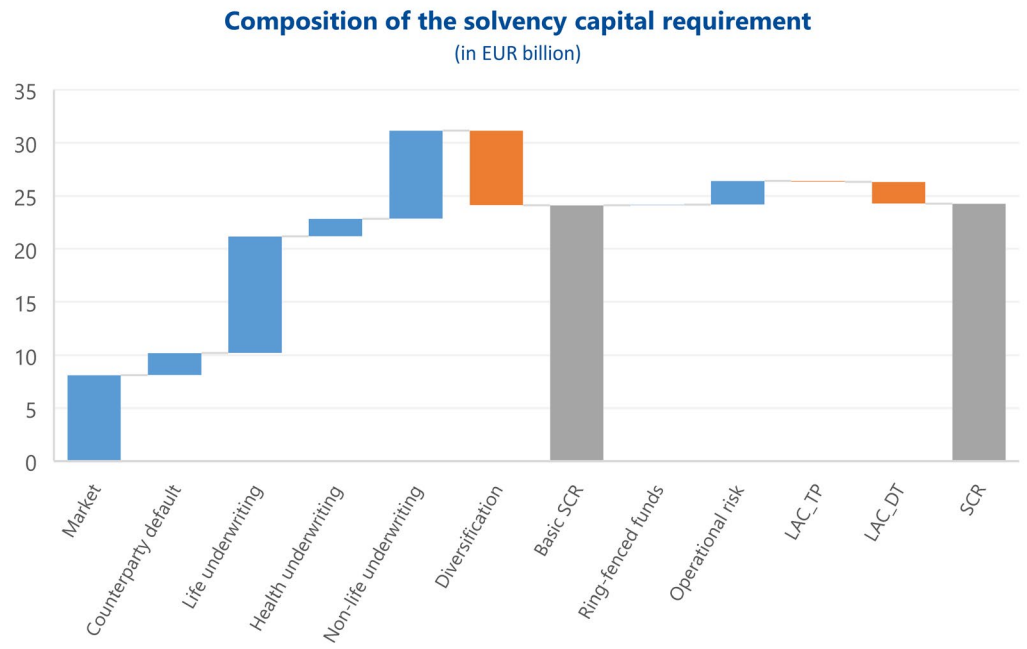
**123. While all 25 participants record before stress solvency ratios above the regulatory threshold of 100 percent, levels of individual insurers differ widely.** For the sample on aggregate, the solvency capital requirement (SCR) composition is relatively balanced: Life underwriting risks dominate, and market risks and non-life underwriting risks contribute roughly equal amounts (Figure 2). Eight participating insurers calculate their SCR with a full or partial internal model. Irish insurers hold high-quality capital, with 95 percent of eligible own funds being unrestricted Tier 1 capital, while only 1 percent is comprised of Tier 3 (Figure 50). The Long-Term

[70] For a summary of the stress testing approach, refer to the Insurance Stress Testing Matrix (STeM) in Appendix IST1.

Guarantee (LTG) measures and "transitionals"[71] have a limited effect in the Irish life insurance sector, although nine insurers in the ST sample have a permission to use the Volatility Adjustment (VA)[72], making it the most relevant LTG measure. Without any LTG measure or transitional being used, the technical provisions of firms using such measures would be only 0.2 percent higher. A slightly larger effect can be observed in the capital position: eligible own funds would be 0.7 percent lower and the SCR 1.1. percent higher, on average. Accordingly, the median SCR ratio of LTG users in the sample would be around 3 percentage points lower (168 instead of 171 percent) (Figure 50).

**Figure 50. Ireland: Own Funds and Long-Term Guarantee Measures**

*As a whole, ST participants show a rather balanced composition of their solvency capital requirement, with life underwriting risks being the most important component.*



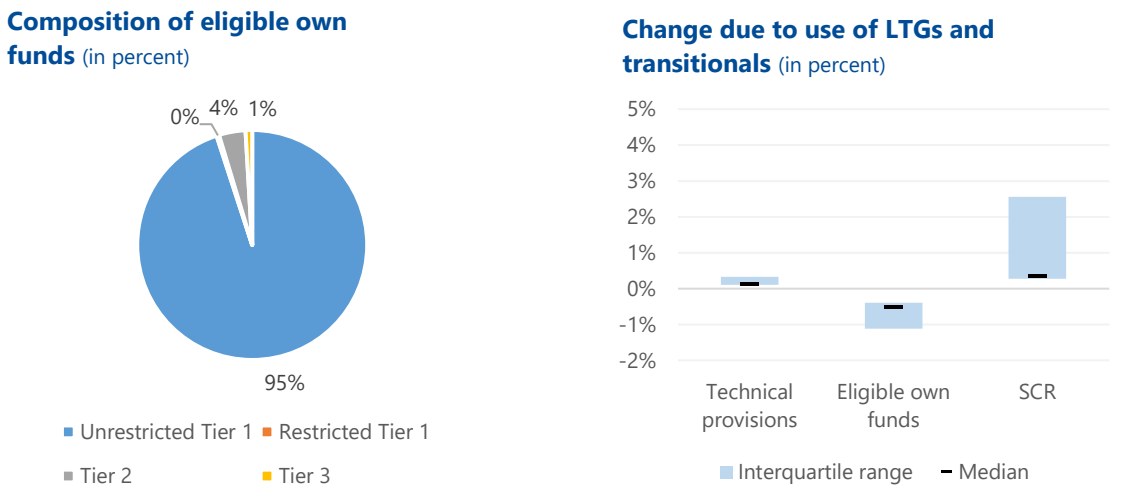

*95 percent of eligible own funds are unrestricted Tier 1 capital, while only 1 percent is comprised of Tier 3.*

*LTG measures and transitionals have a limited effect on the valuation of technical provisions and on the capital position.*

[71] For a period of 16 years after the start of Solvency II (i.e., until end-2031), (re)insurers are allowed to apply the transitional measure on the risk-free interest rate or the transitional measure on technical provisions. Under these transitional measures, insurers apply a transitional adjustment to the risk-free interest rate or a transitional deduction for the valuation of (re)insurance obligations. The transitional measures are linearly phased out over this period.

[72] The VA is a measure by which (re)insurers are allowed to adjust the risk-free discount rate used to value liabilities to mitigate the effect of short-term volatility of bond spreads on their solvency position. In that way, the VA reduces procyclical investment behavior of (re)insurers, particularly in a downturn.

**Figure 50. Ireland: Own Funds and Long-Term Guarantee Measures** (Concluded)




Notes: Stress test participants only. "LAC_TP": Loss-absorbing capacity of technical provisions. "LAC_DT": Loss-absorbing capacity of deferred taxes.
Sources: IMF staff calculations based on Central Bank data.

## B. Scenarios for the Solvency Stress Test

**124. The macrofinancial scenario specified by the FSAP for the banking sector stress test was adjusted for the purpose of the insurance stress test.** The scenario, which features lower and more volatile growth due to further outbreaks of lethal and highly contagious Covid-19 variants, together with a de-anchoring of inflation expectations in the United States and/or advanced European economies, amplified by extended global supply chain disruptions, is highly relevant for the insurance sector. Nevertheless, some adjustments were made to make the scenario directly applicable to an insurer's balance sheet. While the scenario includes a projection of macro and market variables for the next five years, for the insurance stress test all shocks were assumed to occur at the beginning of the first year (instantaneous shock). Market shocks, such as declines in equity and property prices, have therefore been front-loaded so that the maximum drawdown during the projection horizon of the macrofinancial scenario is realized immediately after the reference date (June 30, 2021).

**125. To cover the most relevant risk factors for an insurer's balance sheet, specifically the market risk stresses have been defined more granularly.** The scenario includes shocks to the risk-free interest rate, equity and property prices, as well as credit spreads of corporate and sovereign bonds (Table 10). Given the increase of credit spreads in the scenario, the volatility adjustment also increases, following the Solvency II calculation method. For insurers using the volatility adjustment measure, the result is a higher discount rate which largely offsets the negative impact of the credit spread shock. Finally, to capture higher capital requirements from a deterioration in the credit quality of corporate bond holdings, it was assumed that a third of the bonds is downgraded by three notches.

**126. Despite differences in individual asset classes, the overall severity of the adverse scenario is roughly comparable to the latest stress test run by the European Insurance and Occupational Pensions Authority (EIOPA).** The EIOPA 2021 ST[73] assumed 10-year EUR swap rates to decline by 63 bps and equity prices to drop by 45 percent (EU average); spreads of 10-year Irish government bonds were to increase by 87 bps and those of A-rated EU financials by 109 bps; the shock for Irish commercial real estate amounted to -18 percent. The main difference, therefore, lies in the interest rate shock which, in the FSAP ST, emphasizes more the inflationary pressures.

**Table 10. Ireland: Insurance Stress Test Specification**

| | Adverse scenario | | Adverse scenario |
|---|---|---|---|
| **Equity** | | **Sovereign bond spreads** | |
| Ireland | -58.0% | Ireland | +1.60% |
| United States, Euro area | -18.0% | Other low-yield advanced economies | +0.25% |
| Other advanced economies | -20.0% | High-yield advanced economies | +1.40% |
| Emerging economies | -35.0% | Emerging and developing economies | +1.80% |
| Holdings in related undertakings | -15.0% | Supranationals | 0.00% |
| **Property** | | **Corporate bond spreads** | |
| Residential, domestic | -19.9% | Non-financials, credit quality step 0 | +0.60% |
| Commercial, domestic | -34.1% | Non-financials, credit quality step 1 | +0.75% |
| Residential, other countries | -5.0% | Non-financials, credit quality step 2 | +1.00% |
| Commercial, other countries | -18.0% | Non-financials, credit quality step 3 | +1.30% |
| **Investment funds** | | Non-financials, credit quality step 4 | +1.90% |
| Alternative funds | -8.0% | Non-financials, credit quality step 5 | +2.90% |
| Private equity funds | -10.0% | Non-financials, credit quality step 6 | +4.20% |
| Infrastructure funds | -5.0% | Non-financials, unrated | +2.00% |
| **Risk-free interest rates** | | Financials, CQS 0 | +0.75% |
| EUR, 1 year | +0.06% | Financials, CQS 1 | +0.95% |
| EUR, 10 years | +0.51% | Financials, CQS 2 | +1.25% |
| USD, 1 year | +0.30% | Financials, CQS 3 | +1.60% |
| USD, 10 years | +1.30% | Financials, CQS 4 | +2.20% |
| GBP, 1 year | +0.32% | Financials, CQS 5 | +3.20% |
| GBP, 10 years | +0.26% | Financials, CQS 6 | +4.50% |
| **Currencies** | | Financials, unrated | +2.40% |
| EUR external value | -11.5% | **Other investments** | |
| | | Structured notes | -8.0% |
| | | Collateralised securities | -5.0% |
| | | Other investments, not classified elsewhere | -5.0% |

Notes: Investment funds not explicitly mentioned, like bond funds and equity funds were stressed with the respective shock for the underlying asset class—for bond funds, it was assumed that maturities and ratings resembled those of directly held bonds. More details on the shock to the risk-free interest rates can be found in Appendix II.
Sources: IMF staff.

**127. Additional sensitivity tests, which assumed single-factor shocks, were utilized to complement the stress test.** The result of this sensitivity analysis was not added to the results of the adverse scenario.

[73] One Irish group participated in the 2021 round of the EIOPA ST.

- Interest rates: parallel upward and downward shift of the risk-free term structure (across all currencies) by 100 basis points.
- Currencies: Increase and decrease of the Euro external value by 10 percent.
- Equity: Decline of domestic and foreign equity prices by 40 percent.
- Counterparty risk: Default of the largest banking counterparty. The largest counterparty was determined based on investment asset data in reporting template S.06.02, at the level of the issuer group. It was assumed that equity exposures need to be fully written off (i.e., a 100 percent haircut). Furthermore, a loss given default (LGD) of 50 and 15 percent was applied to unsecured and secured bonds, respectively, and an LGD of 30 percent to other on-balance sheet exposures.

## C. Capital Standard and Modeling Assumptions

**128. Solvency II[74] was implemented in the European Union in 2016 and forms the basis for the insurance stress test.** As a general principle of Solvency II, assets and liabilities are valued mark-to-market. However, Solvency II also allows for some notable deviations from the market-consistent framework in the valuation of insurance liabilities, especially for the discount rate which can incorporate Long-Term Guarantee (LTG) measures and transitional measures.

**129. The main output of the FSAP stress test calculations is the effect on own funds, eligible for the coverage of the solvency capital requirement (SCR).** As the stress also affects the capital requirement, the SCR was partially recalculated after stress.

**130. Data for the TD solvency stress test was gathered from the Solvency II quantitative reporting templates (QRTs).** Solvency II has introduced a very granular supervisory reporting specifically on the asset side. Reported data must meet several automated validation checks, while the Central Bank also has undertaken initiatives to improve the quality and consistency of data. Still, a few inconsistencies and remaining data gaps pose limitations to a TD stress test, notably with regard to derivative data. For the stress test, the following QRTs were used:

- Balance sheet (S.02.01),
- Asset-by-asset investment holdings (S.06.02),
- Derivative positions (S.08.01),
- Cash-flow projections (S.13.01, S.18.01),
- Impact of long-term guarantee measures and transitionals (S.22.01),
- Own funds (S.23.01),
- Calculation of the solvency capital requirement (S. 25.01, S.25.02, S.25.03).

[74] Directive 2009/138/EC of the European Parliament and of the Council of November 25, 2009 on the taking-up and pursuit of the business of Insurance and Reinsurance.

**131. For the TD stress test, the shocks specified in the scenario were applied to the investment assets and insurance liabilities.** Haircuts in line with the adverse scenario were applied to the market value of directly held assets. A look-through to the level of individual securities held by a fund was not applied, so investment fund holdings were stressed with the corresponding shocks for the underlying asset classes. Fixed-income assets were re-valued with the stressed term structure (for each major currency). Similarly, technical provisions (except for unit-linked business) after stress were approximated with the stressed term structure including the volatility adjustment where applicable.[75] For unit-linked business, the decline in liabilities mirrored the market value loss of underlying assets.

**132. The re-calculation of the SCR after stress was limited to selected risk modules.** In the market risk module, the capital charges for equity risk, spread risk and property risk were proportionately adjusted in line with the change in exposures due to the stress. Furthermore, the equity risk capital charge was corrected for the symmetric equity adjustment which changes from +5.7 to -6.0 percentage points after the fall in equity prices in the adverse scenario. The spread risk additionally incorporates the downgrade of a third of the corporate bond holdings. The capital charge for life underwriting risk was assumed to change proportionately with the technical provisions after the application of the stressed discount curve. All other components of the basic SCR, including the capital charge for counterparty default risk, non-life underwriting risk and operational risk were assumed unchanged. For internal model users, the SCR calculations including the aggregation and resulting diversification effects were made in a simplified approach building on the standard formula. In a last step, the loss-absorbing capacity of deferred taxes was re-calculated based on the modeled valuation losses in the excess of assets over liabilities.

**133. Insurance companies have a broad range of risk-mitigating mechanisms in place which cannot be fully captured in a TD stress test, and potential reactive management actions were not modeled in the stress test.** Data granularity of the supervisory reporting does not allow for a comprehensive recognition of financial hedges, stop-loss arrangements, or financial reinsurance. In times of financial stress, insurers have several options to restore their capital adequacy or their profitability, including implementing changes in underwriting standards and in the reinsurance program or by withholding profits. An even more effective way to improve the solvency position relatively quickly is a de-risking of the balance sheet, e.g., by selling equity or high-yield corporate bonds and buying sovereign bonds instead—this change in the asset allocation can significantly reduce required capital. As the stress test assumed a static balance sheet, these types of management actions were not modeled.

## D. Results of the Solvency Stress Test

**134. The results of the stress test need to be interpreted against the heightened market volatility observed during February/March 2022 following the war in Ukraine**. Shocks derived from the macrofinancial scenario were assumed to occur instantaneously at the reference date on

[75] Due to data limitations, not all product features could be fully incorporated in the approximation.

June 30, 2021.[76] Inflation pressures—which existed already prior to the reference date and were accelerated by the war—were only indirectly incorporated, e.g., through an increase in interest rates. In addition to the valuation impact caused by increase in interest rates, higher inflation, particularly for construction material, energy, and wages, could have a significant impact on non-life insurers and reinsurers, raising claims, settlement costs and reducing profitability.

**135. While the valuation impact on assets and liabilities is roughly comparable across sub-sectors, large differences exist across companies and with regard to the extent individual shocks contributed to the overall impact** (Figure 51). Asset values decline by 10 percent for the median life insurer, and by 2 percent for the median non-life insurer. These declines are not fully compensated by lower liabilities (mainly through higher discount rates), hence the asset-liability ratio for the large majority of firms in the sample declines. For the median life insurer, this decline amounts to only 0.5 percentage points (down to 103.2 percent), while for the median non-life insurer and reinsurer the ratio declines by 3.2 and 2.6 percentage points, to 113.3 and 123.9 percent, respectively.

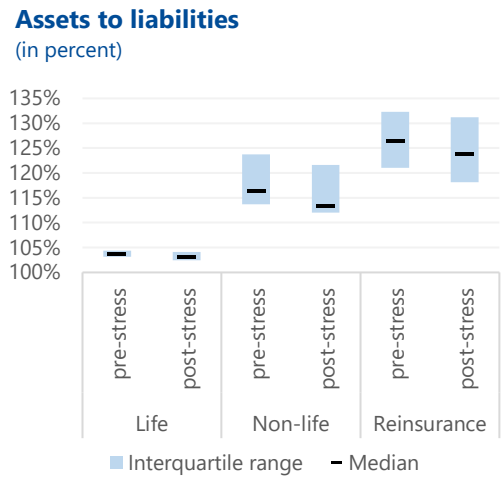
**136. Most of the decline in asset values stems from higher corporate and sovereign spreads, while equity and property shocks have a more muted impact.** Higher interest rates and the depreciation of the Euro offset other adverse shocks as most insurers in the sample have a slight overhang of foreign-denominated assets compared to their liabilities, resulting in a net valuation gain. On the other hand, as some companies in the sample prepare their financial accounts in U.S. dollars—while having also material non-U.S. dollar denominated assets and liabilities—the Euro depreciation tends to affect most of them negatively.

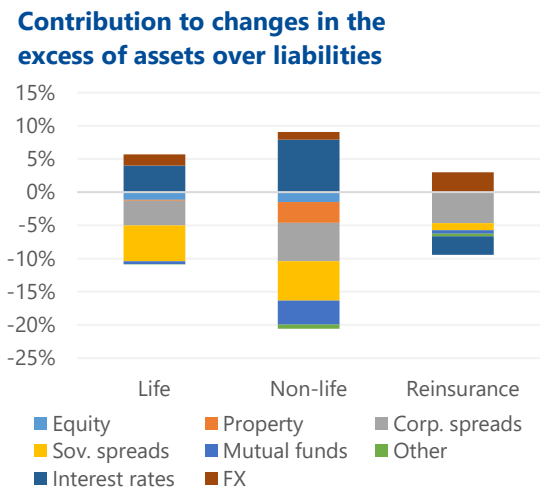
[76] More details on the scenario are included in the Insurance Sector Stress Testing Matrix in Appendix VII.

**Figure 51. Ireland: Insurance Solvency ST—Valuation Impact**

*The ratio of assets to liabilities declines by less than 1 percentage point for the median life insurers, and by around 3 percentage points for non-life and reinsurers.*

*Life and non-life insurers benefit from the assumed increase in interest rates and the Euro depreciation which compensate for valuations losses caused by spread increases.*




Source: IMF staff calculations based on Central Bank.

**137. In terms of solvency levels, Irish insurers are broadly resilient under the adverse scenario** (Figure 52). Non-life insurers are affected most while several life insurers in the sample benefit from the Volatility Adjustment which significantly increases in the scenario—this underlines the countercyclical nature of this mechanism. The coverage of the SCR decreases by 13 percentage points for the median non-life insurer. The median post-stress SCR ratio in the life sector is 6 percentage points higher than pre-stress—however, this overstates the impact on the sector, as for the majority of life firms the SCR ratio declines. Further sensitivity analyses showed that a global -40 percent shock to equity prices[77] would have a more pronounced impact and could bring a small number of life insurers close to, or even below, 100 percent SCR coverage.

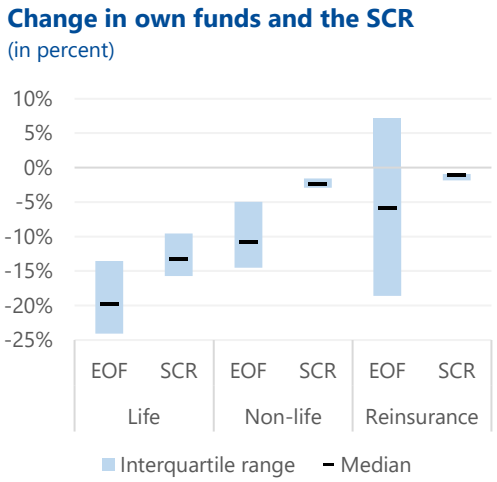
**138. While the ST did not reveal any systemic vulnerabilities under the tested scenario, microprudential follow-up actions are recommended.** The vast majority of insurers remain well-capitalized and only one life insurer drops below the regulatory threshold (100 percent SCR coverage) with a shortfall in eligible own funds to meet the SCR amounts to less than €10m. One more firm, a reinsurer shows a post-stress SCR ratio close to the threshold. Both insurers already had relatively low SCR ratios before stress and are subsidiaries of large internationally active insurance groups.

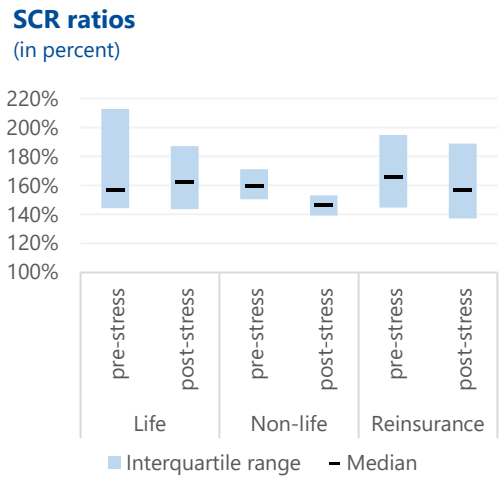
[77] Instead of the more domestic market-focused equity shock used in the solvency adverse scenario.

**Figure 52. Ireland: Insurance Solvency ST—Solvency Impact**

*The decline in eligible own funds (EOF) cannot be compensated by the decline in the SCR which stems mainly from lower investment exposures post stress.*

*Non-life insurers would see the largest decline in SCR ratios (-13 percentage points for the median firm), while the SCR ratio of the median life insurer increases slightly.*




Source: IMF staff calculations based on Central Bank.

In this context, it is recommended that the Central Bank continues to closely monitors risk exposures of those insurers and forthcoming recovery plans, which were submitted by several larger insurers as of April 2022. Results of this ST and future TD ST exercises could be used to validate insurers' own assumptions on adverse scenarios and options available to recover from a capital shortfall.

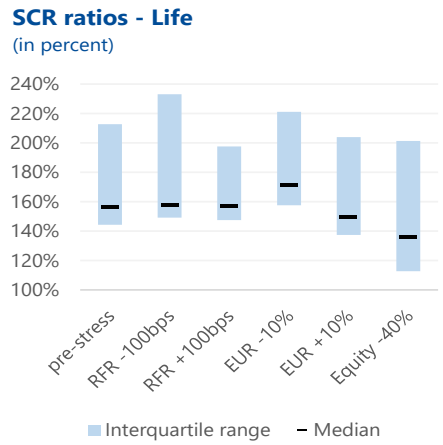
## E. Sensitivity Analyses

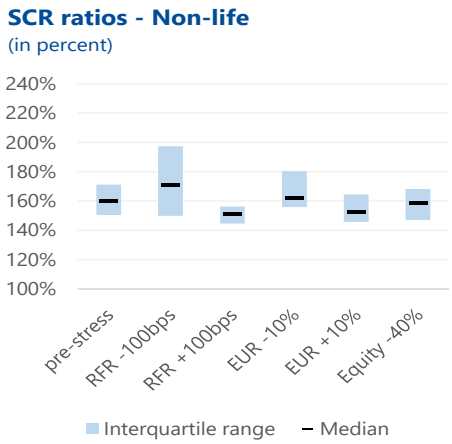
**139. The sensitivity analyses broadly confirm the resilience of Irish insurers, but also highlight the vulnerability to equity price declines for a few life insurers** (Figure 53). For this analysis, the same data and methodology was used as for the solvency ST, including a recalculation of the SCR after stress. The equity shock has the greatest impact in the life sector with one insurer getting close to an SCR coverage of only 100 percent, while non-life insurers and reinsurers are mostly immune given their smaller exposures. Lower interest rates—which were not tested in the adverse macrofinancial scenario—could even have a slightly beneficial effect for many insurers in the sample.

## Figure 53. Ireland: Insurance Solvency ST—Sensitivity Analyses

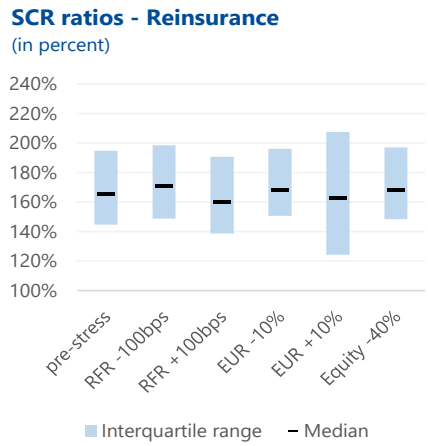
*Life insurers are relatively immune to changes in the risk-free rate (RFR), but some could experience much lower SCR ratios if equity prices decline sharply.*

*Compared to life insurers, non-life firms would not see very substantial changes in their SCR ratios, with small deviations only across the sample.*




*The dispersion of SCR ratios is a bit wider for reinsurers depending largely on their focus on life or non-life business.*




Source: IMF staff calculations based on Central Bank data.

# INSURANCE SECTOR LIQUIDITY RISK ANALYSIS

## A. Results of the Central Bank's Liquidity Risk Analysis

**140. The liquidity analysis builds mostly on the EIOPA 2021 bottom-up ST, which assessed liquidity sources and needs.** In the EIOPA ST, a shock to cash flows comprises a mass lapse event, higher mortality and pandemic claims, as well as lower premiums. The value of liquid assets is shocked with an adverse market risk scenario. As the EIOPA exercise would have included only one Irish insurer at the European level, the Central Bank extended the exercise to comprise four life insurers, three non-life insurers and three reinsurers which were representative of some of the different business models seen in the Irish market.

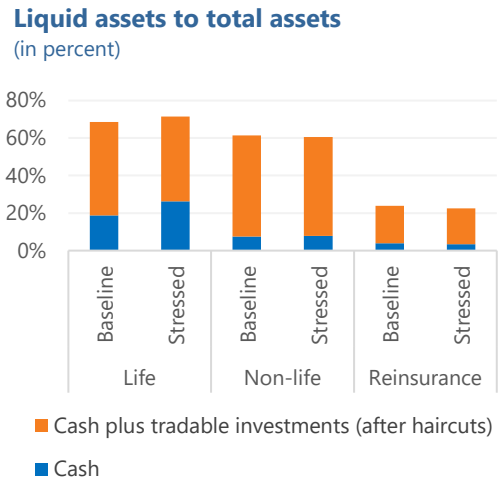
**141. Based on its 2021 ST, EIOPA concluded that liquidity risks are generally less of a concern than solvency risks given insurers' large holdings of liquid assets.** Nevertheless, unexpected cashflows could not in all cases be met solely with available cash holdings, hence some of the most liquid investment assets might need to be liquidated.

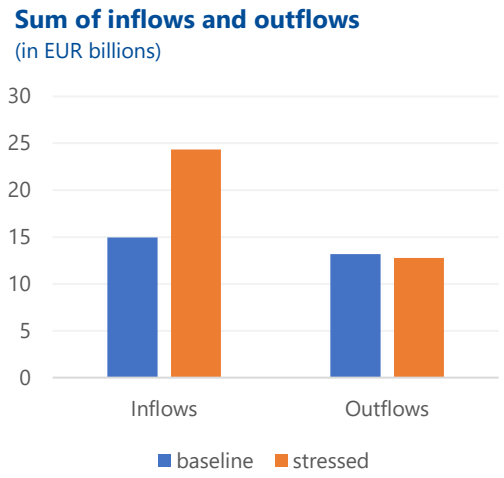
**142. Similarly, a liquidity shock is unlikely to have a systemic impact in the Irish insurance sector, instead, results of the Central Bank's bottom-up analysis are very much driven by company specifics** (Figure 54). The relatively small sample of only ten insurers does not reveal vulnerabilities at the sector level. On aggregate, the share of liquid assets is relatively high. The aggregate cash inflows even increase in the adverse scenario (compared to the baseline) as a result of its impact on the direction of derivative-related collateral flows at some firms—given an increase in the market value of those instruments under the scenario assumptions—leading to inflows. However, this is unlikely to be a sector-wide phenomenon given the limited use of derivatives across the market as a whole. The results underline the importance for the supervisor to understand liquidity flows and liquidity risk management, which also needs to include the insurance group structures. Therefore, the Central Bank is encouraged to follow up the exploratory exercise of 2021 with a broader sample, and different combinations of cash outflows and tighter market liquidity conditions.

**Figure 54. Ireland: Insurance Liquidity Risks**

*Large parts of an insurer's balance sheet are comprised of liquid assets which includes cash and tradable investment assets—this ratio remains stable even in stressed situations.*

*Aggregated inflows increase in the stress scenario, as some firms benefit from lower margin and collateral requirements.*




Notes: Results shown here for life insurers, non-life insurers and reinsurers should not be interpreted as being representative for each sub-sector, as the Central Bank selected a sample with specific business model characteristics.
Source: IMF staff calculations based on Central Bank and company submissions.

## B. Analysis of Risks from Variation Margin Calls

**143. The FSAP carried out a TD analysis of potential liquidity risks from variation margin calls for interest rate swaps, using a methodology recently employed by EIOPA[78] and also in the 2021 U.K. FSAP.** The analysis indicated that variation margin calls for interest rate swaps could be met, even when using very narrow definitions of liquid assets.

**144. Irish insurers hedge only relatively small portions of their interest rate and market risks with derivatives** (Figure 55a). For the insurers included in the ST sample, the market value of asset-side derivatives amounts to 0.8 percent of assets while liability-side derivatives constitute 0.9 percent of total liabilities. Derivative holdings are quite diverse: For life insurers, the dominant types are forwards with 33 percent of the overall notional value of all derivatives, followed by put options and interest rate swaps (17 and 16 percent, respectively). Non-life insurers have their largest derivative holdings in interest rate swaps (26 percent), and other swaps and forwards are relevant types as well.

**145. Data available for top-down analyses of variation margin calls is limited and hampered by incomplete or inconsistent reporting of derivatives in the QRTs.** While the overall quality of

[78] See EIOPA (2019), Impact of Variation Margining on EU Insurers' Liquidity: An Analysis of Interest Rate Swaps Positions.

supervisory reporting has improved since the implementation of Solvency II in 2016, detailed position data for derivatives is not available from all companies, and the quality of available data also differs across different types of derivatives.[79] As insurers have additional reporting requirements under the European Market Infrastructure Regulation (EMIR),[80] a cross-check between both data sources might improve the availability of data and enable further analysis.

**146. An approximative analysis run solely for interest rate swaps showed that insurers would face no major issues in meeting margin calls for those.** Life insurers are typically fix rate receivers in their swap positions making them vulnerable to increases in interest rates, which would trigger variation margin calls—for non-life insurers, swap positions could be either fix-receiving or fix-paying. Limited data availability[81] resulted in a significantly smaller sample than for the solvency ST—five insurers with a market coverage of only around 10 percent were included.

**147. The scenarios for the analysis assume substantial interest rate increases and decreases of up to 100 basis points within a five-day period.** For the liquidity analysis, three interest rate shocks were modeled, stretching over two different time horizons: A 25 basis points (bps) increase (parallel shift of the interest rate term structure, for all relevant currencies) is assumed to occur overnight, hence to meet cash margin calls, only the most liquid assets could be drawn upon—the FSAP analysis uses the narrowest definition by including only cash deposits.[82] The other two scenarios, interest rate increases of 50 and 100 bps, would unfold over a period of five days. In that case, it is assumed that insurers could liquidate some of their most liquid high-quality assets, so that the pool of cash deposits enlarges. Concretely, the margin calls could be met with cash deposits plus unencumbered sovereign bonds of credit quality steps 0 and 1,[83] revalued after the interest rate increase and with an additional haircut.

**148. All five insurers are capable of meeting margin calls with their cash equivalents only, even in the case of a 100-basis points interest rate change** (Figure 55b)—on average, the variation margin calls for those insurers with a positive margin call amount to €96 million in the higher interest rate scenario (55 percent of cash holdings) and to €35 million in the lower interest rate scenario (27 percent of cash holdings). Adding high-quality sovereign bonds to the cash holdings reduces the share of the variation margin further to 8 and 2 percent, in the higher and lower rate scenarios, respectively. With less than 5 percent, encumbrance levels of high-quality

[79] Certain non-plain vanilla options cannot be revalued based on the available information, and some information on underlyings (particularly interest rates) is reported inconsistently.

[80] Regulation (EU) No 648/2012 of the European Parliament and of the Council of 4 July 2012 on OTC derivatives, central counterparties and trade repositories

[81] The analysis uses derivative positions as reported in QRT S.08.01. An alternative source would be the data reporting introduced with the European Markets and Infrastructure Regulation (EMIR).

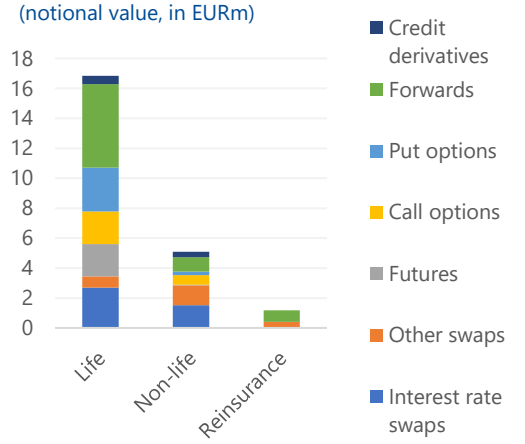
[82] Central counterparties would often also allow the use of high-quality securities as a means to meet margin calls.

[83] Typically corresponding to AAA and AA ratings.

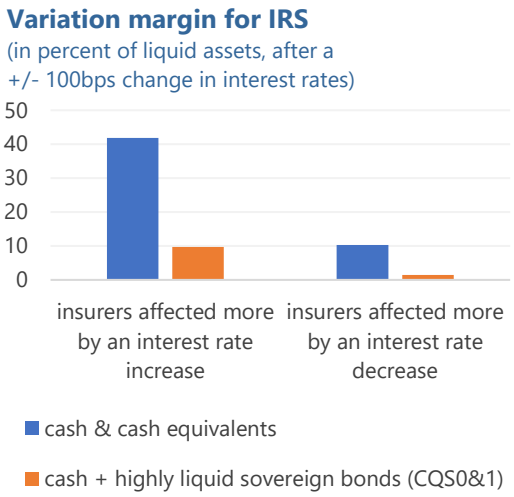
sovereign bonds are low for the insurers in the sample, providing them buffers in liquidity stress environments.

**Figure 55. Ireland: Insurers' Variation Margin Calls**

*Derivative holdings of Irish insurers are very diverse, and forward are the largest type in terms of notional amounts.*




*Insurers are able to meet variation margin calls for interest rate swaps after a +/-100 bps change in interest solely with their cash holdings.*




Source: IMF staff calculations based on Central Bank data.

# INSURANCE SECTOR CLIMATE RISK ANALYSIS

## A. Physical Risk

**149. The insurance sector is exposed to physical climate risks mainly through its non-life underwriting.** Domestically, the most important natural perils are windstorms, floods, and freezes, but several Irish (re)insurers underwrite business globally, exposing them also to other types of international climate-related risks, such as U.S. hurricanes and wildfires.

**150. Physical risks were assessed with a bottom-up approach in collaboration with firms.** The analysis used a simulation of both one-time natural catastrophes and a permanent increase in the frequency and severity of adverse weather events. The catastrophic events included Ireland/U.K. windstorms, Ireland flood, as well as U.S. hurricanes and California wildfires; while being aligned with historic scenarios, their loss impact was inflation-adjusted and scaled up by 150 percent.

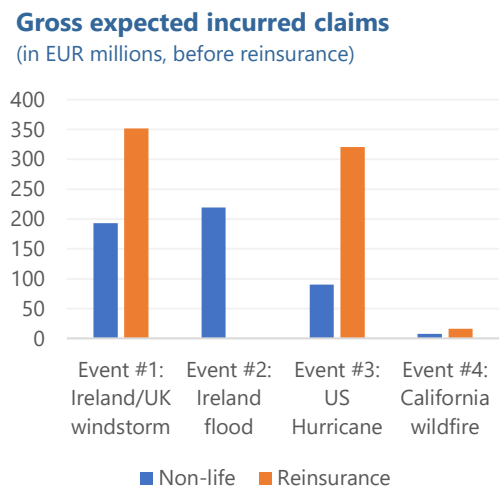
**151. Even large natural catastrophes, when seen in isolation, would likely not have a pronounced impact on insurers' solvency levels** (Figure 56). For example, while the payouts, following a major windstorm in Ireland and the United Kingdom would result in gross claims of around €550 million and net claim payments (i.e., after reinsurance) of around €140 million, the impact would be seen mostly in profits, while the SCR ratios would decline by less than 3 percentage points, on average. However, it is important to note that large domestic loss events have been rare

in recent years, instead smaller and medium-size events are quite frequent. This limitation on historic data complicates loss modeling of extreme events, particularly for Irish flood risk, where participants in the bottom-up ST used very different assumptions for the occurrence probability of the scenario. It is therefore recommended that the Central Bank follows up on these observations in its ongoing supervision of catastrophe risks.

**152. Irish insurers use relatively high levels of reinsurance for extreme events, but also rely largely on group-internal reinsurance.** As subsidiaries of internationally active insurance groups, many of the larger Irish insurers use either their parent company or a dedicated entity within the group to reinsure against extreme events like natural disasters. Typically, such a dedicated reinsurer would use retrocession to mitigate its own risks, but for the Irish subsidiary, the strong reliance on just one reinsurer poses a counterparty risk which requires regular monitoring by the central bank as the host supervisor.

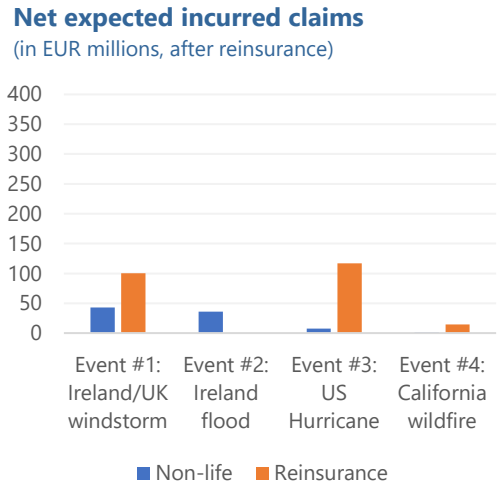
**Figure 56. Ireland: Insurers' Physical Climate Risks—Natural Catastrophes**

*Ireland/U.K. windstorms, Ireland floods, and U.S. hurricanes would result in significant gross claim payments by Irish insurers…*




*… and, seen in isolation, none of the events would reduce solvency levels below regulatory thresholds—for most perils, the effect would be rather minor.*

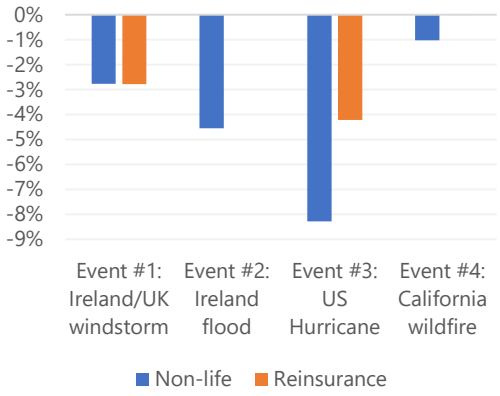
*which are, however, mitigated through reinsurance, effectively reducing the net loss on each event …*



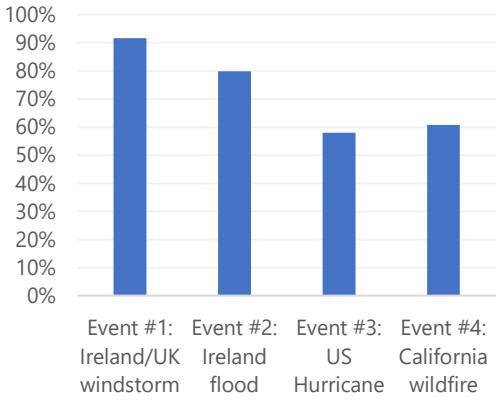

*Irish insurers are relying to a very large degree on group-internal reinsurance for the most relevant natural disasters.*

## Figure 56. Ireland: Insurers' Physical Climate Risks—Natural Catastrophes (Concluded)

**Average reduction in SCR ratios**
(in percentage points)

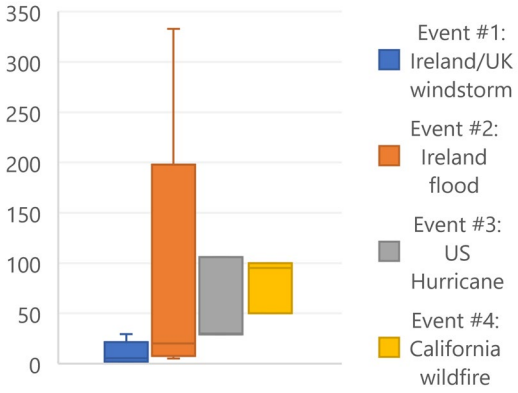



**Average recoverables from group-internal reinsurance** (in percent)




*Modeling of domestic flood risk is very diverse, and insurers' assumptions on the occurrence probability of the simulated flood event vary significantly.*

**Insurers' assumptions on occurrence probabilities** (1-in-X years)



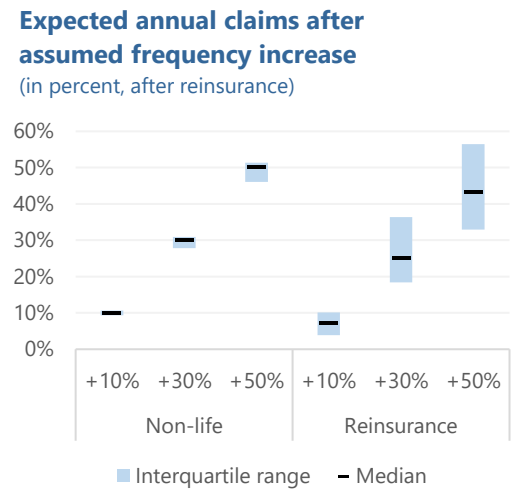

Source: IMF staff calculations based on Central Bank and company submissions.

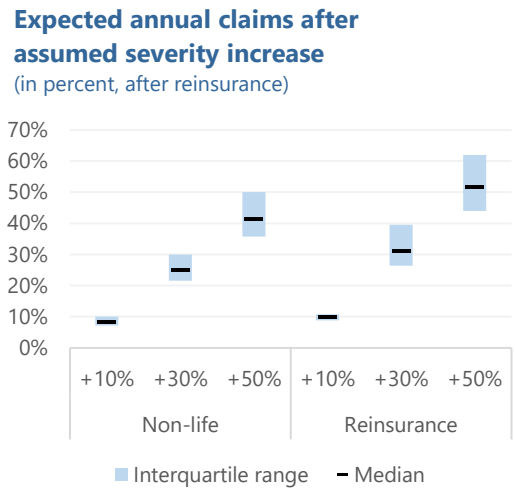
**153. A higher frequency or severity of weather-related events would directly translate into higher net claims for non-life insurers and reinsurers** (Figure 57). The results particularly highlight the differences between more frequent and more severe events with regard to the coverage of losses through reinsurance. Claims related to more frequent events would largely be borne by primary non-life insurers as their reinsurance coverage would often set in only above a certain loss amount—hence, for the median non-life insurer, the net expected annual claims raise in line with the assumed frequency increase. For reinsurers, the net claims tend to raise by a lower amount, but variations across the sample are very large. A higher severity of weather-related events would typically be covered by reinsurance, which results in a slightly lower increase of net claims than what is suggested by the tested scenarios. However, any increases in claims would very likely—at least over a medium-term horizon—result in an increase in the premiums charged to policyholders and/or cover design changes as insurers aim to keep their underwriting business profitable.

**Figure 57. Ireland: Insurers' Physical Climate Risks—Parametric Approach**

*For primary non-life insurers, more weather-related events would cause higher net claims in a rather proportionate way—while for reinsurers, net claims would increase by less than what the higher frequency suggests, but with larger variation across firms.*

*With greater severity of events, the expected net claims would typically increase by a little less for primary insurers than what the severity increase suggests—while reinsurers would see claims increasing more proportionately.*




Source: IMF staff calculations based on Central Bank and company submissions.

**154. EIOPA's pilot dashboard on protection gaps from natural catastrophes indicated a low risk for the Irish market.** Compared to other European countries, the historic occurrence of large catastrophes is low, and insurance penetration levels are high. Particularly with regard to windstorm risks, the building structure is sufficiently robust to withstand larger storm events.[84]

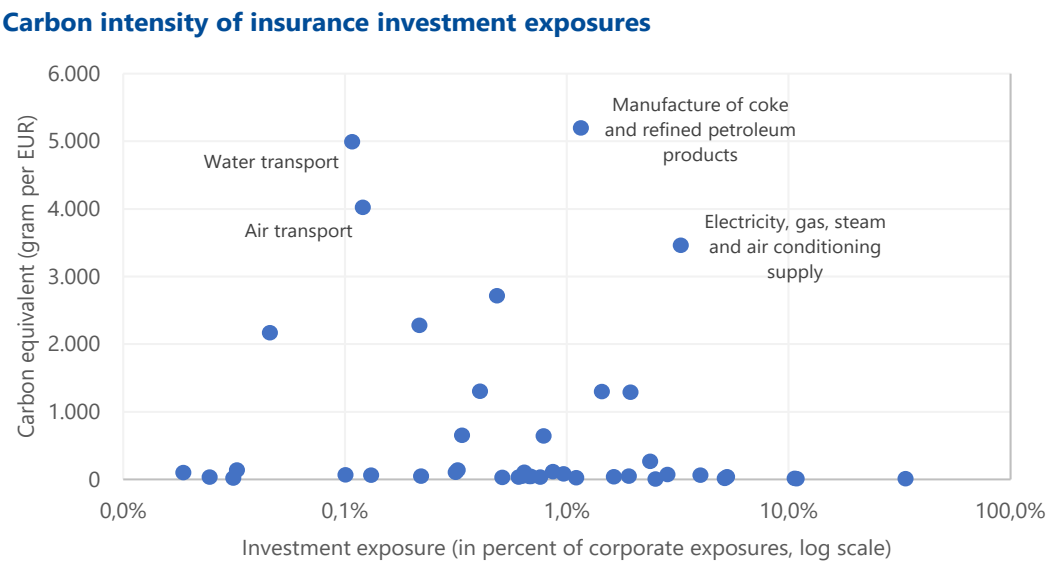
**155. While protection gaps are not observed at a national level, local areas exist where flood protection cannot be obtained due to elevated local risks.** For the DoF and the Central Bank it is therefore recommended to monitor these issues—also in the context of their ongoing work being pursued on the cost of insurance—and to understand price dynamics and options to ensure protection being available at an acceptable cost. One possible option in this context could be to gather the indicators used in the EIOPA dashboard at a regional or, where necessary, at a local level. The FSAP observed that a close cooperation between the insurance industry and the Office for Public Works has already been established to discuss, inter alia, flood protection measures.

## B. Transition Risk

**156. Transition risks could materialize for investment assets in certain sectors.** About 8 percent of insurance investments is allocated to sectors with a high carbon footprint, i.e., carbon equivalents of greenhouse gases greater than 1,000 gram per Euro of output (Figure 58). Among those, the most relevant sector is "Electricity, gas, steam and air conditioning supply" with around 4 percent. Still, the five largest sectoral exposures are towards sectors with limited greenhouse gas emission, below 50 gram per Euro. For example, "Financial service activities except insurance and pension funding", with around one third the largest sectoral exposure, emits only 11 gram per Euro, according to Eurostat data.

[84] EIOPA's pilot dashboard on insurance protection gap for natural catastrophes.

**Figure 58. Ireland: Insurers' Sectoral Exposures**




Notes: Greenhouse gas emissions of NACE sectors at EU level expressed as carbon equivalents. Exposures include only stress test firms (see the Insurance Sector Stress Testing Matrix). Exposures to NACE sectors K.64.3 and K.66.3 (investment funds) as well as sector O (public sector) are excluded.
Source: IMF staff calculations based on Central Bank, and Eurostat.

**157. Transition risks were analyzed via a top-down approach, assuming an instantaneous "Minsky moment" of re-pricing in certain asset classes and sectors.** It was assumed that the effect of the NGFS scenario of an orderly 1.5 degree increase until 2050—a rather optimistic scenario—is priced by investors instantaneously. Modeling the impact on corporate balance sheets produced equity price changes, spread changes and corporate defaults which were then applied to insurers' investment assets.[85]

**158. A lower valuation could be expected particularly for equity investments, while bond valuations and default rates are expected to be more stable** (Figure 59). For the median insurer, the value of equity investments declines by 3.8 percent, while the value of corporate bonds and investment funds[86] declines by only 1.6 and 1.4 percent, respectively.

**159. The impact of transition risk is overall manageable, but larger for life insurers, mainly due to their comparably riskier asset allocation and the type of funds chosen by customers—however, results vary substantially across firms and come with considerable modelling uncertainties.** For the median life insurer, the reduction in asset values amounts to 2.7 percent. This

[85] For more details on the methodology, see the U.K. 2021 FSAP Technical Note on Balance Sheet Resilience.

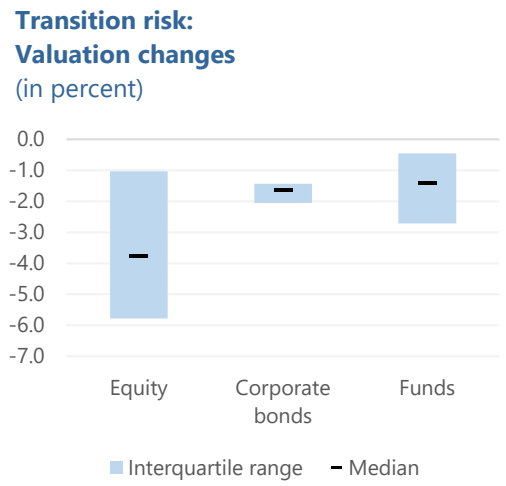
[86] "Investment funds"comprises also fund types which were not stressed in the transition scenario, like e.g., money-market funds or alternative funds.

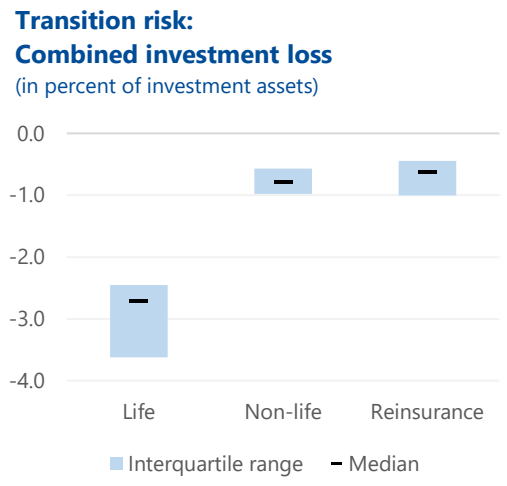
compares with declines of less than 1 percent for non-life and reinsurers, reflecting lower exposures to equities and the shorter duration of corporate bonds, which results in a lower valuation impact from bond spread increases. In absolute amounts, assets could decline by around €7 billion but this would likely be an upper bound, as transition risks would likely not realize instantaneously as assumed in the model, and insurers would have time to adjust their asset allocation. Still, uncertainties remain, and risks could also materialize much earlier than the NGFS path of carbon price increases until 2050 suggests.

**Figure 59. Ireland: Insurers' Transition Risks**

*The valuation impact of the transition scenario is highest for equity investments, which could fall by around 4 percent for the median insurer.*

*For the median life insurer, the value of investments could decline by almost 3 percent if transition risks materialize.*




Source: IMF staff calculations based on Central Bank and company submissions.

# INVESTMENT FUND LIQUITY STRESS TEST ANALYSIS

## A. Introduction

**160. Ireland's investment fund industry is among the largest in the world and has experienced explosive growth since the 2016 Ireland FSAP.** Assets under management (AUM) of Irish-domiciled investment funds (IFs) amounted to over 840 percent of GDP in 2021 Q1—leading to Ireland having the second-largest fund sector globally relative to GDP, and the third-largest based on absolute AUM.[87] IF assets have increased by around 90 percent in the last five years.

[87] The United States and Luxembourg are the only two countries in the world with investment fund sectors larger than Ireland. Ireland ranks second in the world after Luxembourg in terms of IF assets relative to GDP.

**161. Ireland is an attractive domicile for non-banks, comprised in large part of investment funds, due to a confluence of factors.** Ireland has a high degree of local expertise and technical know-how in the financial industry, transparent and efficient regulatory practices, and favorable tax and legal regimes conducive to non-bank financial operations. These factors have contributed to Ireland developing a non-bank dominant financial structure over time. Non-bank assets, the majority of which are investment fund assets, are 87 percent of total domestic financial sector assets in Ireland, which is around 37 percentage points higher than the global average (FSB, 2020).

**162. The FSAP assessed the liquidity resilience of investment funds in Ireland through a liquidity stress-testing approach.** The objective of the stress test is to assess the ability of individual funds to withstand severe but plausible redemption shocks. Of note is that the stress test does not consider the use liquidity management tools (LMTs), and the results should be interpreted keeping in mind that LMTs could mitigate shocks to some extent. While the stress test is micro-prudential in nature, it has broader implications for financial stability. If individual funds are unable to weather redemption shocks, then events of market stress could lead to significant liquidation of assets by funds which may not be absorbed smoothly by markets. Should this happen on a collective basis, there is the potential for wide scale fire sales having a systemic impact. While this TN does not estimate the aggregate price effects of fire sales as it is micro prudential in nature, this would be a useful step in the future to assess the systemic impact in the broader Irish financial system of the collective selling of assets by investment funds in stressed market conditions.

**163. Liquidity mismatch is the fundamental premise of the stress test.** While open-ended investment fund liabilities are highly liquid, and funds must typically meet redemption requests on a daily basis, the assets of certain types of investment funds are less liquid. This implies a focus in the stress test on cohorts of funds with relatively fewer liquid assets, such as funds that invest in high-yield debt or emerging market debt within the fixed-income category.

**164. The results indicate that the majority of Irish-domiciled funds are resilient, but pockets of vulnerability exist.** The vast majority of investment funds in the stress test sample are found to be able to withstand severe but plausible redemption shocks. However, a significant share of funds that invest primarily in high-yield bonds could experience liquidity shortfalls, or the inability to meet redemption requests out of liquid assets, when faced with severe redemption shocks. To a lesser extent, funds with an emerging market focus are also found to be susceptible to redemption pressures in certain scenarios.

**165. The Central Bank has made good progress on developing an internal stress-testing framework for funds, but the work is yet to be completed.** The Central bank currently conducts liquidity analysis of money market funds (MMFs) but has not yet developed a complete liquidity stress-testing framework for funds as per the recommendation of the 2016 Ireland FSAP. The CBI's development of an internal stress testing model for IFs and MMFs remains in progress. To further develop the framework, the CBI might consider enhancing their estimation of the aggregate price effects, including the second-round effects of collective selling by funds on Irish financial markets to assess financial stability risks. The CBI should also continue to collaborate with the ECB to develop a macro stress testing framework across jurisdictions in Europe.

## B. Potential Spillovers from the Funds Sector

**166. Fire sale of assets by investment funds trying to meet unexpected redemption demands has the potential to affect other segments of the financial system.** If financial institutions, such as banks and other non-banks, have common asset holdings with funds, these assets could experience a downward price spiral due to the fire sales by the funds experiencing redemption shocks. Given the potential mismatch between the highly liquid liabilities of investment funds and their relatively less liquid assets, it is important to monitor the liquidity resilience of funds and periodically test their ability to withstand severe redemption shocks. This resilience assessment at the fund level should be supplemented with monitoring of common asset holdings between funds and other segments of the financial system (banks and non-banks), to assess the potential for spillovers of redemption shocks to the broader financial system via fire sales by funds.

**167. In addition to indirect linkages via asset holdings, the funds sector has sizeable direct linkages to the rest of the economy.** In particular, funds have significant linkages with the OFI sector with financial asset claims of funds on Irish-domiciled OFIs amounting to around 21 percent of GDP in 2020Q4. Given, in turn, that parts of the OFI sector have significant connections to the domestic economy (see the Technical Note on the interconnectedness of the MBF sector), the fund sector's linkages with OFIs have the potential to create indirect linkages of Irish funds to the domestic economy. Additionally, real estate funds are a significant source of funding for the domestic CRE property market. Liquidity shocks to the funds sector could lead to pressure on the CRE sector, which in turn could result in losses for other financial institutions that have larger exposures to CRE. These direct linkages with the other sectors highlight the importance of monitoring liquidity resilience of funds, as part of a system-wide financial stability monitoring.

## C. Liquidity-Stress Testing Model

**168. The liquidity stress test assessed the ability of fixed-income investment funds to weather redemption shocks and consists of three stages.** The first step involves the calibration of the redemption shock, which could be done at either the individual fund level or at a fund category level. The second step involves the calculation of liquidity buffers on the asset side of the balance sheet. The third step consists of assessing the resilience of investment funds based on the amount of liquidity that funds have available to meet redemption shocks. Of note is that the stress test in this TN is micro-prudential in scope. A further step, which is more macro-prudential in nature, would involve analyzing the market price impact of fund sales, which would affect other financial entities, and would depend on the liquidation strategy (e.g., slicing or waterfall) of funds. This depends on the availability of local market data and is left for future analysis.

**169. The redemption shock, defined as net outflows in percentage of total net assets, is calibrated using the historical distribution approach.** In this approach, the redemption shock is based on a certain low percentile of the historical distribution of net outflows to capture tail risk events. Further details on the specific time period and summary statistics for the shock are provided in the following sections. The historical distribution data can be analyzed at either the fund level or

at the category level, and the specific tail event can be based on either a Value-at-Risk (VaR) model or an Expected Shortfall (ES) model both of which are employed in this note.[88]

**170. Liquidity buffers in the stress test are calculated using a liquidity buckets approach which assigns liquidity weights for each portfolio asset.** Specifically, the analysis utilizes weights defined by the Basel III high-quality liquid assets (HQLA) method to calculate liquidity weights for assets held by investment funds as in the 2017 Luxembourg and the 2020 U.S. FSAPs. While the HQLA method was originally designed for liquidity requirements for banks, they provide a useful benchmark for liquidity buffers of investments in a stressed market liquidity environment. One potential drawback of this approach is that it could overweight a fund's cash buffer since part of a fund's cash may be needed for operational purposes and to meet future margin calls and, hence, it may not be fully utilized to meet redemptions. At the same time, it could penalize funds with less liquid assets. A second potential drawback is that for HQLA liquidity buffers—debt assets are discounted based on ratings and all equities are treated the same way and discounted at 50 percent. Ratings may not be a good indicator of liquidity of debt in all scenarios and there are certainly differences in liquidity across equity assets and across debt markets. This may mean for example that funds with higher levels of lower rated debt may appear less liquid in the stress test than they might be in actual stress depending on how that stress unfolds.

**171. Finally, the resilience of funds is assessed through the redemption coverage ratio (RCR) and liquidity shortfall metrics.** The RCR measures the amount of liquidity that funds have, either at the individual fund level or at the category level, compared to the size of the redemption shock. It is the ratio of HQLA to the redemption shock and differs by fund or category based on the type, strength, and distribution of the shocks. An RCR greater than 1 would indicate that the fund has enough liquidity buffers to weather redemption shocks, whereas an RCR less than 1 would indicate that, when faced with significant redemption shocks, the fund would have to sell its less liquid assets, potentially at fire sale prices. Of note is that the stress test does not consider the use of LMTs, which could potentially mitigate redemption pressures for funds with low RCRs, and this would be an interesting topic for further research. The liquidity shortfall is the difference between a fund's HQLA and the simulated redemption shock for funds with RCR < 1.

**172. The technical approach followed in this FSAP resembles aspects of the investment fund stress-testing frameworks in recent IMF FSAPs.** The model used here is closest to, and builds upon, the micro-prudential aspect of the stress-testing model used in the 2020 U.S. FSAP. Other FSAPs that have stress-tested IFs include Hong Kong (2021), Brazil (2018), Luxembourg (2017), Ireland (2016), and Sweden (2016).

[88] The VaR model calculates the redemption shock as a percentile (for example, the worst first, third, or fifth percentiles of net outflows) and the ES model calculate the shock as the average net outflows below the VaR.

# INVESTMENT FUND STRESS TEST DESCRIPTIVE ANALYSIS

## A. Data and Sample Selection

**173. The data used for the stress test was downloaded from the commercial database, Morningstar, based on a comprehensive list of investment funds provided by CBI.** CBI provided a list of fund IDs and corresponding International Securities Identification Number (ISIN) codes covering the majority of the investment fund industry in Ireland.[89] Of this list, 82 percent of funds, covering 86 percent of total AUM, were available in Morningstar (Table 2). After imposing the first stress test filter of selecting funds with a portfolio reporting date of January 1, 2021, or later—to ensure that funds in the sample were still active in 2021—a total of 3,289 investment funds were available, corresponding to around three quarters of the AUM of Irish funds (Table 11).

**Table 11. Ireland: Investment Fund Data Availability in Morningstar**

| | CBI-provided list of investment funds | Morningstar availability | Portfolio reporting date > Jan 1, 2021 |
|---|---|---|---|
| Number of funds | 4,942 | 4,042 | 3,289 |
| Total Net Assets (TNA) | €3.5 trillion | €3 trillion | €2.8 trillion |

Sources: CBI; Morningstar; and IMF staff calculations.

**174. The dataset is of monthly frequency, from 2007-21 and includes key fund attributes at the individual fund level.** Data on net flows (redemptions minus subscriptions), fund size (total net assets), and portfolio composition (percentage of cash, bonds, equities, and other assets, as well as the credit quality of selected instruments) were downloaded from Morningstar for each of the 3,289 Irish-domiciled funds.

**175. Given the liquidity stress vulnerability assessment aim, the stress test focused on the type of funds that are on average more likely to have larger liquidity mismatches between their assets and liabilities.** Accordingly, only those funds with a primary focus of fixed-income or property investments were chosen. These funds corresponded to 89 unique "Morningstar categories"[90] which were then mapped to seven broader categories based on their primary investment focus. These categories are: High Yield (HY), Investment Grade (IG), Emerging Markets

[89] As each CBI fund ID corresponds to multiple ISINs (which represent different fund share classes, for example), the data was averaged across the corresponding ISINs for each unique fund ID.

[90] Some examples of the selected Morningstar categories are Global Emerging Markets Bond, USD Diversified Bond, EUR Inflation-Linked Bond.

(EM), Sovereign, Mixed, Property, and "Other" (see Appendix Table 1 for the mapping). HY funds invest primarily in high-yield bonds, while IG funds invest primarily in investment grade bonds. EM funds focus on emerging market fixed income instruments, while Sovereign funds have a sovereign bond focus. Mixed funds maintain allocations across bonds and equity, while still primarily focusing on bonds. Finally, Property funds invest in real estate, and "Other" funds is a catch-all category of funds that have a fixed-income focus but cannot be explicitly grouped into any of the other six categories. These seven categories comprised 929 funds that were active in 2021, corresponding to around one-fourth of the AUM of the Morningstar Irish investment fund universe (Table 12).

**176. To generate the final sample of funds, an additional selection was made based on availability of net flows and portfolio composition data that are required for the ST exercise.** First, the sample was restricted to those funds with at least 50 monthly flow observations during the full sample period with the aim of ensuring a long enough time series of monthly flows to calculate redemption shocks based on tail measures.[91] Second, all funds were required to have complete data on the portfolio composition with the relative shares of cash, bonds, equities, and other assets and the credit quality of fixed-income instruments. These additional filters lead to a final sample for the stress test amounting to 274 Irish investment funds.

**Table 12. Ireland: Sample of Investment Funds in the Stress Test**

| Investment fund category | I. Data exists on net flows, TNA, holdings | | II. Net flows/TNA > 50 monthly observations | | III. Portfolio ratings & composition data exists | |
|---|---|---|---|---|---|---|
| | Number of Funds | Total Net Assets | Number of Funds | Total Net Assets | Number of Funds | Total Net Assets |
| EM | 123 | € 93,989.1 | 76 | € 70,895.1 | 33 | € 48,658.4 |
| HY | 119 | € 86,002.6 | 72 | € 71,882.7 | 32 | € 47,909.2 |
| IG | 291 | € 263,565.7 | 180 | € 191,345.3 | 91 | € 131,553.5 |
| Mixed | 66 | € 18,690.7 | 42 | € 13,861.1 | 18 | € 4,237.0 |
| Other | 193 | € 158,871.8 | 127 | € 123,386.5 | 76 | € 63,455.7 |
| Property | 39 | € 19,468.0 | 34 | € 16,677.2 | - | - |
| Sovereign | 98 | € 95,676.4 | 52 | € 65,247.1 | 24 | € 51,567.4 |
| Total | 929 | € 736,264.2 | 583 | € 553,295.0 | **274** | **€ 347,381.2** |

Sources: Morningstar; and IMF staff calculations.
Notes: The table contains data on Irish-domiciled investment funds categorized into six groups based on their listed investment strategies in Morningstar: HY – high-yield bond funds, IG – investment-grade bond funds, EM – emerging market bond funds, Mixed – funds with mixed investment strategies with a predominant focus on fixed-income instruments, sovereign – Sovereign bond funds, property – funds investing in real estate, and other – other funds. Number of funds refers to the number of IFs satisfying each criterion, and Total Net Assets (TNA) are reported in € millions. The third column contains the final sample for the stress test.

[91]Outlier observations with monthly net flows above 50 percent of TNA are also dropped from the calculation of tail statistics.

## B. Portfolio Composition

**177. The portfolios of funds in the stress test comprise of bonds, cash, equities, and other assets.** The bonds are further broken down into corporate bonds, sovereign bonds, and securitized products. Additionally, Morningstar includes data on the credit ratings of the bonds. Those credit ratings are used to classify bonds as IG or HY, with bonds rated AAA to BBB classified as IG, and those rated below BBB classified as HY. Each fund's liquidity buffers depend on the composition and liquidity weights of assets in its portfolio. The liquidity weights for assets are informed by the Basel III high quality liquid assets (HQLA) liquidity weights, as also in the 2017 Luxembourg FSAP and 2020 U.S. FSAP, and are provided in Table 13.

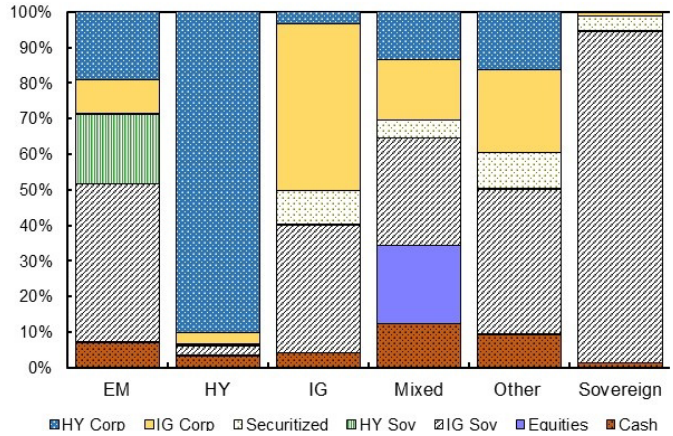
**Table 13. Ireland: Liquidity Weights**

| | | Cash | Sovereign bonds | Corporate bonds | Securitized Products | Equities |
|---|---|---|---|---|---|---|
| Investment Grade | AAA to AA- | 100% | 100% | 85% | 85% | 50% |
| | A+ to A- | | 85% | 50% | 50% | |
| | BB+ to BBB- | | 50% | 50% | 0% | |
| High-Yield | Below BBB- | | 0% | 0% | 0% | |

Source: Basel Committee on Banking Supervision.
Notes: The table contains data on liquidity weights to calculate high quality liquid assets (HQLA) at the fund level.

**178. The portfolio composition of funds differs by their investment strategies.** HY funds hold a substantial portion of total assets in high-yield corporate bonds with a low percentage of investment grade corporate and sovereign bonds and relatively limited cash buffers (Figure 60). Sovereign funds' portfolios consist mostly of sovereign bonds, with a low percentage of securitized products and cash. Within IG funds' portfolios, investment-grade corporate and sovereign bonds have the high shares. EM, other, and mixed funds appear to have more diversified portfolios with the mixed funds investing also in equities. In general, all the funds in the stress test sample invest primarily in fixed-income instruments, with their portfolio composition and risk depending on their particular investment focus.

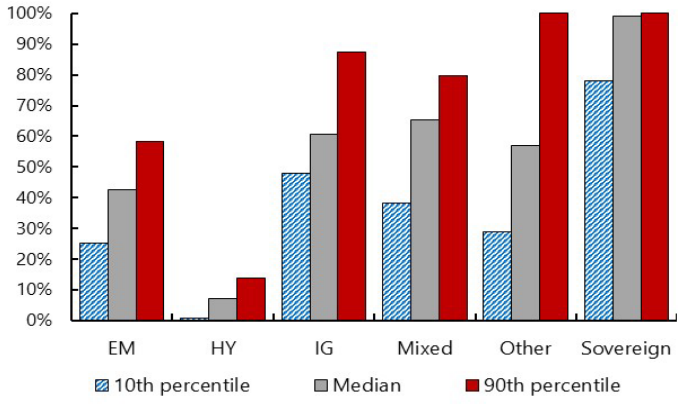
**Figure 60. Ireland: Portfolio Composition of Irish-Domiciled Fixed-Income Funds**




Source: Morningstar; and IMF staff calculations.
Notes: The portfolio composition per fund category is based on the percentage of relevant cash and/or securities held by a representative sample of Irish-domiciled fixed-income investment funds (the 274 funds in the stress test). HY – high-yield bond funds, IG – investment-grade bond funds, EM – emerging market bond funds, mixed – funds with mixed investment strategies with a predominant focus on fixed-income instruments, sovereign – sovereign bond funds, and other – other funds.

**179. The liquidity buffers of funds display significant variation across fund categories.** Liquidity buffers are estimated using the HQLA liquidity buckets approach, which has benefits and limitations as described in the previous section. HY funds tend to have fewer liquid assets available to meet any given redemption shock, with median HQLA buffer at below ten percent (Figure 61). Their low HQLA buffers imply that HY funds would be more susceptible to a liquidity shortfall facing the same-sized shock than other categories of funds. Sovereign funds have high liquidity buffers, while IG, mixed, and other funds have moderate buffers. EM funds have relatively low buffers compared to all other categories, apart from HY funds, with median HQLA at just over 40 percent.

**Figure 61. Ireland: HQLA Buffers - Irish-domiciled Fixed-Income Funds**




Source: Morningstar; and IMF staff calculations.
Notes: The figure provides data on the portfolio share of high-quality of liquid assets (HQLA) available at the fund category level, with the percentiles representing the 10th, 50th, and 90th percentile of HQLA per category. HY – high-yield bond funds, IG – investment-grade bond funds, EM – emerging market bond funds, mixed – funds with mixed investment strategies with a predominant focus on fixed-income instruments, sovereign – sovereign bond funds, and other – other funds.

## C. Redemption Shock

**180. The redemption shock is derived under the approaches of homogeneity as well as heterogeneity.** Under the homogeneity approach, redemption shocks are calculated based on the distribution of net flows for the pooled sample of *all* funds within a category. Then, the same redemption shock is applied to all funds within the same category, while the shock differs across categories. Under the heterogeneity approach, redemption shocks are fund-specific and calculated based on the historical distribution of each fund's *own* net flows. Under either approach, redemption shocks are calculated based on the first, third, and fifth percentile of the historical distribution of $f_t$, which is defined as net outflows in percent of lagged total net assets (TNA) as follows

$$f_t = \frac{Outflows_t - Inflows_t}{TNA_{t-1}}$$

**181. The VaR and ES approaches are used to refine the redemption shock under the homogeneity and heterogeneity assumptions.** While the VaR approach is commonly used in fund stress test exercises, it faces the potential shortcoming that any shocks below the VaR threshold are discarded (ESMA, 2019). This approach risks missing relevant tail shocks in the case of significant redemption shocks just below the selected VaR threshold. To overcome this, the ES metric uses the average $f_t$ below the VaR threshold. To ensure that a range of relevant tail shocks are covered, the ST exercise utilizes both VaR and ES metrics, each of which are calculated at 1st, 3rd, and 5th percentiles of the flows distributions. Combined with the homogenous (fund category level) vs. heterogenous (individual fund level) shocks, this approach leads to a total of twelve different redemption shock scenarios. The sample average shocks under each of these scenarios are presented in Table 14.

**182. Over the 2007-2021 sample period, HY, EM, and sovereign bond funds tend to face larger outflows as a percent of their total net assets.** The large outflows faced by HY funds are broadly consistent with the redemptions from HY funds observed during the 2020 pandemic-induced market turmoil.

**Table 14. Ireland: Average Redemption Shocks for the ES and VaR Models**

| | Heterogeneity assumption | | Homogeneity assumption | |
|---|---|---|---|---|
| | ES | VaR | ES | VaR |
| | 1st percentile | | | |
| EM | 31 | 22 | 23 | 19 |
| HY | 30 | 20 | 23 | 17 |
| IG | 26 | 18 | 20 | 15 |
| Mixed | 18 | 9 | 12 | 8 |
| Other | 29 | 20 | 21 | 15 |
| Sovereign | 35 | 25 | 27 | 20 |
| | 3rd percentile | | | |
| EM | 21 | 13 | 18 | 12 |
| HY | 20 | 11 | 17 | 11 |
| IG | 17 | 10 | 15 | 9 |
| Mixed | 11 | 5 | 8 | 4 |
| Other | 19 | 11 | 15 | 10 |
| Sovereign | 24 | 14 | 20 | 13 |
| | 5th percentile | | | |
| EM | 17 | 9 | 15 | 9 |
| HY | 15 | 8 | 14 | 8 |
| IG | 14 | 7 | 12 | 6 |
| Mixed | 8 | 3 | 6 | 3 |
| Other | 15 | 8 | 13 | 7 |
| Sovereign | 19 | 10 | 17 | 10 |

Source: Morningstar; and IMF staff calculations.
Notes: Net outflows in percent of total net assets (TNA). Average flows by fund category for the heterogeneity assumption. HY – high-yield bond funds, IG – investment-grade bond funds, EM – emerging market bond funds, mixed – funds with mixed investment strategies with a predominant focus on fixed-income instruments, sovereign – sovereign bond funds, and other – other funds. Shock models: ES – expected shortfall approach, VaR – Value-at-Risk approach.

# INVESTMENT FUND STRESS TEST EMPIRICAL RESULTS

## A. Liquidity Resilience of Funds

**183. The redemption coverage ratio (RCR) is the first step in assessing the ability of investment funds to withstand severe but plausible redemption shocks.**[92] The RCR compares the liquidity buffers of each fund to the size of the simulated redemption shock. If the RCR>=1, then the fund would have enough liquidity available to meet the redemption demand, but a fund with an RCR<1 would have to sell its less liquid assets, potentially at fire sale prices. The RCR is defined as:

$$RCR = \frac{HQLA}{Shock}$$

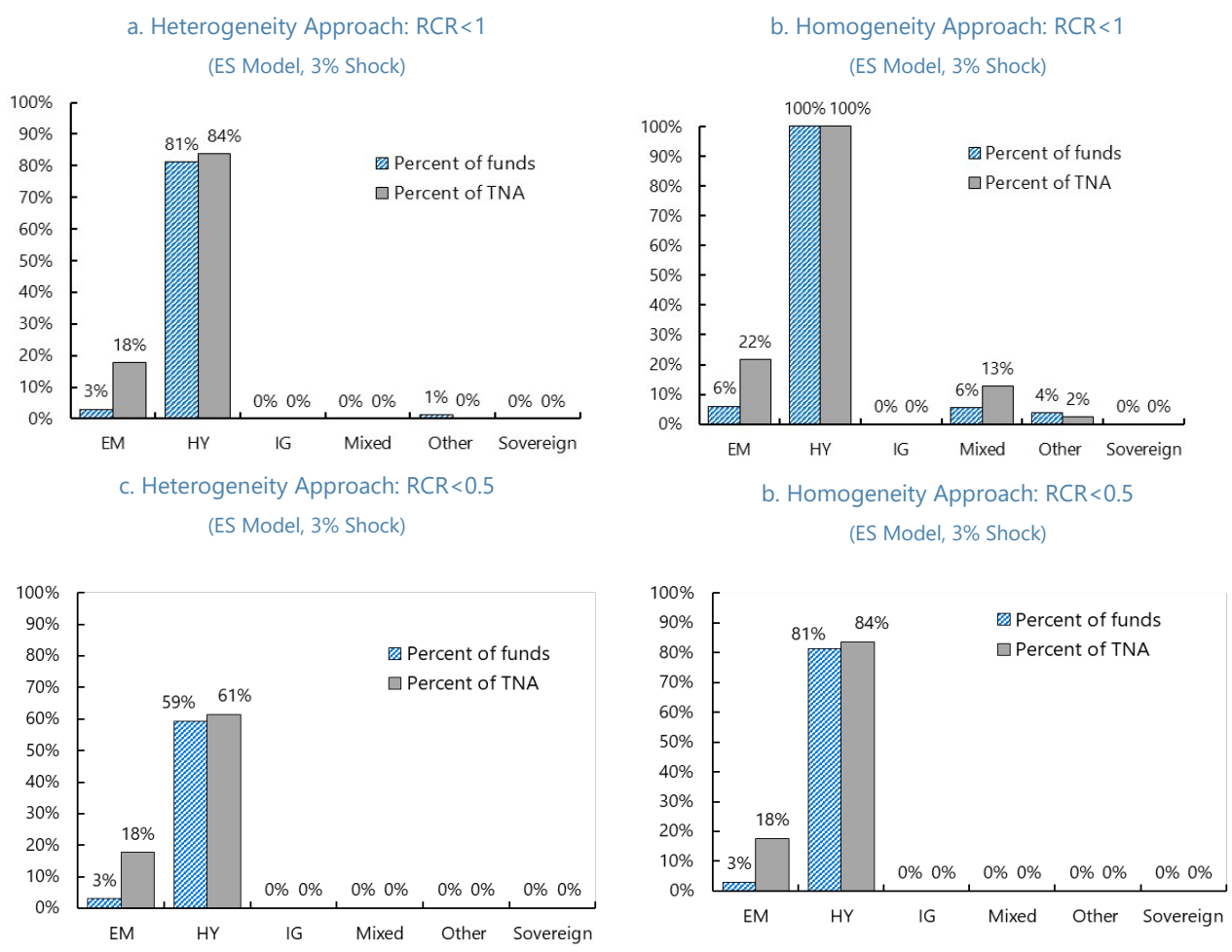
**184. The results indicate that high-yield corporate bond funds are the most vulnerable to redemption shocks, followed by emerging market funds.** Figure 3 presents the key results of the liquidity stress test for the benchmark stress scenario, which uses the ES shock model with the shock calibrated at the third percentile of net outflows (under both the heterogeneity and homogeneity approaches).[93] Vulnerable is taken to mean that the fund is not able to meet redemption requests

[92] For the purposes of computational simplicity and obtaining a conservative estimate of liquidity stress, the stress test analysis makes certain assumptions such as that funds sell all HQLA at the hair-cut value as per Table 4, funds cannot sell other assets without a significant discount, and funds cannot use credit lines or liquidity management tools.

[93] RCR results for the full set of twelve shock scenarios are presented in the Appendices XI and XII.

during a shock, given the assumptions underpinning the ST. Most HY funds (81 percent and 100 percent, under the heterogeneity and homogeneity approaches, respectively) would experience RCR <1 following a redemption shock. The remaining fund groups display much more limited vulnerability to redemption shocks. However, the results indicate that some larger EM funds are also susceptible to liquidity stress. EM funds with RCR<1 constitute a small fraction of the EM funds category by count, but they hold around a fifth of TNA of within that category. The mixed funds category shows some vulnerability only under the homogeneity assumption with 6 percent of funds experiencing RCR < 1. Sovereign and IG bond funds appear to be most resilient, followed by the other category, which is not surprising considering that they have significantly larger high-quality liquidity buffers. Of note is that HY and EM funds are still very vulnerable to redemption shocks when the criteria of RCR<0.5 is imposed as can be seen in the latter two panels of Figure 62. Around 3 percent of EM funds, and close to 60 and 80 percent of HY funds under the heterogeneity and homogeneity approaches, respectively) would experience RCR <0.5 following a redemption shock.

**Figure 62. Ireland: RCR and the Resilience of Funds**




Sources: Morningstar; and IMF staff calculations.
Notes: Figures show the share of funds with RCR <1 following a redemption shock for each fund category. The model used for the redemption shock is the ES model with the redemption shock calibrated at the third percentile of net outflows as a percent of TNA.

## B. Liquidity Shortfall

**185. The RCR metric can be supplemented by "liquidity shortfall" which quantifies the amount of the shortfall a fund would experience following a redemption shock.** The liquidity shortfall is the difference between HQLA and the redemption shock for a fund with RCR<1 and provides an assessment of the extent to which the fund's highly liquid assets would fall short of meeting the redemption demand in a given scenario. If the liquidity shortfall for a fund were to be very large, this would increase the case for enhanced liquidity risk monitoring and management. The liquidity shortfall (as a percent of TNA) is defined as:

$$LiquidityShortfall = HQLA - Shock$$

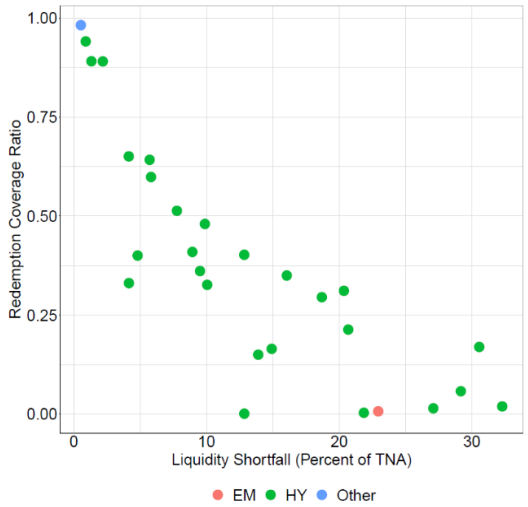
**186. High-yield bond funds face the largest liquidity shortfall.** As shown in Figure 63, investment funds with a focus on high-yield bonds face the greatest liquidity shortfall with a few funds experiencing shortfalls around 30 percent of TNA, highlighting the importance of liquidity management by funds. Emerging market fixed-income and other bond funds also face some extent of liquidity shortfall in certain scenarios, albeit at a much lower scale than high-yield bond funds.

**187. Irish investment funds have a range of liquidity management tools available to them.**[94] The tools are either expressly provided for in Ireland's legislative framework (transposing the UCITS Directive and AIFMD) or the Central Bank's domestic regulatory requirements, but the CBI does not actively encourage IFs to have a particular set of tools available to them at authorization. The CBI is currently finalizing a discussion paper on IF liquidity risk management, which will address the availability and use of liquidity management tools.

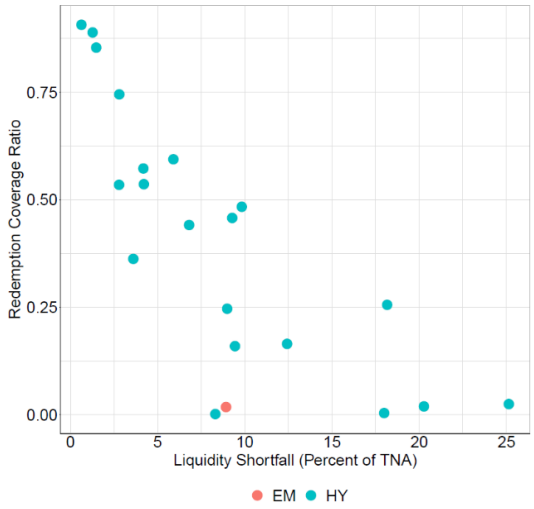
[94] For more details on this topic, please see the Technical Note *Oversight of Market-Based Finance: Investment Funds and Special Purpose Entities*.

**Figure 63. Ireland: Liquidity Shortfall and RCR**

a. Heterogeneity Approach (ES Model, 3% Shock)




b. Heterogeneity Approach (VaR Model, 3% Shock)




Sources: Morningstar; and IMF staff calculations.
Notes: Figures a and b present the liquidity shortfall associated with funds with RCR<1 for the heterogeneity approach using ES and VaR models respectively, with the redemption shock calibrated at the third percentile of net outflows as a percent of TNA.

## C. Conclusions of the Investment Fund Liquidity Stress Test Analysis

**188. The FSAP conducted a liquidity stress test of Irish-domiciled investment funds.** Following the HQLA approach and simulating a range of shock scenarios for a representative sample of fixed-income investment funds, the results indicate that high-yield bond funds are vulnerable to severe but plausible redemption shocks. Emerging market fixed-income funds are also vulnerable to shocks in certain shock scenarios.

**189. The key recommendations to the authorities are to review liquidity management tools for vulnerable cohorts of funds and to expedite the completion of the internal stress-testing framework.** As part of its ongoing policy development on IF liquidity risk management and taking into account developments at the EU and international level, the CBI should review the use of liquidity management tools by HY bonds funds, and emerging market fixed-income funds in light of the results of the liquidity resilience analysis discussed above. CBI should also prioritize the completion of its internal stress-testing framework, and enhance internal resources and capacity as appropriate, as was also recommended in the 2016 Ireland FSAP. The stress testing exercise should ideally include an estimate of market price impact of fund liquidation and sales in episodes of market stress which will allow CBI to analyze the potential spillovers from the fund sector to other segments of the financial system.

**190. Based on the investment fund liquidity analysis, the FSAP makes the following recommendations:**

- CBI should prioritize the completion of its internal stress-testing model to be able to conduct more frequent liquidity and market risk stress tests for IFs and MMFs.
- CBI and CSO should co-ordinate to analyze the common asset holdings of investment funds, banks, and relevant non-banks.
- As part of its ongoing policy development on IF liquidity risk management and taking into account developments at the EU and international level, the CBI should review the use of liquidity management tools by IFs, with a particular focus on funds that have demonstrated liquidity challenges in recent periods of stress.

# Appendix I. Ireland Risk Assessment Matrix

| Risk | Overall Level of Concern | |
|---|---|---|
| | Relative Likelihood | Expected Impact if Materialized |
| **Conjunctural Risks** | | |
| **Russia's invasion of Ukraine leads to escalation of sanctions and other disruptions.** Sanctions on Russia are broadened to include oil, gas, and food sectors. Russia is disconnected almost completely from the global financial system and large parts of the trading system. This, combined with Russian countersanctions and secondary sanctions on countries and companies that continue business with Russia, leads to even higher commodity prices, refugee migration, tighter financial conditions, and other adverse spillovers, which particularly affect LICs and commodity-importing EMs. | **High** | **Low**<br>• Global supply chain and economic disruptions induced by sanctions on Russia may lead to direct and indirect spillovers to domestic economy via trade, consumption and investment, which can transform to deterioration in economic growth and credit quality of borrowers, resulting in credit losses in the banking system.<br>• Higher energy and commodity price may weaken consumer affordability and intensify inflationary pressure. In the meantime, slower growth in nominal wage than domestic price may stifle domestic economic activities. Tightened global financial condition as a response to hyperinflation may exacerbate slowdown in growth, trigger capital outflows, and pose downside risks to both financial and nonfinancial sector more broadly. |
| **Outbreaks of lethal and highly contagious COVID-19 variants.** Rapidly increasing hospitalizations and deaths due to low vaccine protection or vaccine-resistant variants force more social distancing and/or new lockdowns. This results in extended supply chain disruptions and a reassessment of growth prospects, triggering capital outflows, financial tightening, currency depreciations, and debt distress in some EMDEs. | **Medium** | **High**<br>• The renewed pandemic lockdown and social distancing measures may erode market confidence and adversely affect growth, with uneven impact across sectors.<br>• Constrained policy space as a result of sustained deterioration of fiscal balance dents market confidence, exacerbates slowdown and long-term scarring of the economy.<br>• Persistent flattening or contraction of consumption and investment activities impairs private sector financial health, leading to reassessment of asset value and sizable formation of NPLs.<br>• A protracted slowdown of real estate activities and market demand translates to broad-based deterioration of prices in the commercial real estate market, with effect propagating to banks loan book with significant exposures. |
| **De-anchoring of inflation expectations in the United States and/or advanced European economies.** Worsening supply-demand imbalances, higher commodity prices (in part due to war in Ukraine), and higher nominal wage growth lead to persistently higher | **Medium (for U.S.) / Medium/Low (for EA)** | **Medium/Low**<br>• Persistent confidence effects increasing term premia and tightening of financial condition may adversely impact corporates and household credit worthiness., and lead to considerable market |

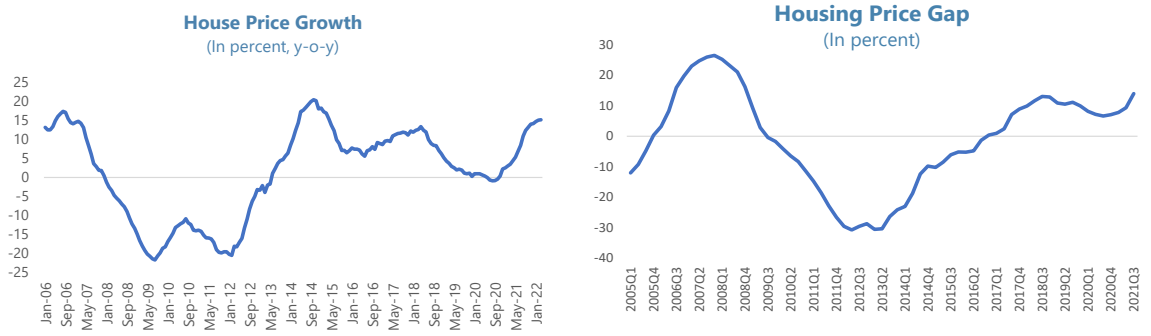
| | | |
|---|---|---|
| inflation and/or inflation expectations, prompting central banks to tighten policies faster than anticipated. The resulting sharp tightening of global financial conditions and spiking risk premia lead to lower global demand, currency depreciations, asset market selloffs, bankruptcies, sovereign defaults, and contagion across EMDEs. | | losses in bank trading portfolios and insurers' investments due to a sharp decline in asset values.<br>• Higher borrowing cost for government may result in unsustainable fiscal path, a decompression of sovereign risk premia, and devaluation of sovereign securities held by banks.<br>• Sharp asset price correction due to rising risk premia and rapid selloffs may lead to collateral revaluation and result in lower recovery value of defaulted loans.<br>• Inflationary pressures driven by supply bottlenecks may constrain consumer purchasing power, give rise to additional financial pressures and stretch corporate and household balance sheets. |
| **Geopolitical tensions and deglobalization.** Intensified geopolitical tensions, security risks, conflicts, and wars cause economic and political disruptions, fragmentation of the international monetary system, production reshoring, a decline in global trade, and lower investor confidence. | **High** | **Low**<br>• Economic disruption and bearish investor sentiment resulting from intensified and persistent geopolitical tension and deglobalization may translate to growth slowdown, abrupt reversal in asset prices and credit delinquency, with shock permeating through the financial market leading to system-wide liquidity and solvency stress. |
| **Structural Risks** | | |
| **Continued trade frictions and uncertainty related to the detailed implementation of post-Brexit arrangements.** Details are being negotiated to minimize non-tariff barriers to goods and services trade. Further delays in finalizing remaining detailed implementation of post-Brexit arrangements can hamper trade and raise tensions. | **Medium** | **Medium**<br>• Higher input cost and logistic expenses for Irish business may curtail firms' profitability and risk financial viability, escalating debt failures.<br>• Significant credit exposure of Irish banking sector to the U.K. market could entail a shock to bank profitability in Ireland due to negative impact on the U.K. economy. |
| **Natural disasters related to climate change.** Higher frequency of natural disasters causes severe economic damage to smaller vulnerable economies and accelerate emigration. Severe events in large economies reduce global GDP, cause further supply chain disruptions and inflationary pressures, and prompt a recalculation of risk and growth prospects. Disasters hitting key infrastructure or disrupting trade raise commodity price levels and volatility. | **Medium** | **Medium**<br>• Natural disasters related physical damages may impair financial health for firms and households, translating to higher credit and market risks facing the financial sector. |

# Appendix II. Housing Price Developments

**191. Residential house prices are on the rise largely due to market imbalances.** Recent evidence in the Irish housing market suggests the emergence of upward pressure on housing price. The newly updated March 2022 growth rate of 15 percent is fueling both the recent continuous growth and gaps to the upside (Figure 1). Even preceding the pandemic, there had been a persistent imbalance driven by limited supply and strong demand from both non-household and household buyers, leading to upward pressure on house prices and rents.

**192. Staff's own estimate of the housing price at risk, which measures potential shock to housing price growth at a pre-defined likelihood based on various underlying risk factors, signaled heightened vulnerabilities in the housing market in a stressful state** (Figure 1). The exercise considers three main factors as the main driver of the downside risks to the housing prices: domestic financial condition index, leverage indicator explained by credit related variables such as credit to GDP gap, as well as household affordability indicator represented by house price to disposable income. When shocking these risk factors by one standard deviation simultaneously, over a 3-year horizon, the compounded growth rate is estimated to be at -31 percent at the 5-percentile of the housing price growth distribution. When replacing GDP with GNI* as the input in computing house price related risk factors, the resulting 5-percentile housing price at risk become even more adverse, reaching to -43 percent cumulative growth over a three-year horizon. These findings suggest that the continuing upward trend, if synchronizing with a resurgence of the pandemic and other forms of downside global shocks, may undermine borrows' affordability especially on the lower income tranche, posing considerable risks to the housing market and financial market stability more broadly.

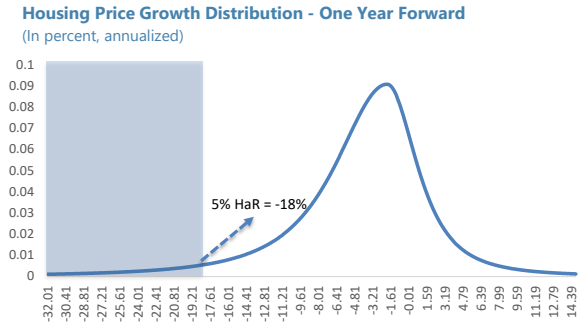
**Figure 1. Housing Market Development and Housing Price at Risk**

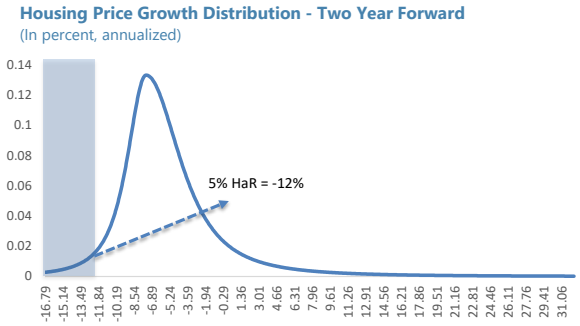


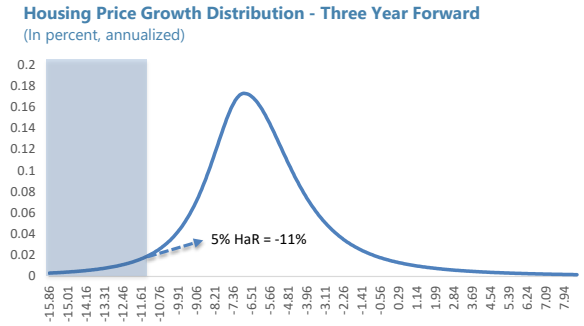

*Housing Price at Risk*

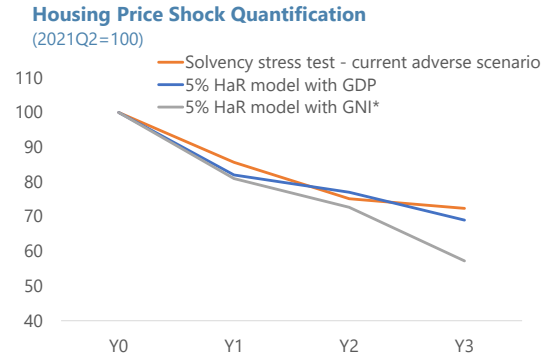
## Figure 1. Housing Market Development and Housing Price at Risk (Concluded)

| Factor variable under PCA (Independent Variable) | Sub-Component |
|---|---|
| Lagged | Lagged house price growth, percent, y-o-y |
| FCI | Ireland financial condition index |
| Leverage | Credit impulse, change in credit growth as percent of GDP<br>Credit to GDP gap, percent |
| Affordability | House price to disposable income per capita, percent<br>House price to disposable income, percent<br>House price to GDP per capita, percent |




Sources: Haver analytics and IMF staff estimate.
Note: Shock distribution presented above uses nominal GDP as input and corresponds to a house price growth distribution conditional on a one-standard deviation shock to FCI, leverage and affordability indicator.

# Appendix III. The Estimation of the PD Satellite Models

**193. Historical probability of default was used in the estimation of the credit risks.** Separate satellite models were estimated for the PDs of financial institution, corporate CRE, corporate non-CRE, household retail and household mortgages.[1] For portfolios outside Ireland, Moody's expected default frequency (EDF) was used as a proxy for corporate portfolios in United Kingdom, United States, other Euro Area, and rest of the world. PDs for financial institutions within Ireland were also sourced from Moody's.

Both data sources were obtained on a quarterly frequency with the former starting from 2008 and the latter from 2002. The regressions use data up to 2019 to minimize statistical distortion introduced by public supports to mute rising default since the pandemic. The conditional PD forecasts for each segment were then attached to the starting point of each individual bank's PDs to generate full path under both the baseline and the adverse scenarios. The satellite models for PDs as a dependent variable were constructed as follows:

- 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:

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

- To estimate impact of shocks of macro-financial 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 PDs can be expressed as:

$$Y_{it} = \alpha + \boldsymbol{\beta} Y_{i,t-k} + \boldsymbol{\delta} \boldsymbol{X}_{i,t-s} + \varepsilon_{i,t}$$

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, $Y_{i,t-k}$ is vector of the lagged dependent variable (k=1 to N), $\varepsilon_{i,t}$ is an independent and identically distributed error-term, and $\alpha$, and vectors $\beta$, and $\delta$ are parameters to be estimated;

- The projected logit PDs for each of the exposure classes were transformed back to PD space.

[1] For household mortgage portfolios, a differentiation between U.K. and non-U.K. exposure was made by implementing an ad-hoc adjustment on the adverse PD shocks to the U.K. mortgage portfolios by reducing them to 50 percent of the original shock to reflect the lower historical default rates observed for U.K. mortgages.

**194. The satellite models for credit risk were estimated using linear Bayesian Model Averaging (BMA) framework[2] to remove model uncertainty.** BMA overcome the issue of over-confident inferences in a single model estimation by averaging over the best models in the model class according to approximate posterior model probability. The framework also enables sign restriction in the estimation process to ensure reasonable relationship among input variables and the robustness of out-of-sample forecast conditional on a constrained sample size.

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

**196. Real output, unemployment rate, short-term and long-term interest rates as well as asset prices proved to be relevant for the buildup of credit risk** (Table 1). This is reflected in the higher than prior posterior inclusion probability and sizable, long-run multiplier estimate (i.e., coefficients for both the contemporaneous and lagged terms of the independent variables) for the sectoral PDs. The type and number of significant variables varies distinctly across segments, as manifested by the individual characteristics of their historical PDs.

[2] The model was developed by Marco Gross and Javier Población (2017).

## Table 1. Ireland: Probability of Default and Coverage Ratio

| | Ireland - Probability of Default and Coverage Ratio (In unit, logit transformed) | | | | | |
|---|---|---|---|---|---|---|
| | PD Household retail | PD Household mortgage | PD Corporate non-CRE | PD Corporate-CRE | PD Financial | Coverage ratio |
| | Long run multiplier with sign restriction | | | | | |
| Real GNI* growth, percent, y-o-y | 0 | 0 | 0 | 0 | -0.005 | 0 |
| Real GNI* growth, 4-quarter moving sum, percent, y-o-y | 0 | 0 | -0.001 | -0.069* | -0.042* | -0.052 |
| Unemployment rate, percent | 0.086* | 0.159* | 0.069* | 0.181* | 0.119* | 1.85* |
| Three-month interbank rate, percent | 0.123* | 0.024* | 0.257* | 0.645* | 0 | 0.363 |
| Ten-year government bond yield, percent | 0.062* | 0.015 | 0.065* | 0 | 0.005 | 2.056* |
| Stock price growth, percent, y-o-y | 0 | -0.006* | -0.001 | 0 | -0.012* | 0 |
| House price growth, percent, y-o-y | 0 | -0.011* | -0.024* | 0 | 0 | -0.089 |
| CRE price growth, percent, y-o-y | -0.01* | 0 | -0.004 | -0.001 | -0.017* | -0.023 |
| Number of lags of independent variables | 2 | 2 | 3 | 3 | 2 | 2 |
| R-square | 0.99 | 0.97 | 0.96 | 0.97 | 0.75 | 0.98 |

| | Foreign Corporate Portfolios - Probability of Default (In unit, logit transformed) | | | |
|---|---|---|---|---|
| | UK | US | EA | ROW (Rest of the World) |
| | Long run multiplier with sign restriction | | | |
| UK Real GNI* growth, percent, y-o-y | -0.028 | | | |
| UK Real GNI* growth, 4-quarter moving sum, percent, y-o-y | -0.001 | | | |
| UK Unemployment rate, percent | 0.272* | | | |
| UK Three-month interbank rate, percent | 0.107* | | | |
| UK Ten-year government bond yield, percent | 0.642* | | | |
| UK Exchange rate, Sterling per USD | 9.799* | | | |
| UK Stock price growth, percent, y-o-y | 0 | | | |
| UK House price growth, percent, y-o-y | 0 | | | |
| US Real GNI* growth, percent, y-o-y | | 0 | | |
| US Real GNI* growth, 4-quarter moving sum, percent, y-o-y | | -0.039* | | |
| US Unemployment rate, percent | | 0.013* | | |
| US Three-month interbank rate, percent | | 0 | | |
| US Ten-year government bond yield, percent | | 0.046* | | |
| US Stock price growth, percent, y-o-y | | -0.011* | | |
| US House price growth, percent, y-o-y | | 0 | | |
| EA Real GNI* growth, percent, y-o-y | | | -0.002 | |
| EA Real GNI* growth, 4-quarter moving sum, percent, y-o-y | | | -0.264* | |
| EA Unemployment rate, percent | | | 0 | |
| EA Three-month interbank rate, percent | | | 0 | |
| EA Ten-year government bond yield, percent | | | 0.499* | |
| EA Exchange rate, EUR per USD | | | 4.698* | |
| EA Stock price growth, percent, y-o-y | | | -0.02* | |
| EA House price growth, percent, y-o-y | | | 0 | |
| ROW Real GNI* growth, percent, y-o-y | | | | 0 |
| ROW Real GNI* growth, 4-quarter moving sum, percent, y-o-y | | | | 0 |
| ROW Inflation rate, percent | | | | 0 |
| ROW Short term interest rate, percent | | | | 0.355* |
| ROW GDP gap, percent | | | | -0.343* |
| ROW Stock price growth, percent, y-o-y | | | | -0.001 |
| Number of lags of independent variables | 2 | 2 | 2 | 2 |
| R-square | 0.90 | 0.67 | 0.93 | 0.66 |

Sources: CBI, Moody's Analytics, IMF World Economic Outlook, and IMF staff calculations.
Notes: 1. * denotes a higher posterior inclusion probability than the prior, which indicates variable statistical significance.
2. A long run multiplier is defined as the sum of all coefficients of a given right hand-side variable on its contemporaneous and lagged terms.

## Appendix IV. The Estimation of the Interest Rate Satellite Models

**197. Bank funding costs and lending rates were estimated based on interest rate for new business (front book) for each bank.** The data on interest rates was sourced from ECB statistical warehouse and Refinitiv Datastream on a quarterly basis from 2000 Q1. The macroeconomic data was sourced from IMF International Financial Statistics, the IMF World Economic Outlook (WEO) database, Bloomberg, and Haver Analytics. The macroeconomic series for the adverse scenario followed the scenario set for this stress test.

**198. Bank interest rates on new business were estimated and used as the input for interest risk assessment on the banking book.** Using BMA methodology, the satellite models estimate aggregate funding and lending rates on the portfolio level, which include interest rates on corporate, household retail and household mortgage loans, coupon rates for sovereign, corporate and bank bonds, and overnight and term deposits. Subsequently, the period changes of the aggregate rates in the forecasting horizon were mapped with outstanding sensitive assets and liabilities reported in the IRRBB template to derive the impact on net interest margins arising from adverse movements in interest rates.

**199. Euro Area interbank rate (EURIBOR) and Ireland long-term bond yield were used as main input in explaining and projecting bank interest rates.** This reflects that the bulk of the corporate and household loans and deposits are either domestically focused or oriented towards the European markets and therefore are expected to closely tracks Euro Area or Irish specific interest rates including sovereign bond yield.

**200. Results from satellite models on aggregated interest rates reveals high explanatory power of short-term rate and long-term rates** (Table 2). On the asset side, lending rates appear to be highly correlated with short term interest rate, which conforms with the dominating share of floating rate loans in the banking book. Intuitively, on the liability side, cost of overnight deposits is largely determined by short-term rates while term deposits and bond interest rate appear to be driven by both short-term and long-term interest rates, respectively. The long-run pass-through from Irish sovereign bond yield and short-term interest rate on funding rates appears to be large, particularly to term deposit rate and corporate debt securities.

## Table 2. Ireland: Satellite Model Estimation – Bank Interest Rates

| | Ireland - Interest Rates (In percent) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Corporate loans | Household retail loans | Household mortgage loans | Overnight deposits | Term deposits | Debt securities - sovereign | Debt securities - corporate | Debt securities - financial |
| | Long run multiplier with sign restriction | | | | | | | |
| Real GNI* growth, percent, y-o-y | 0 | -0.006 | 0 | -0.003 | -0.009 | 0 | 0 | 0 |
| Real GNI* growth, 4-quarter moving sum, percent, y-o-y | 0 | -0.02 | 0 | -0.013* | -0.045* | 0 | 0 | 0 |
| Three-month interbank rate, percent | 0.633* | 0.031 | 0.433* | 0.193* | 0.731* | 0.001 | 0.393* | 0.381* |
| Ten-year government bond yield, percent | 0 | 0.388* | 0 | 0.005 | 0.032* | 0.136* | 0.221* | 0.187* |
| Number of lags of independent variables | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 3 |
| R-square | 0.93 | 0.83 | 0.80 | 0.92 | 0.99 | 0.31 | 0.81 | 0.81 |

Sources: ECB statistical warehouse, Refinitiv Datastream, IMF IFS, IMF WEO database, Bloomberg, Haver Analytics, and IMF staff calculations.
Notes: 1. * denotes a higher posterior inclusion probability than the prior, which indicates statistical significance.
2. A long run multiplier is defined as the sum of coefficients of a given explanatory variable on its contemporaneous and lagged terms.

# Appendix V. Shock Calibration of the Physical Risk Analysis of the Banking Sector[1]

**201. Literature providing estimates of country-specific macroeconomic effects of physical climate change is limited.** The most detailed source for the European countries is the EC JRC PESETA IV project estimate that quantifies the impact for seven climate impact categories: river floods, coastal floods, agriculture, energy supply, droughts, windstorms, and human mortality. It considers three future global warming levels (compared to pre-industrial): those set out in the Paris Agreement (1.5 and 2°C) as well as a high level of warming (3°C). The economic analysis is made with a general equilibrium model in a comparative static context. Overall, the estimated impact appears to be rather small—for Ireland and United Kingdom global warming of 3°C would result in an annual welfare loss of 0.6 percent of GDP. Under a 2°C scenario the welfare loss would be 0.2 percent of GDP and 0.1 percent of GDP under 1.5°C.

**202. Dottori and others (2018) model economic losses from the river floods and find higher impact globally but similar for the European countries:** with temperature increases of 1.5 °C, direct flood damage increases by 160–240 percent, with a relative welfare reduction between 0.23 and 0.29 percent. In a 2 °C world direct economic damage doubles and welfare losses grow to 0.4 percent.

**203. In light of more frequent occurrence of extreme weather events, an increasing number of studies offer more conservative estimates on the damages while incorporating non-linear impact of further elevated sea levels.** One of them being the latest published United Nations IPCC report on sea level rise and implications for low lying islands and coasts. The analysis shows that the resulting damage from exposure to extreme sea levels could increase significantly with sea level rise, potentially amounting to 10 percent of global GDP by the end of the century in the absence of adaptation.[2]

**204. Likewise, Kirezci et al. (2020) indicated coastal flooding made worse by climate change could potentially compromise 20 percent of the global GDP within the century as rising seas inundate coastal homes and infrastructure.[3]** Nonetheless, these estimates should be treated as upper bounds of the potential losses as they assume little or no policy intervention or adaptation efforts. Furthermore, although they cover a broad range of risks for areas that are most exposed to coastal flooding, they are not fully representative of the coastal vulnerabilities facing Ireland.

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[1] This section was prepared jointly by Anna Shabunina and Xiaodan Ding.

[2] For details see https://www.ipcc.ch/srocc/chapter/chapter-4-sea-level-rise-and-implications-for-low-lying-islands-coasts-and-communities/

[3] For more details see https://www.nature.com/articles/s41598-020-67736-6

**205. The NGFS scenario extended by NiGEM also provide useful benchmarks on output shocks associated with physical risks.** For example, the hot house world scenario calibrated in the June 2021 publication, which is considered closest to a physical shock scenario, points to a peak of 4.8 percent deviation of the output level below the baseline by 2050.

**206. The alternative approach to be used is to look at the extreme historical weather events in Europe and across the world and use them as an initial first-year shock on GDP.** The costliest natural events (notwithstanding the earthquakes) in Europe were flash floods in Spain in 1983 causing 1.2 percent of GDP damage and river floods in France in 1966 costing 0.6 percent of GDP. Current estimates for 2021 floods in Germany are around 0.1-0.2 percent of GDP.

**207. Combining the estimates of past events with the model predictions of increased damages facing global warming and rising sea levels, the suggested range for the physical shock in Ireland could be 2 to 20 percent of GDP, equivalent to 0.5 to 5 percent losses of capital stocks and 0.4 to 4 percent of output losses.**

# Appendix VI. Banking Sector Stress Testing Matrix (STeM)

| Banking Sector: Solvency Stress Test | | |
|---|---|---|
| **Top-down by IMF** | | |
| 1. Institutional Perimeter | Exercise | • Top-Down by FSAP team. |
| | Institutions included | • 12 banks subcategorized as SIs (7 banks) and LSIs (5 banks). Among the total, 5 are domestically focused retail banks and 7 are internationally oriented banks which are subsidiaries of foreign parents. LSIs are only subject to sensitivity analysis.<br>• Scenario based stress test for retail and large international banks (8 banks); sensitivity analysis for other international banks (4 banks). |
| | Market share | • Total coverage is about 80 percent of the banking sector, with 73 percent for SIs and 7 percent for LSIs. |
| | Data and baseline date | • Multiple data vintages: December 2019, December 2020, June 2021<br>• Supervisory data: bank balance sheet and supervisory statistics (including FINREP and COREP), information on interest rate risk in the banking book (IRRBB), liquidity risk and market risk sensitivities (including STE templates) provided by the authorities and the ECB. Expected Default Frequency sourced from Moody's. Also provided was further supervisory information, among others, probability of defaults and stage transition matrix by credit portfolios. The data also includes transparency templates for banks in the 2021 EBA stress test sample.<br>• Market and publicly available data, such as information from ECB statistical data warehouse on funding and lending rates by type of asset and funding portfolios.<br>• Data on policy mitigation impact on banking sectors in the context of COVID-19 primarily through moratoria, public guarantees, and liquidity support measures.<br>• Scope of consolidation: banking activities of the consolidated banking group for banks having their headquarters in Ireland. Foreign subsidiaries are assessed on the unconsolidated level covering domestic activities only.<br>• Coverage of sovereign and non-sovereign securities exposures: debt securities measured through fair value (FVPL and FVOCI) and amortized cost (AC) account.<br>• Coverage of lending exposure: credit institutions, nonbank financial institutions, household (retail and mortgage), corporate (Ireland non-CRE, Ireland CRE, United Kingdom, United States, rest of Euro Area, and rest of the world). |

| | | |
|---|---|---|
| 2. Channels of Risk Propagation | Methodology | • FSAP team satellite models and methodologies.<br>• Balance-sheet regulatory approach.<br>• Market risk is treated as an add-on component, with a separate calibration. The market risk stress scenario has an impact on both capital resources (either via profit and loss or via Other Comprehensive Income (OCI)) and capital requirements (RWA). The impact on capital resources comprises of positions in the trading book as well as other fair valued items in the banking book. The impact on RWA for market risk evolve with balance sheet assumptions.<br>• Traded risk impact from the revaluation of trading assets (FVPL) and securities classified as fair value thorough other comprehensive income (FVOCI) securities by counterparty: central government (by country issuers), credit institutions, other financial institutions, and nonfinancial corporates. Credit spreads on sovereign, credit institutions and corporate securities interpolated using bank-specific residual maturity at the book and issuer level (i.e., sovereign issuers by country and individual corporate issuers by ISIN codes). Credit spreads on other securities estimated on a hypothetical portfolio using a duration proxy. Valuation effects assessed using a modified duration approach. Hedges are considered as ineffective under stress. |
| | | • The losses for securities portfolios are based on modified duration approach. Losses on equities (both long and short position) were based on stock market price movement specified by the scenario.<br>• For internally modelled exposures (IRB), projection of PiT and TTC PDs, LGD, EAD and RWA. For standardized (STA) exposures, projection of new flows of defaulted exposures, risk weights downgrades and coverage ratio for defaulted loans. Credit risk projections for IRB and STA exposures covers ten asset classes: credit institutions, nonbank financial institutions, household (retail and mortgage), corporate (Ireland non-CRE, Ireland CRE, United Kingdom, United States, rest of Euro Area, and rest of the world). Credit risks from domestic nonfinancial corporations adopt a sectoral approach to differentiate impact on COVID and Brexit sensitive sectors. PDs (or flow of new nonperforming loans) are obtained from country authorities for domestic exposures and proxied by Moody's EDFs for foreign exposures. Resulting impact is translated into credit loss impairment charges and shifts to RWAs due to capital charges for defaulted assets.<br>• Provisioning. Provisioning for IRB and STA was modeled using IFRS9 transition matrix approach. Transition matrices, PiT PDs, PiT LGDs for loan and securities classified under financial asset measured through amortized cost (AC) and other comprehensive income (FVOCI) were modeled using CBI submissions and COREP data.<br>• Funding costs projected at the portfolio level using funding structure by product (deposits, debt securities, etc.) and maturity bucket (overnight vs. term). Funding cost projections capture systematic risk linked to the scenario and utilized bank level data on 8 Irish banks from COREP templates. Lending rates were projected at the system level and attached to bank-specific effective interest rates and outstanding amount at cut-off date (interest rate on corporate and household loans and debt securities). |

| | | |
|---|---|---|
| | Stress test horizon | • 2021 Q2–2026 Q2 (5 years) |
| 3. Tail Shocks | Scenario | 2 Scenarios:<br>• A baseline scenario based on the March 2022 WEO macroeconomic projections.<br>• An adverse scenario that captures the key risks in the RAM. This scenario relies on Global Macro-financial Model (GFM), a structural macroeconometric model of the world economy, disaggregated into forty national economies, documented in Vitek (2018). Scenarios for foreign countries where Ireland has significant exposure is extracted from GFM and is internally consistent with country scenarios of ongoing FSAPs. |
| | Sensitivity analysis | • Single-factor sensitivity test for other international banks (4 banks) to test banks' capital adequacy by imposing a lower bound (10 percentile) of the historical distribution of net interest margin, net trading income ratio and net fees and commission income ratio, and an upper bound (90 percentile) of net loan loss ratio and loss ratio from off-balance sheet exposure with 50 percent conversion rate to on-balance sheet exposure.<br>• Single-factor sensitivity test further assess the resilience of the banking sector to concentrations risk for SI and LSIs, where the banks' top 3 to 5 exposures are assumed to fail.<br>• Effect of policy mitigation under Covid-19: sensitivity analysis assessing the effects unwinding of supportive policies (e.g., payment breaks) on bank solvency condition. |
| 4. Risks and Buffers | Risk covered | • Risks covered include credit (on loans and debt securities), market (valuation impact of debt instruments through repricing and credit spread risk as well as the P&L impact of net open positions in market risk factors such as foreign exchange risks) and interest rate risk (IRRBB) on the banking book.<br>• Concentration risk by sensitivity analysis.<br>• Solvency and liquidity risk interactions, mainly through asset haircut. |
| | Behavioral Adjustment | • For the growth of the banks' balance sheet over the stress-test horizon, a quasi-static approach is used. Asset allocation and the composition of funding remain the same, whereas the balance sheet grows in line with the nominal GDP paths of major geographical exposures and subject to reduced credit demand in material jurisdictions and FX shock from revaluation effects on foreign currency loans specified in the stress test scenario. However, to prevent the banks from deleveraging, the rate of change of balance sheets is set at a floor of zero percent. This constraint is binding in the adverse scenario.<br>• In projecting RWAs, standardized and IRB portfolios are differentiated. For the standardized portfolios, RWAs changed due to the balance sheet growth, new inflows of non-performing loans, new provisions for credit losses, exchange rate movements, and the conversion of a portion of off-balance sheet items (undisbursed credit lines and guarantees) to on-balance sheet items. For the IRB portfolios, through-the-cycle-PDs, downturn LGDs and EAD for each asset class/industry are used to project risk weights.<br>• Interest income from non-performing loan is not accrued. |

| | | |
|---|---|---|
| | | • We assume that banks do not issue new shares or make repurchases during the stress test horizon. Dividends are assumed to be paid out at 25 percent of current period net income after taxes (i.e., only if net income is positive) by banks that were in compliance with supervisory capital requirements. |
| 5. Regulatory and Market-Based Standards and Parameters | | • National regulatory framework Basel III regulatory minima on CET1 (4.5 percent). In addition to the CET1, we evaluated the banks' total capital adequacy ratio against the 8 percent level, their Tier 1 capital ratio against the 6 percent benchmark and the leverage ratio during the stress test horizon against the 3 percent Basel III minimum requirement. Baseline scenario is subject to bank specific Pillar 2 requirement. The hurdle rate for CET1, T1 and total capital adequacy include any requirements due to systemic buffers for other systemically important institution (O-SII), and do not include capital conservation and capital countercyclical buffers. Banks that end the stress test horizon with a capital level or a leverage ratio below the relevant hurdle rates, are considered to have failed the test. |
| 6. Reporting Form for Results | Output presentation | • The results of the stress tests are reported using a variety of charts and tables. These potentially include Evolution of capital ratios for the system as a whole and as groups of retail banks and large international banks. Outputs also include information on impact of different result drivers, including profit components, losses due to realization of different risk factors; capital shortfall as sum of individual shortfalls; in euros and in percent of nominal annual GDP; number of banks and corresponding percentage of assets below the regulatory minimum (or below the minimum leverage ratio). |
| **Banking Sector: Liquidity Stress Test** | | |
| **Top-down by IMF** | | |
| 1. | | • |
| | Institutions included | • 12 banks subcategorized as Sis (7 banks) and LSIs (5 banks). Among the total, 5 are domestically focused retail banks and 7 are internationally oriented banks which are subsidiaries of foreign parents. |
| | Market share | • Total coverage is about 80 percent of the banking sector, with 73 percent for Sis and 7 percent for LSIs. |
| | Data and baseline date | • Latest data: June 2021<br>• Source: supervisory data (LCR, NSFR and ALMM Maturity Ladder template)<br>• Scope of consolidation: banking activities of the consolidated banking group for banks having their headquarters in Ireland. Foreign subsidiaries are assessed on the unconsolidated level covering domestic activities only. |
| 2. Channels of Risk Propagation | Methodology | • Basel III LCR and cash-flow based liquidity stress test using maturity buckets by banks, incorporating both contractual and behavioral (where available) with assumption about combined interaction of funding and market liquidity and different level of central bank support.<br>• Liquidity test in total currency, USD, and Sterling. |

| | | |
|---|---|---|
| 3. Risks and Buffers | Risks | • Funding liquidity<br>• Market liquidity |
| | Buffers | • The counterbalancing capacity, including liquidity obtained from markets and/or the central bank's facilities. Expected cash inflows are also included in the cash-flow based analysis. |
| 4. Tail shocks | Size of the shock | • The run-off rates are calibrated to reflect scenarios of system-wide deposit runs and dry-up of unsecured wholesale and retail funding, with additional run-off for non-resident deposits on top of the retail and wholesale run-off, which is calibrated following historical events, recent international experience in liquidity crisis and IMF expert judgment.<br>• Retail scenario key assumptions are: (i) 10 percent run-off rates for stable retail deposits and 20 percent for less stable retail; (ii) 5-25 percent for operational deposits and 20-40 percent for non-operational deposits; and (iii) no changes in liquid assets weights<br>• Wholesale scenario key assumptions are: (i) 5 percent run-off rates for stable retail deposits and 15 percent for less stable retail; (ii) 15-35 percent for operational deposits and 30-50 percent for non-operational deposits; and ((iii) no changes in liquid assets weights<br>• Combined run-off and price shock scenario key assumptions are: (i) 10 percent run-off rates for stable retail deposits and 20 percent for less stable retail; (ii) 15-35 percent for operational deposits and 30-50 percent for non-operational deposits; and ((iii) liquid assets weights reduction of 0-5 percent for level 1 assets, 3-20 for level 1 covered bonds, 5-15 percent for level 2A assets and 5-25 for level 2B assets<br>• The liquidity shocks will be simulated for 1–month for both LCR, and 5 days, 1 month, 3 months and 1 year for cash-flow based approach.<br>• The haircuts of high-quality liquid assets (HQLA) are calibrated against ECB haircuts, past Euro Area FSAPs, and market shock for investment securities and money market instruments in the solvency stress test. |
| 5. Regulatory and Market-Based Standards and Parameters | Regulatory standards | • Consistent with Basel III regulatory framework (LCR).<br>• Liquidity shortfall by bank. |
| 6. Reporting Format for Results | Output presentation | • Liquidity ratio or shortfall by groups of banks and aggregated (system wide).<br>• Number of banks that still can meet or fail their obligations. |

| Bank and Non-bank Sector: Contagion Analysis | | |
|---|---|---|
| **Top-down by IMF** | | |
| 1. Institutional Perimeter | Exercise | • Top-Down by FSAP team. |
| | Institutions included | • Domestic interbank contagion: 12 banks subcategorized as Sis (7 banks) and LSIs (5 banks). Among the total, 5 are domestically focused retail banks and 7 are internationally oriented banks which are subsidiaries of foreign parents.<br>• Cross-border contagion: country-pair bilateral exposure across Ireland, rest of Euro Area countries, United Kingdom, and United States.<br>• Cross-sectoral contagion: entity specific bilateral exposure across Irish banks and top 10 nonbank financial institutions (NBFIs) in terms of exposure size, drawing from sample including but not limited to, financial vehicle corporations (FVCs) and special purpose vehicles (SPVs), other financial service companies, as well as investment fund, pension and insurance companies. |
| | Market share | • Total coverage is about 80 percent of the banking sector, with 73 percent for SIs and 7 percent for LSIs. |
| | Data and baseline date | • Latest data: Supervisory as of June 2021 (and to the extent possible December 2021)<br>• BIS consolidated banking statistics |
| 2. Channels of Risk Propagation | Methodology | • Balance-sheet model: Interbank and cross-border network model by Espinosa-Vega and Solé (2010). |
| 3. Tail shocks | Size of the shock | • Pure contagion: hypothetical default of institutions.<br>• Default threshold: banks would default if their total CET1 ratios falling below 4.5 percent. |
| 4. Reporting Format for Results | Output presentation | • Capital shortfall systemwide, by bank and by group: contagion and vulnerability scores.<br>• Direction and size of spillovers within the network. |
| **Banking Sector: Climate Risk Analysis** | | |
| **Top-down by IMF** | | |
| 5. Institutional Perimeter | Exercise | • Top-Down by FSAP team. |
| | Institutions included | • 12 banks subcategorized as SIs (7 banks) and LSIs (5 banks). Among the total, 5 are domestically focused retail banks and 7 are internationally oriented banks which are subsidiaries of foreign parents. |
| | Market share | • Total coverage is about 80 percent of the banking sector, with 73 percent for SIs and 7 percent for LSIs. |

| | | |
|---|---|---|
| | Data and baseline date | • Supervisory data as of June 2021.<br>• Public data from 2003 to 2020 from capital IQ, Moody's Analytics and Eurostat. |
| 6. Channels of Risk Propagation | Methodology | • Transition risk: single factor sensitivity analysis to assess the near-term impact on corporate credit quality from a rising carbon tax. The analysis will allow for a sectoral level differentiation.<br>Bank credit impairment are generated by applying changes in sectoral PDs from entire firm sample to bank corporate loan PDs.<br>Market losses from bank holdings of mark-to-market (MTM) debt securities are estimated using a duration approach while replying on estimated PDs and Merton theory.<br>• Physical risk: scenario-based analysis simulating the macroeconomic impact of a severe flooding event, which is translated into bank losses through credit, market, and interest rate risk channel. |
| 7. Risks and Buffers | Risks | • Transition risk<br>• Physical risk |
| | Firm behavioral response | • Firms are allowed to pass through partial or full cost of carbon tax to consumers through increase in prices. Corresponding drop in demand is incorporated based on pre-determined price elasticity. |
| 8. Tail shocks | Size of the shock | • Increase of carbon tax from €33.50 to €100 per ton, based on CBI national targets and NGFS scenarios. Impact was assessed from 1-year to 5-year horizon, assuming shock materializes immediately in the first year. |
| 9. Regulatory and Market-Based Standards and Parameters | Regulatory standards | • No capital thresholds are applied. |
| 10. Reporting Format for Results | Output presentation | • Change in corporate PDs by sector with and without firm behavioral response from 1-year to 5-year horizon.<br>• Bank credit impairment by sectors due to shock on PDs on corporate loan, from 1-year to 5-year horizon.<br>• Bank market losses on holdings of debt securities due to shock on credit spread induced from corporate PDs, from 1-year to 5-year horizon.<br>• Bank capital ratio impact from 1-year to 5-year horizon. |

| Insurance Sector: Solvency Risk | | |
|---|---|---|
| **Top-Down by IMF** | | |
| 1. Institutional perimeter | Institutions included | • 10 life insurers: Aviva Life & Pensions Ireland DAC, AXA MPS Financial DAC, Darta Saving Life Assurance dac, Intesa SanPaolo Life dac, Irish Life Assurance Plc, Metlife Europe d.a.c., New Ireland Assurance, Standard Life International, Utmost PanEurope dac, Zurich Life Assurance plc<br>• 8 non-life insurers: Allianz Plc, Aviva Insurance Ireland, AXA Insurance DAC, AXIS Specialty Europe SE, FBD Insurance Plc, RSA Insurance Ireland dac, XL Insurance Company SE, Zurich Insurance plc<br>• 7 reinsurers: Allianz Re Dublin, Hannover Re (Ireland) DAC, Partner Reinsurance Europe SE, RGA International Reinsurance, SCOR Global Life Reinsurance Ireland dac, SCOR Life Ireland Designated Activity Company, XL Re Europe SE |
| | Market share | • Life: >70 percent (gross premiums written, total and domestic business, 2020 market shares)<br>• Non-life: >70 percent (gross premiums written, total and domestic business, 2020 market shares)<br>• Reinsurance: >70 percent (gross premiums written, total and domestic business, 2020 market shares) |
| | Consolidation | • Solo-entity level |
| | Data | • Regulatory reporting |
| | Reference date | • June 30, 2021 |
| 2. Channels of risk propagation | Methodology | • Investment assets: market value changes after price shocks, affecting the solvency position<br>• Insurance liabilities: impact on value of the best estimate by changing discount rate of future cash flows, proportionate change for the risk margin<br>• Recalculation of required capital after stress: approximated by the Solvency II standard formula also for internal model users |
| | Time horizon | • Instantaneous shock |
| 3. Tail shocks | Scenario analysis | • Adverse scenario (in line with narrative severity of the banking sector stress test):<br>• risk-free interest rates (without volatility adjustment) -17 bps (1yr EUR), -49 bps (10yr EUR); -17 bps (1yr USD), -48 bps (10yr USD); -17 bps (1yr GBP), -49 bps (10yr GBP).<br>• sovereign bond spread +160 bps (domestic), +25 bps for other low-yield advanced economies, up to +180 bps for emerging and developing economies.<br>• stock prices -58.0 percent (domestic), -18.0 percent (Euro Area and United States), -20.0 percent (other advanced economies), -35.0 percent (emerging and developing economies). |

| Insurance Sector: Solvency Risk | | |
|---|---|---|
| **Top-Down by IMF** | | |
| | | • property prices -19.9 percent (domestic, residential), -34.1 percent (domestic, commercial), -5.0 percent (foreign, residential), -18.0 percent (foreign, commercial).<br>• corporate bond spreads between +60 bps (AAA, non-financials) and +420 bps (CCC and lower, non-financials), and between +75 bps (AAA, financials) and +450 bps (CCC and lower, financials).<br>• Rating downgrades of one category (3 notches) for one third of the corporate bond portfolio<br>• EUR external value: -11.8 percent |
| | Sensitivity analyses | • Risk-free interest rates +/-100 bps (all currencies)<br>• EUR external value +/-10 percent<br>• Stock prices -40 percent<br>• Default of largest banking counterparty |
| 4. Risks and buffers | Risks/factors assessed | • Market risks: interest rates, share prices, property prices, credit spreads, currency<br>• Credit risks: default of largest financial counterparty<br>• Summation of risks, no diversification effects |
| | Buffers | • Solvency II long-term guarantee measures and transitionals:<br>  • Volatility Adjustment (VA)<br>• Unit-linked life insurance: Investment losses borne by policyholders |
| | Behavioral adjustments | • None |
| 5. Regulatory/accounting standards | | • Solvency II<br>• National GAAP |
| 6. Reporting format for results | Output presentation | • Impact on valuation of assets and liabilities<br>• Impact on solvency ratios (including and excluding the effect of long-term guarantee measures and transitionals)<br>• Contribution of individual shocks to changes of eligible own funds<br>• Dispersion measures of solvency ratios<br>• Capital shortfall and possible de-risking of investment assets to re-establish a full coverage of solvency requirements |

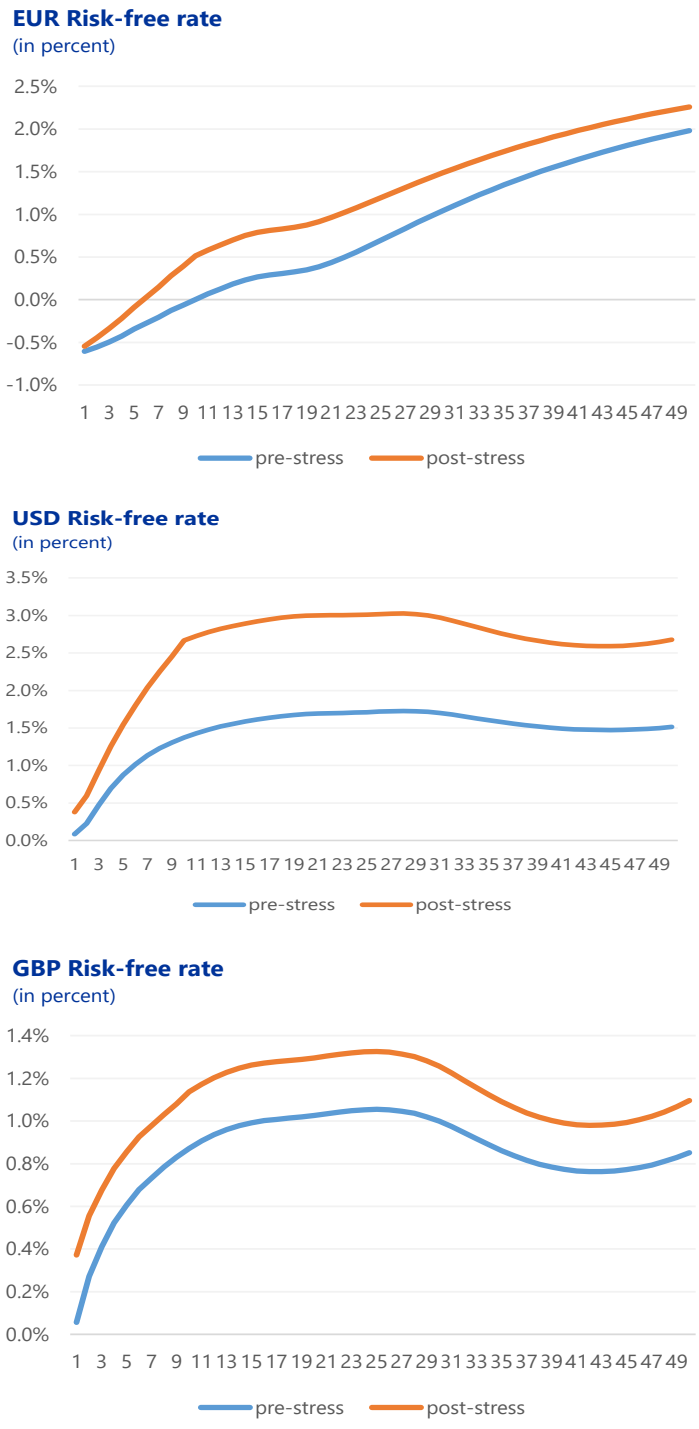
| Insurance Sector: Liquidity Risk | | | |
|---|---|---|---|
| | | **Bottom-up by CBI** | **Top-down by IMF** |
| 1. Institutional perimeter | Institutions included | • 10 insurers: Allianz Global Life, Amtrust International Underwriters, Hannover Re (Ireland) DAC, Intesa SanPaolo Life dac, Metlife Europe d.a.c., Partner Reinsurance Europe SE, RGA International Reinsurance, Utmost PanEurope dac, XL Insurance Company SE, Zurich Insurance plc | • 10 life insurers, 8 non-life insurers, 7 reinsurers: As for the solvency ST |
| | Market share | • Life: 20 percent (gross premiums written)<br>• Non-life: 45 percent (gross premiums written) | • >70 percent (gross premiums written, total and domestic business, 2020 market shares) |
| | Data | • Regulatory reporting | • Regulatory reporting |
| | Reference date | • December 31, 2020 | • June 30, 2021 |
| 2. Channels of risk propagation | Methodology | • Stock/flow assessment of liquidity sources and liquidity needs<br>• Shock to cash flows, based on EIOPA's 2021 adverse scenario (market and insurance risks)<br>• Reduction in the value of liquid assets, based on EIOPA's 2021 adverse scenario (market shocks) | • Revaluation of derivative positions after interest rate shock |
| | Time horizon | • 90 days | • Instantaneous (1 day, 5 days) |
| 3. Tail shocks | Scenario analysis | • EIOPA 2021 adverse scenario | • None |
| | Sensitivity analysis | • None | • Parallel shift of the interest rate term structure (for all currencies): +25 bps, +50 bps, +100 bps |
| 4. Risks and buffers | Risks/factors assessed | • Liquidity risk: Shock to market value of assets, mass lapse shock, mortality shock, pandemic morbidity shock and increase of non-life cost of claims, shock to reinsurance inflows, reduction in written premiums | • Liquidity risk: Margin calls for interest rate swaps |
| | Buffers | • None | • None |
| 5. Regulatory/accounting standards | | • Solvency II<br>• National GAAP | • Solvency II<br>• National GAAP |
| 6. Reporting format for results | Output presentation | • "Sustainability indicator": Net flows divided by liquid assets | • Total amount of variation margin calls<br>• Variation margin as percent of cash holdings<br>• Variation margin as percent of high-quality liquid assets |

# Appendix VIII. Investment Fund Liquidity Stress Testing Matrix (STeM)

| Investment Fund Sector: Liquidity Risk | | |
|---|---|---|
| **Top-Down by IMF** | | |
| 1. Institutional perimeter | Institutions included | • Fixed-income bond funds. |
| | Market share | • Varies by type of fund |
| | Data | • Morningstar |
| | Reference date | • Portfolio reporting date: January 1, 2021, or later |
| 2. Channels of risk propagation | Methodology | • Various levels of redemptions shock compared level of highly liquid assets at the fund level.<br>• Redemption shocks calculated based on historical data on redemptions using VaR and Expected Shortfall methodologies with multiple thresholds.<br>• Historical time series with monthly frequency |
| | Time horizon | • Instantaneous shocks |
| 3. Tail shocks | Scenario analysis | • Pure redemption shock: severe outflows based on historical distribution |
| | Sensitivity analyses | • Risk-free interest rates +/-100 bps (all currencies)<br>• EUR external value +/-10 percent<br>• Stock prices -40 percent<br>• Default of largest banking counterparty |
| 4. Risks and buffers | Risks/factors assessed | • Liquidity risk: severe redemption shock |
| | Buffers | • Stock of highly liquid assets |
| 5. Reporting format for results | Output presentation | • Number of funds with a redemption coverage ratio (ratio of highly liquid assets to redemptions) below one.<br>• Liquidity shortfall amount for individual funds after redemptions. |

# Appendix IX. Insurance Sector Interest Rate Scenarios

**Figure xx. Risk-free rates**
(Without the volatility adjustment)




Source: IMF staff.

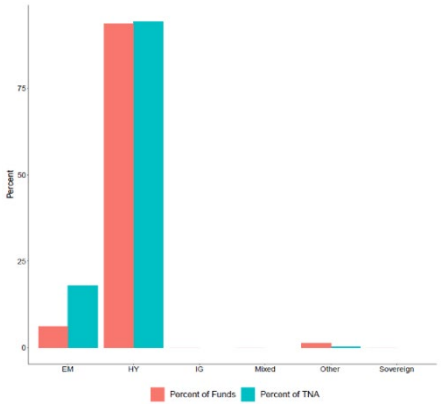
# Appendix X. Investment Fund Category Correspondence Table

| Morningstar Category | New category |
|---|---|
| EAA Fund Asia High Yield Bond | HY |
| EAA Fund Greater China High Yield Bond | HY |
| EAA Fund EUR High Yield Bond | HY |
| EAA Fund NOK High Yield Bond | HY |
| EAA Fund SEK Flexible High Yield Bond | HY |
| EAA Fund Global High Yield Bond - EUR Hedged | HY |
| EAA Fund Global High Yield Bond - GBP Hedged | HY |
| EAA Fund Global High Yield Bond - CHF Hedged | HY |
| EAA Fund USD High Yield Bond | HY |
| EAA Fund Global High Yield Bond | HY |
| EAA Fund Global Corporate Bond - GBP Hedged | IG |
| EAA Fund Global Corporate Bond - EUR Hedged | IG |
| EAA Fund Global Corporate Bond - USD Hedged | IG |
| EAA Fund Global Bond - GBP Hedged | IG |
| EAA Fund Global Bond | IG |
| EAA Fund Global Corporate Bond - CHF Hedged | IG |
| EAA Fund Global Bond - EUR Hedged | IG |
| EAA Fund Global Bond - USD Hedged | IG |
| EAA Fund Global Bond - EUR Biased | IG |
| EAA Fund Global Bond - CHF Hedged | IG |
| EAA Fund Global Corporate Bond | IG |
| EAA Fund Global Bond - NOK Hedged | IG |
| EAA Fund Global Bond - ILS | IG |
| EAA Fund EUR Corporate Bond | IG |
| EAA Fund EUR Diversified Bond | IG |
| EAA Fund EUR Corporate Bond - Short Term | IG |
| EAA Fund GBP Diversified Bond | IG |
| EAA Fund GBP Diversified Bond - Short Term | IG |
| EAA Fund GBP Corporate Bond - Short Term | IG |
| EAA Fund GBP Corporate Bond | IG |
| EAA Fund USD Corporate Bond | IG |
| EAA Fund USD Diversified Bond | IG |
| US Fund Corporate Bond | IG |
| EAA Fund SEK Corporate Bond | IG |
| EAA Fund USD Diversified Bond - Short Term | IG |
| EAA Fund Global Emerging Markets Bond - EUR Biased | EM |
| EAA Fund Global Emerging Markets Bond | EM |
| EAA Fund Global Emerging Markets Corporate Bond | EM |
| EAA Fund Global Emerging Markets Corporate Bond - EUR Biased | EM |
| EAA Fund Global Emerging Markets Bond - Local Currency | EM |

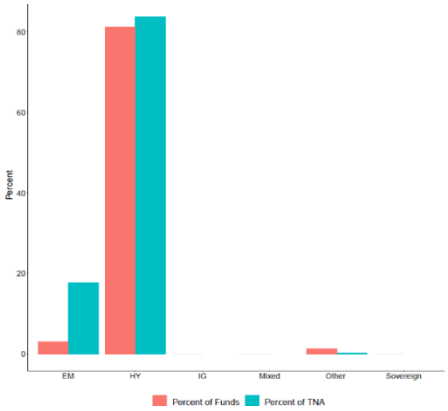
| | |
|---|---|
| EAA Fund Asia Bond | Other |
| EAA Fund RMB Bond - Onshore | Other |
| EAA Fund Asia Bond - Local Currency | Other |
| EAA Fund EUR Subordinated Bond | Other |
| EAA Fund EUR Flexible Bond | Other |
| EAA Fund NOK Bond | Other |
| EAA Fund NOK Bond - Short Term | Other |
| EAA Fund EUR Ultra Short-Term Bond | Other |
| EAA Fund EUR Diversified Bond - Short Term | Other |
| EAA Fund Europe Bond | Other |
| EAA Fund Global Flexible Bond - EUR Hedged | Other |
| EAA Fund Global Flexible Bond - GBP Hedged | Other |
| EAA Fund Global Flexible Bond - USD Hedged | Other |
| EAA Fund Global Flexible Bond - CHF Hedged | Other |
| EAA Fund Global Flexible Bond | Other |
| EAA Fund JPY Bond | Other |
| EAA Fund GBP Inflation-Linked Bond | Other |
| EAA Fund USD Flexible Bond | Other |
| EAA Fund EUR Bond - Long Term | Other |
| EAA Fund GBP Flexible Bond | Other |
| EAA Fund EUR Inflation-Linked Bond | Other |
| EAA Fund Global Inflation-Linked Bond - EUR Hedged | Other |
| EAA Fund Global Inflation-Linked Bond - USD Hedged | Other |
| EAA Fund Global Inflation-Linked Bond - GBP Hedged | Other |
| EAA Fund Global Inflation-Linked Bond | Other |
| EAA Fund USD Inflation-Linked Bond | Other |
| EAA Fund USD Cautious Allocation | Mixed |
| EAA Fund EUR Cautious Allocation - Global | Mixed |
| EAA Fund GBP Moderately Cautious Allocation | Mixed |
| EAA Fund EUR Cautious Allocation | Mixed |
| EAA Fund CHF Cautious Allocation | Mixed |
| EAA Fund GBP Cautious Allocation | Mixed |
| EAA Fund SEK Cautious Allocation | Mixed |
| EAA Fund NOK Cautious Allocation | Mixed |
| EAA Fund Convertible Bond - Global | Mixed |
| EAA Fund Convertible Bond - Global, EUR Hedged | Mixed |
| EAA Fund Convertible Bond - Global, GBP Hedged | Mixed |
| EAA Fund Convertible Bond - Global, CHF Hedged | Mixed |
| EAA Fund Convertible Bond - Global, USD Hedged | Mixed |
| EAA Fund EUR Government Bond | Sovereign |
| EAA Fund EUR Government Bond - Short Term | Sovereign |
| EAA Fund GBP Government Bond | Sovereign |
| EAA Fund USD Government Bond | Sovereign |
| EAA Fund Property - Indirect Global | Property |
| EAA Fund Property - Indirect Other | Property |
| EAA Fund Property - Indirect Europe | Property |
| EAA Fund Property - Indirect North America | Property |
| EAA Fund Property - Indirect Asia | Property |
| EAA Fund Property - Direct UK | Property |

# Appendix XI. RCR for a Range of Shock Scenarios

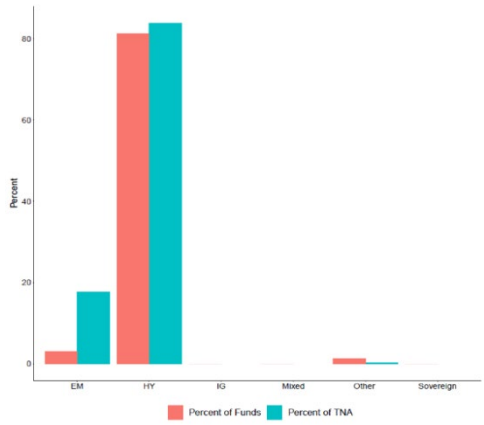
ES Model, 1% Shock, Heterogeneity



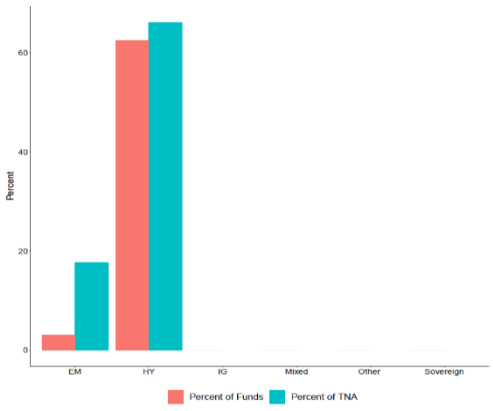

VaR Model, 1% Shock, Heterogeneity



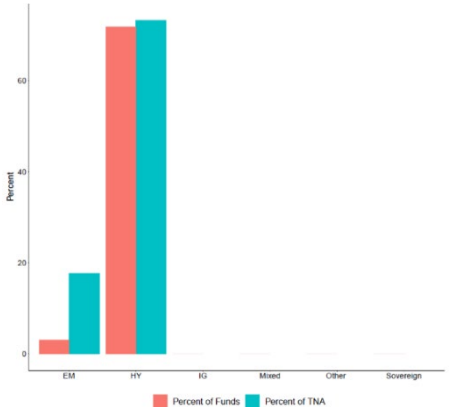

ES Model, 3% Shock, Heterogeneity



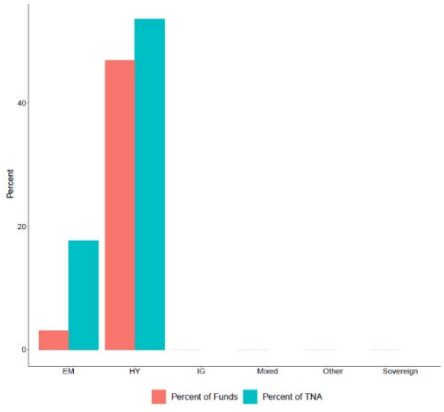

VaR Model, 3% Shock, Heterogeneity



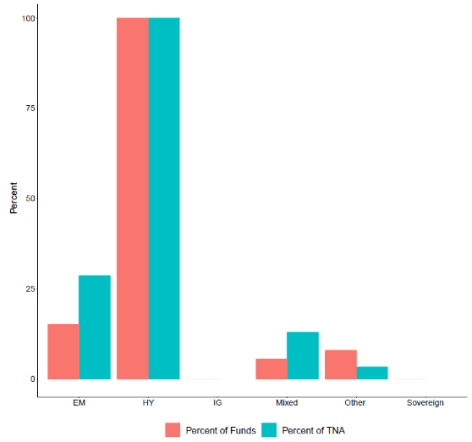

ES Model, 5% Shock, Heterogeneity



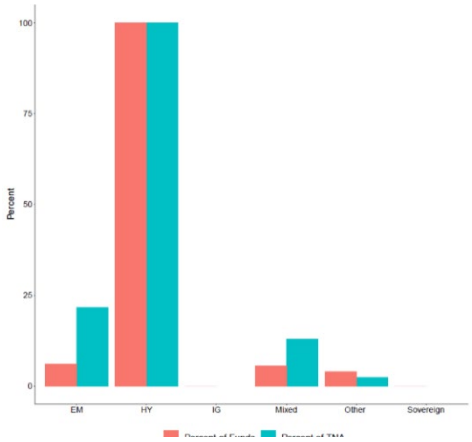

VaR Model, 5% Shock, Heterogeneity



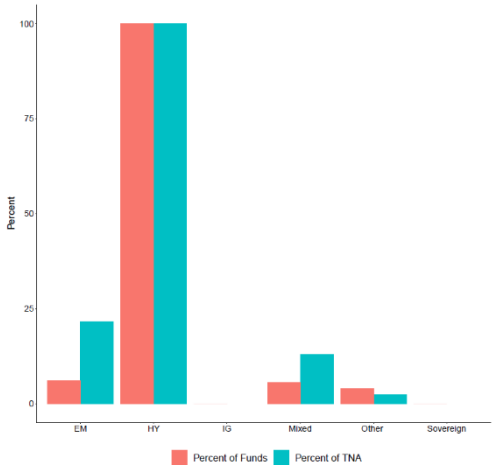
ES Model, 1% Shock, Homogeneity



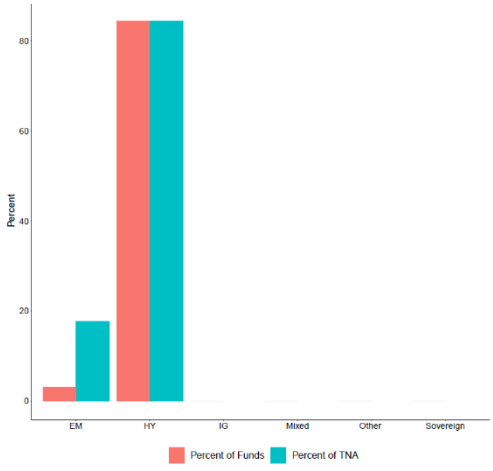

VaR Model, 1% Shock, Homogeneity



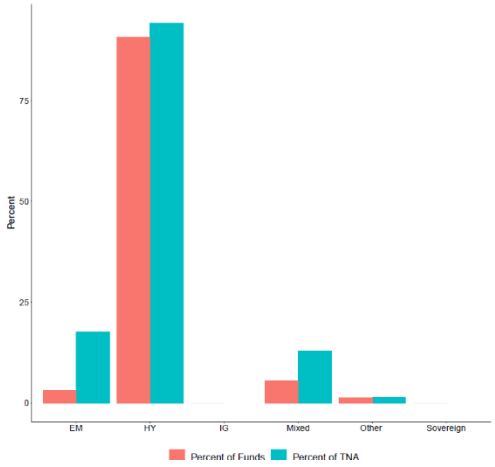

ES Model, 3% Shock, Homogeneity



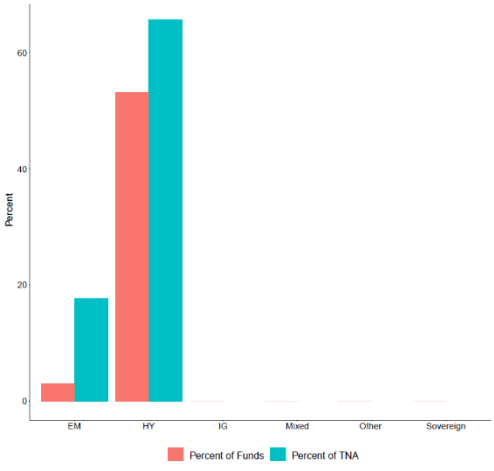

VaR Model, 3% Shock, Homogeneity




ES Model, 5% Shock, Homogeneity

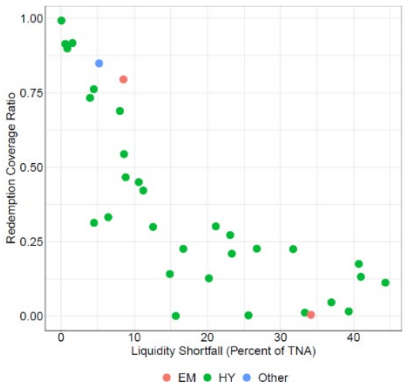



VaR Model, 5% Shock, Homogeneity

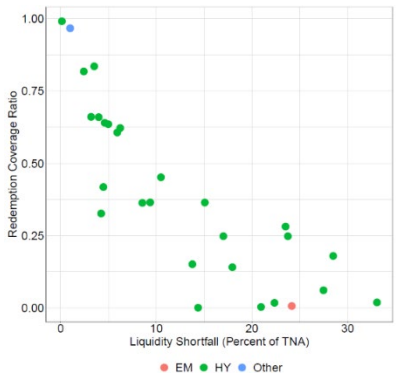


# Appendix XII. RCR and Liquidity Shortfall under the Heterogeneity Approach

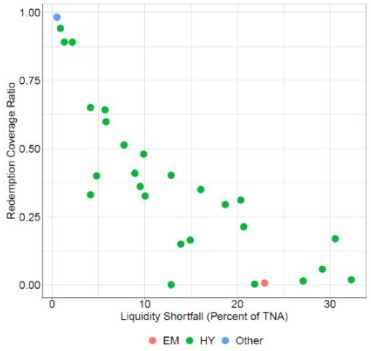
ES Model, 1% Shock



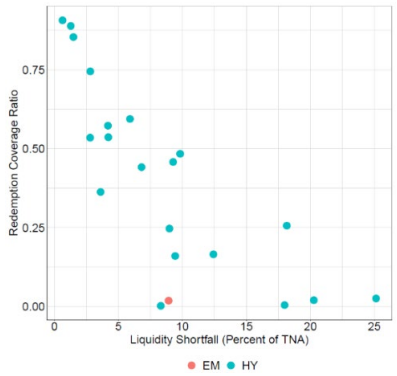

VaR Model, 1% Shock



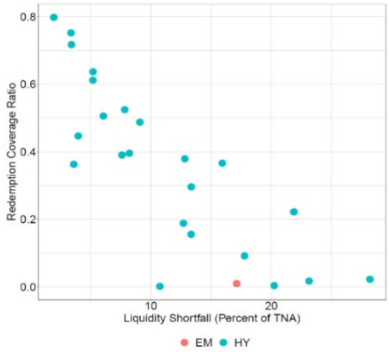

ES Model, 3% Shock



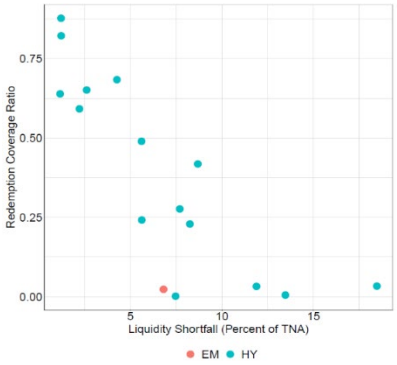

VaR Model, 3% Shock




ES Model, 5% Shock




VaR Model, 5% Shock



# References

Bank for International Settlements (BIS). Introduction to BIS statistics. BIS Quarterly Review. September 2015.

Central Bank of Ireland. II 2020. "Financial Stability Review." Dublin. Ireland.

Central Bank of Ireland. I 2021. "Financial Stability Review." Dublin. Ireland.

Central Bank of Ireland. II 2021. "Financial Stability Review." Dublin. Ireland.

European Central Bank. 2020. ECB announces €750 billion Pandemic Emergency Purchase Programme (PEPP) [Press release]. https://www.ecb.europa.eu/press/pr/date/2020/html/ecb.pr200318_1~3949d6f266.en.html.

European Banking Authority. 2020. Report on the Benchmarking of National Loan Enforcement Frameworks. EBA/Rep/2020/29.

European Systemic Risk Board. 2020. EU Non-bank Financial Intermediation Risk Monitor 2020 (NBFI Monitor). No 5.

European Central Bank. 2020. "Developments in the Sovereign-Bank Nexus in the Euro Area: The Role of Direct Sovereign Exposures". Financial Stability Review. November 2020.

European Commission. 2020. "Energy Prices and Costs in Europe." Report from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. SWD (2020) 951 Final Part 3/6. October 2020.

Espinosa-Vega, Marco A., and Juan Solé. 2011. "Cross-Border Financial Surveillance: A Network Perspective." Journal of Financial Economic Policy 3 (3): 182–205.

Gross, Marco and Javier Población. 2017. "Implications of Model Uncertainty for Bank Stress Testing." Journal of Financial Services Research DOI: 10.1007/s10693-017-0275-4.

Heine, Dirk, and Simon Black, 2019. "Benefits beyond Climate: Environmental Tax Reforms in Fiscal Policies for Development and Climate Action." Pigato, M. (ed.). World Bank Group. Washington, DC.

International Monetary Fund (IMF). 2022. "The Global Bank Stress Test." Departmental Papers, DP/2022/009, Washington, DC

International Monetary Fund (IMF). 2020. "Norway: Financial Sector Assessment Program-Technical Note-Risk Analysis and Stress Testing." Technical Notes, Washington, DC

International Monetary Fund (IMF). 2022. "United Kingdom: Financial Sector Assessment Program-Systemic Stress, and Climate-Related Financial Risks: Implications for Balance Sheet Resilience." Technical Notes, Washington, DC

International Monetary Fund (IMF). 2021. "Consideration for Climate Change Mitigation in Ireland". Ireland Article IV Consultation. Selected Issues. IMF Country Report No. 21/124. June.

International Monetary Fund (IMF), 2019a. Fiscal Policies for Paris Climate Strategies—From Principle to Practice. International Monetary Fund, Washington, DC.

International Monetary Fund (IMF), 2019b. Fiscal Monitor: How to Mitigate Climate Change. International Monetary Fund, Washington, DC.

Kirezci, E., et al. 2020. "Projections of global-scale extreme sea levels and resulting episodic coastal flooding over the 21st Century". Sci. Rep. 10, 11629 (2020).

Oppenheimer, Michael, et al. (2019). Sea Level Rise and Implications for Low-Lying Islands, Coasts and Communities. IPCC Special Report on the Ocean and Cryosphere in a Changing Climate, Vol. 126, Geneva: IPCC.

Parry, Ian, Victor Mylonas, and Nate Vernon. 2021. "Mitigation Policies for the Paris Agreement: An Assessment for G20 Countries." Journal of the Association of Environmental and Resource Economists. University of Chicago Press. vol. 8(4). pages 797-823.

Vitek, Francis. (2018). "The Global Macro-Financial Model". IMF Working Paper No. 2018/081