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BELGIUM

FINANCIAL SECTOR ASSESSMENT PROGRAM

December 2023

TECHNICAL NOTE ON SYSTEMIC RISK ANALYSIS AND STRESS TESTING

This paper on Belgium 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 17, 2023.

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TECHNICAL NOTE

SYSTEMIC RISK ANALYSIS AND STRESS TESTING

Prepared By
Monetary and Capital Markets Department

This Technical Note was prepared by IMF staff in the context of the Financial Sector Assessment Program (FSAP) that visited Belgium in June 2023. It contains technical analysis and detailed information underpinning the FSAP's findings and recommendations. Further information on the FSAP can be found at http://www.imf.org/external/np/fsap/fssa.aspx

CONTENTS

FIGURES

TABLES

APPENDICES

Glossary

AC	Amortized Cost
ALM	Assets and Liabilities Mismatch
ASRF	Asymptotic Single Risk Factor
AT1	Additional Tier 1
BIC	Bayesian Information Criterion
BIS	Bank of International Settlements
BU	Bottom-Up
CBC	Counterbalancing capacity
CCoB	Capital Conservation Buffer
CET1	Common Equity Tier 1
COREP	Common Reporting Framework
CPI	Consumer Price Index
CRE	Commercial Real Estate
CSD	Central Securities Depository
CSP	Critical Service Provider
DSTI	Debt Service to Income
DT	Down-Turn
ECB	European Central Bank
EAoL	Excess of Assets over Liabilities
EDF	Expected Default Frequency
EOF	Eligible Own Funds
EPIFP	Expected profits in future premiums
ESMA	European Securities and Markets Authority
EURIBOR	Euro Interbank Offered Rate
EVS	Espinosa-Vega-Sole
FINREP	Financial Reporting
FMIs	Financial Market Infrastructures
FSAP	Financial Sector Assessment Program
FSMA	Financial Services and Markets Authority
FVOCI	Fair Value through Other Comprehensive Income
FVPL	Fair Value through Profit and Loss
FX	Foreign Exchange
GDP	Gross Domestic Product
GFC	Global Financial Crisis
GMM	Global Macrofinancial Model
GRAM	Global Risk Assessment Matrix
HTM	Held-to-Maturity
IFRS9	International Financial Reporting Standard 9
IRB	Internal Ratings-Based Approach
IRRBB	Interest Rates Risk in the Banking Book
IRS	Interest Rate Swap

IT	Information Technology
LE	Loans Exposure
LCR	Liquidity Coverage Ratio
LGD	Loss Given Default
LMTs	Liquidity Management Tools
LSI	Less Significant Institution
LTG	Long-term guarantees
LTV	Loan to Value
MacD	Macaulay Duration
MD	Modified Duration
ME	Mastercard Europe
MER	Mutual Evaluation Report
NBB	National Bank of Belgium
NFC	Non-financial Corporate
NII	Net Interest Income
Non-II	Non-Interest Income
NPL	Non-Performing Loan
NPLE	Non-Performing Loans Exposure
NSFR	Net Stability Funding Ratio
OCI	Other Comprehensive Income
O-SIIB	Other Systemically Important Institutions Buffer
PAT	Profit After Tax
PBT	Profit Before Tax
PD	Probability of Default
PiT	Point in Time
PnL	Profit and Loss
RRE	Residential Real Estate
ROA	Return on Assets
rOCI	rest Other Comprehensive Income
RWA	Risk Weighted Assets
SI	Significant Institution
SCR	Solvency Capital Requirement
SME	Small and Medium Enterprises
SRA	Systemic Risk Assessment
SSM	Single Supervisory Mechanism
SSRB	Sectoral systemic risk buffer
SSS	Securities Settlement System
STA	Standardized Approach
STE	Short-Term Exercise
STeM	Stress Test Matrix
SWIFT	Society for Worldwide Interbank Financial Telecommunication
TCI	Total Comprehensive Income
TD	Top-Down

TLTRO	Targeted longer-term refinancing operations
TM	Transition Matrix
TTC	Through-the-cycle
UCITS	Undertakings for collective investment in transferable securities
VA	Volatility Adjustment
VECM	Vector Error Correction Model
WEO	World Economic Outlook

EXECUTIVE SUMMARY[1]

The financial sector has remained resilient to a series of shocks and is well capitalized and profitable, but risks remain. Bank profitability and capital have surpassed pre-pandemic levels. Liquidity buffers remain strong and banks' direct exposures to Russia are limited. The insurance and investment funds sectors have also weathered the pandemic well. There is limited evidence of credit or asset price booms over the past decade. However, inflationary pressures, partly the result of spillovers from Russia's war on Ukraine, and a rapid tightening of financial conditions have weakened activity and reined in credit demand. Among high uncertainty, GDP growth is projected to slow in 2023, before returning to potential over the medium-term.

The FSAP banks solvency stress tests shows that the Belgian significant institutions (SIs) are resilient under the adverse scenario while some heterogeneity exists. The main risks that are considered in the scenario are: intensifying fallout from the war in Ukraine, worsening energy crisis and supply disruptions, and higher inflation lead to monetary tightening. This exacerbates the downturn and leads to housing market corrections. These factors impact both banks and non-banks through asset valuations, funding costs, interest rate risks, and credit risk. The consequential drop in property prices leads to increased riskiness of mortgages. The combined effect across multiple channels causes insolvency in weaker corporates, resulting in market dislocations and adverse cross-border spillovers. The adverse scenario commences with two consecutive years of recession, with real GDP growth rates of -3.8 percent and -2.2 percent respectively. Under this severe but plausible scenario, the aggregate common equity tier 1 (CET1) ratio of the group of stressed banks drops to 14 percent from 18.3 percent, still well above regulatory requirements. While some heterogeneity between banks exists, mainly in the asset and liability management (ALM) and their net interest income (NII) projections, all banks can meet minimum capital requirements.

The FSAP team also conducted a sensitivity analysis where non-term deposits are converted to term deposits owing to the steep surge in interest rates. Throughout four years, the scenario of 20 percent and 50 percent conversion revealed a decreasing trajectory for the CET1 ratio, starting at 18.3 percent to 13.1 and 11.5 percent, respectively.

The results from the liquidity stress tests show that liquidity levels are comfortable for the system but need to be reinforced for some banks. Liquidity risk was evaluated through three types of analyses: Liquidity Coverage Ratio (LCR) stress tests, cash flow-based analysis, and descriptive analysis of the Net Stable Funding Ratio (NSFR). LCR analysis shows that Belgian banks are more susceptible to stress originating from the retail and wholesale sectors, while they are relatively insulated from market-driven stress. Similarly, cash-flow based analysis exhibits that banks are well protected against market-induced stress, but some of them are vulnerable to liquidity

[1] This Technical Note (TN) was prepared by Apostolos Panagiotopoulos (MCM), Sergio Sola (MCM), Dan Cheng (MCM), Massimo Ferrari , and Bernhard Mayr (external experts). The team is grateful to the National Bank of Belgium (NBB), the Financial Services and Markets Authority (FSMA), and the European Central Bank (ECB) for their excellent collaboration in this exercise.

strains caused by deposit outflows. The qualitative NSFR test reveals the heavy reliance of banks stable funding sources, consisting mostly of deposits covered by the public guarantee.

An additional study examining the interplay between solvency and liquidity risks under stress shows that banks are resilient to shocks that will result in forced liquidation of assets. The framework simulates a situation where severe liquidity stress drives banks to divest assets from their Held-To-Maturity (HTM) portfolio at market value, leading to a devaluation. The analysis encompasses four scenarios, each determined by the fraction of the HTM portfolio sold. Under all the four scenarios CET1 ratios remained between 15.3 percent and 15 percent by the end of year 3 (2025), when banks record their highest losses. All banks still meet their minimum capital requirements.

Insurance companies are broadly resilient against simulated shocks. A stress test on insurance companies was run to assess the sector's resilience against severe macrofinancial shocks and strong increases of lapses. The solvency stress test shows that the insurance industry is generally able to withstand the severe scenario, even though solvency ratios see a significant fall, especially if management actions are ignored. The analysis showed that there is scope to gradually improve the quality of insurers' capital. The median solvency ratio drops from 192 percent before stress to 113 percent after stress. Including reactive management actions, the new median solvency ratio is 142 percent. The FSAP also analyzed the sector's resilience against liquidity shocks from variation margin calls on derivatives and large surrenders. Low derivative exposures for most insurers make the sector largely resilient to margin calls following steep interest rate hikes. Insurers generally have sufficient liquid funds to withstand significant redemptions, but results show high levels of dispersion.

The FSAP also conducted an investment fund liquidity stress test to assess the resilience of the Belgian fund industry. The exercise revealed that the sector largely would be able to withstand severe but plausible redemption shocks. Less than 2 percent of the investment funds analysed would not have enough highly liquid assets to meet investors' redemption requests in a market stress situation and thus present liquidity shortfalls.

The interconnectedness analyses show that Belgian domestic and cross-border interconnections are relatively modest. The domestic interbank market reflects low levels of contagion risks for Belgian banks; however, there are a few banks that exhibit a high degree of systemic importance within the interbank system. Cross-border analysis reveals Belgian banks' strong exposures to non-financial sectors.

Table 1. Belgium: FSAP Systemic Risk Analysis Key Recommendations

	Recommendation	Addressee	Timing[1]
1.	Further strengthen the National Bank of Belgium's (NBB) General Stress Testing Framework by (i) integrating individual models within the stress testing framework to offer a comprehensive impact analysis on banks' profitability and capital adequacy, (ii) incorporating the IFRS 9 Approach into Credit Risk Modeling and (iii) continuing to adopt advanced analytical methods to better monitor Assets Liabilities Management risks.	NBB	MT
2.	Increase insurers' resilience against macrofinancial shocks, by i) engaging with industry to reduce dependence of insurers on lower tier capital and ii) implementing liquidity stress tests and scenario analysis to identify potential sources of stress.	NBB	MT, NT
3.	The National Bank of Belgium (NBB) to run a detailed assessment of the impact of the use of the volatility adjustment on the insurance firms' solvency ratio in a changing interest rate environment.	NBB	NT
4.	The NBB and the Financial Services and Markets Authority (FSMA) to establish a formal agreement for sharing data on investment funds' portfolio holdings and supervisory data and continue common reporting on asset management and Non-bank Financial Institutions (NBFI). The FSMA to (i) develop and adapt a stress test framework to assess the structural vulnerabilities stemming from the investment fund sector and integrate into the NBB's systemic risk assessment, (ii) improve their data driven risk-based supervisory framework by using this enhanced information set. (iii) monitor more closely Belgian managers of non-public open-ended AIFs, to enhance their liquidity management including by recommending the availability and use of Liquidity Management Tools (LMT) where necessary, (iv) monitor and assess the use of LMTs by investment funds (IFs) within the European framework,	FSMA NBB	C, MT

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

BACKROUND

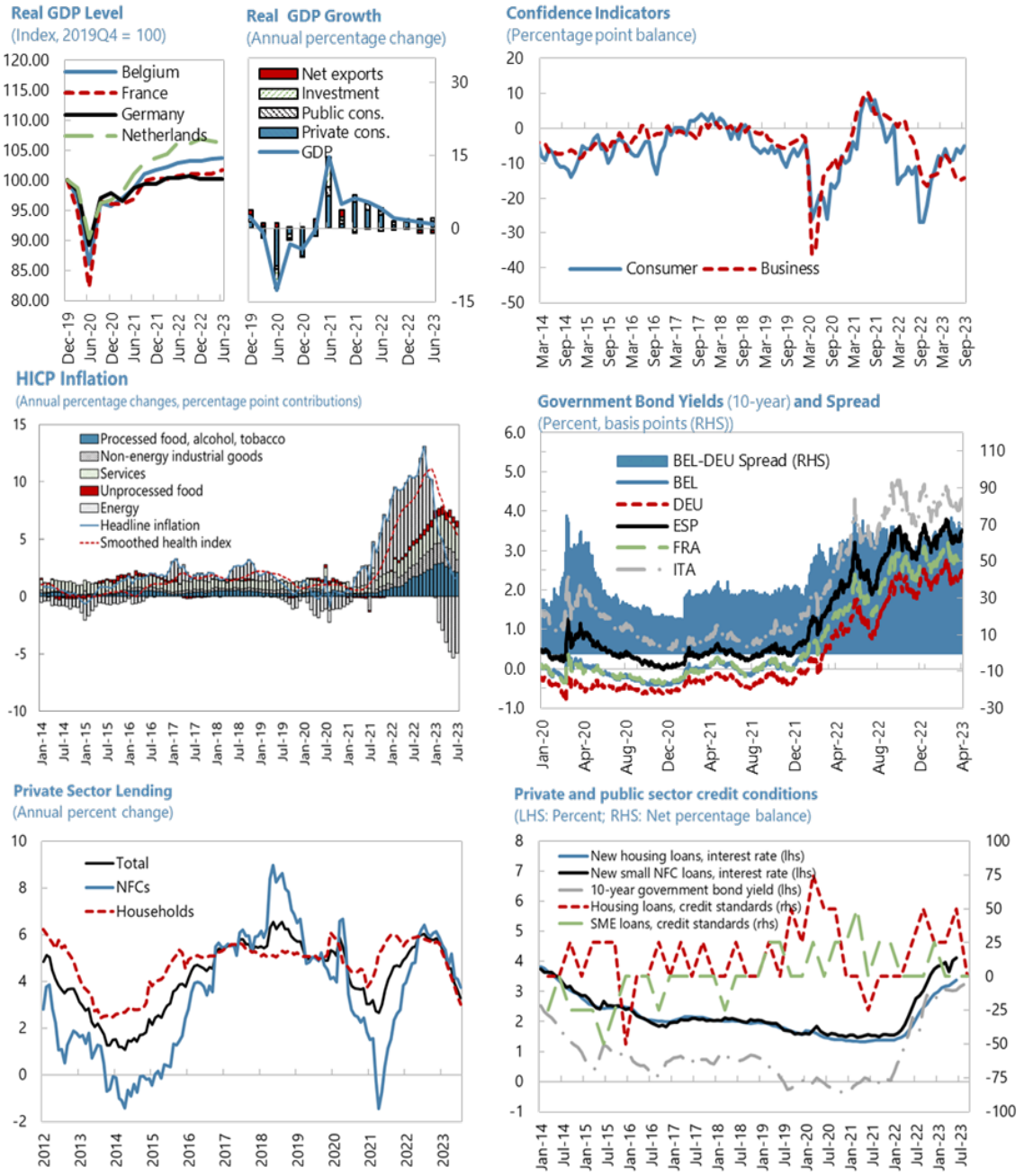
A. Context and Macrofinancial Developments

1. Economic activity has weakened, inflation remains high, and the fiscal outlook is challenging. Indirect spillovers from Russia's war on Ukraine have softened demand and growth has weakened (Figure 1)**.** Automatic wage indexation and government measures have supported households. Uncertainty remains elevated and rapidly tightening financial conditions are likely to dampen credit and activity going forward. GDP growth is projected to slow in 2023, before returning to potential over the medium-term.

2. The financial sector remained resilient during the pandemic. At end-2022, banks' capital adequacy ratio for systemically important institutions (SIs) stood at 18.3 percent (Figure 2) and was dominated by CET1 (AT1 capital buffers were a small fraction). Profitability is at pre-pandemic levels and non-performing loans (NPLs) have continued to decline. The Liquidity Coverage Ratio (LCR) and Net Stable Funding Ratio (NSFR) are at 163 percent and 128 percent respectively. The main funding source is retail deposits (60 percent insured). Similarly, the insurance sector remained robust, with solvency ratios higher than in the pre-pandemic period. Investment funds did not face any redemption shock and did not need to test their liquidity management tools.

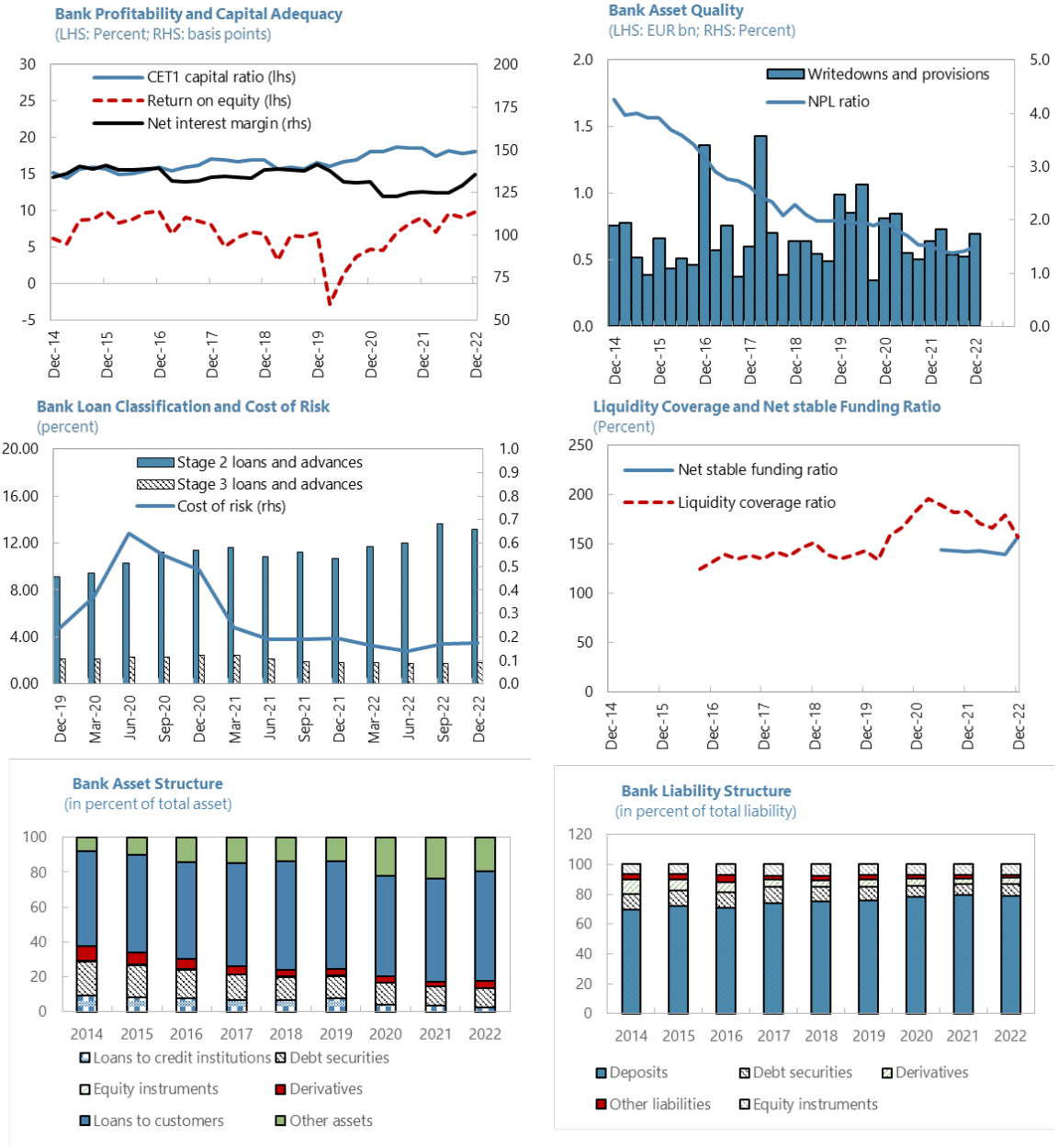
3. House prices and mortgage debt have steadily increased, heightening systemic risks. Domestic credit has risen from 75 percent of GDP to nearly 85 percent of GDP since the Global Financial Crisis (GFC). The credit-to-GDP gap turned slightly negative in 2022Q2 on lower contributions from both the household and corporate sectors. Increases in residential (RRE) and commercial (CRE) real estate prices below other Euro Area (EA) countries have limited the extent of overvaluation (Figure 3, Figure 4). Available model-based estimates indicate house prices being approximately 10 percent (NBB) and 15 percent (ECB) above their fundamentals. Stage 2 loans since year-end 2021 rose from 16.3 percent to 19.1 percent for non-financial corporations (NFC) and from 8.2 percent to 9.9 percent for households by Q12023, pointing to increasing vulnerabilities.

Figure 1. Belgium: Recent Economic Developments



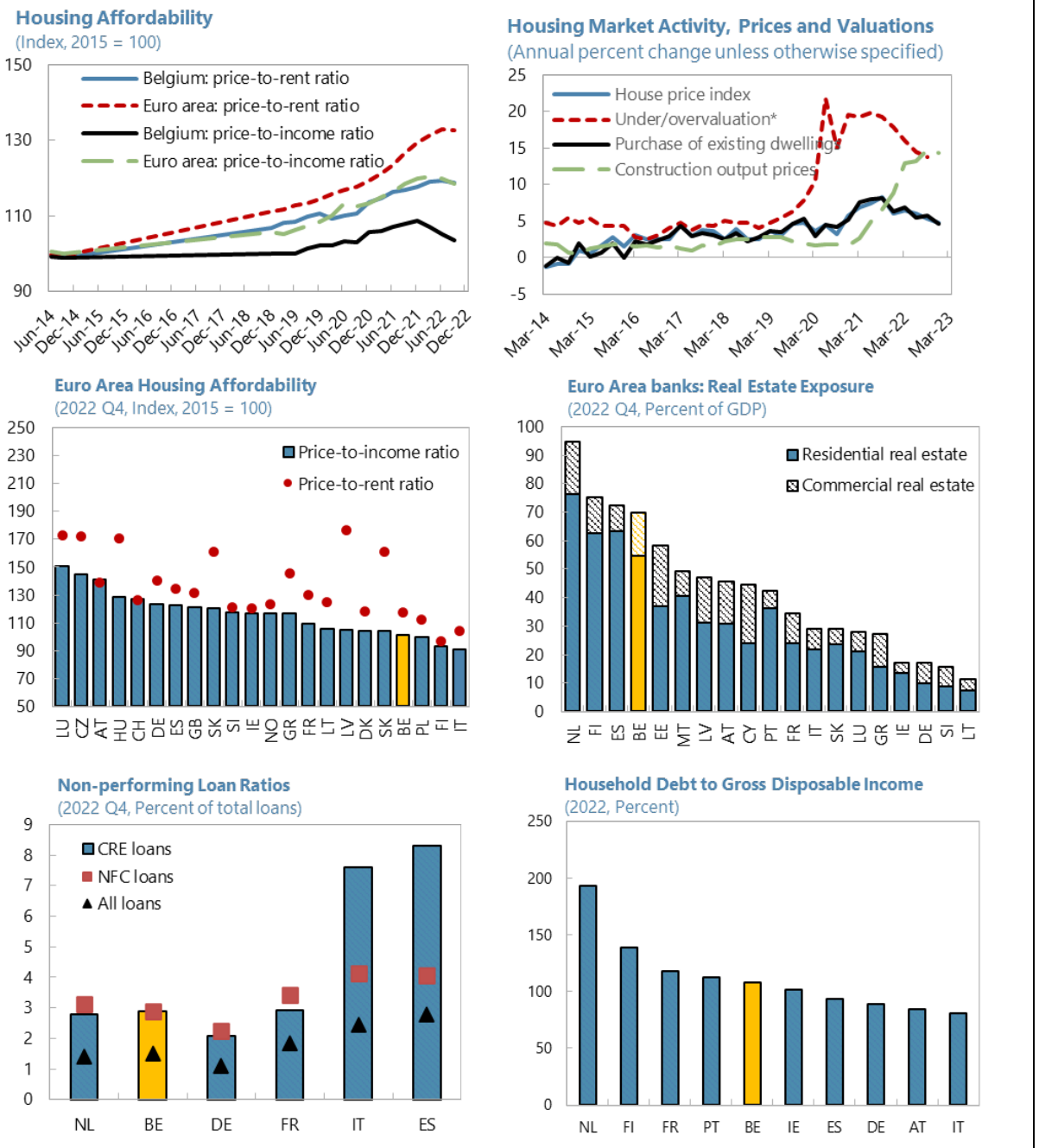
Sources: Eurostat, NBB, StatBel, Haver, ECB, and IMF staff calculation.

Figure 2. Belgium: Banking Sector Indicators



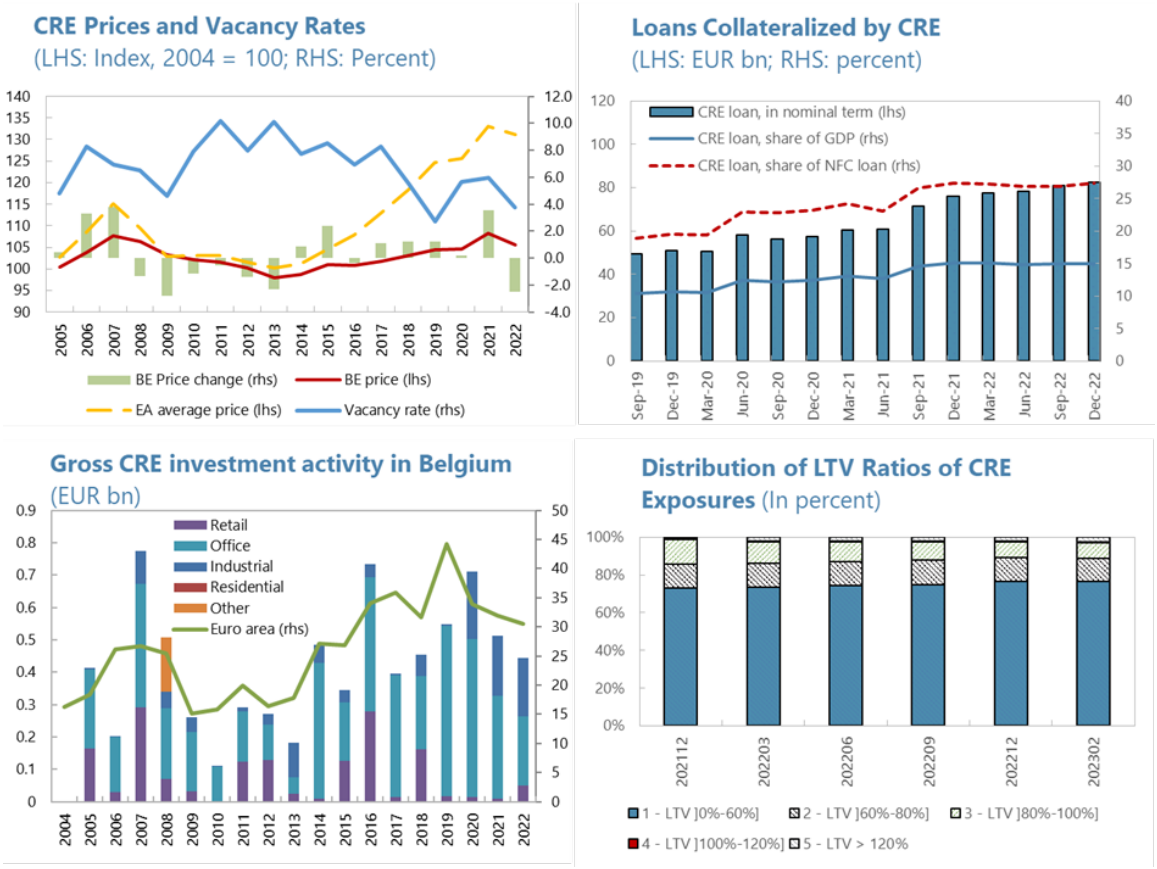
Sources: EBA, NBB, and IMF staff calculation.

Figure 3. Belgium: Real Estate Developments



Sources: Eurostat, and IMF staff calculation. OECD, EBA, ECB.

Figure 4. Belgium: Commercial Real Estate Developments



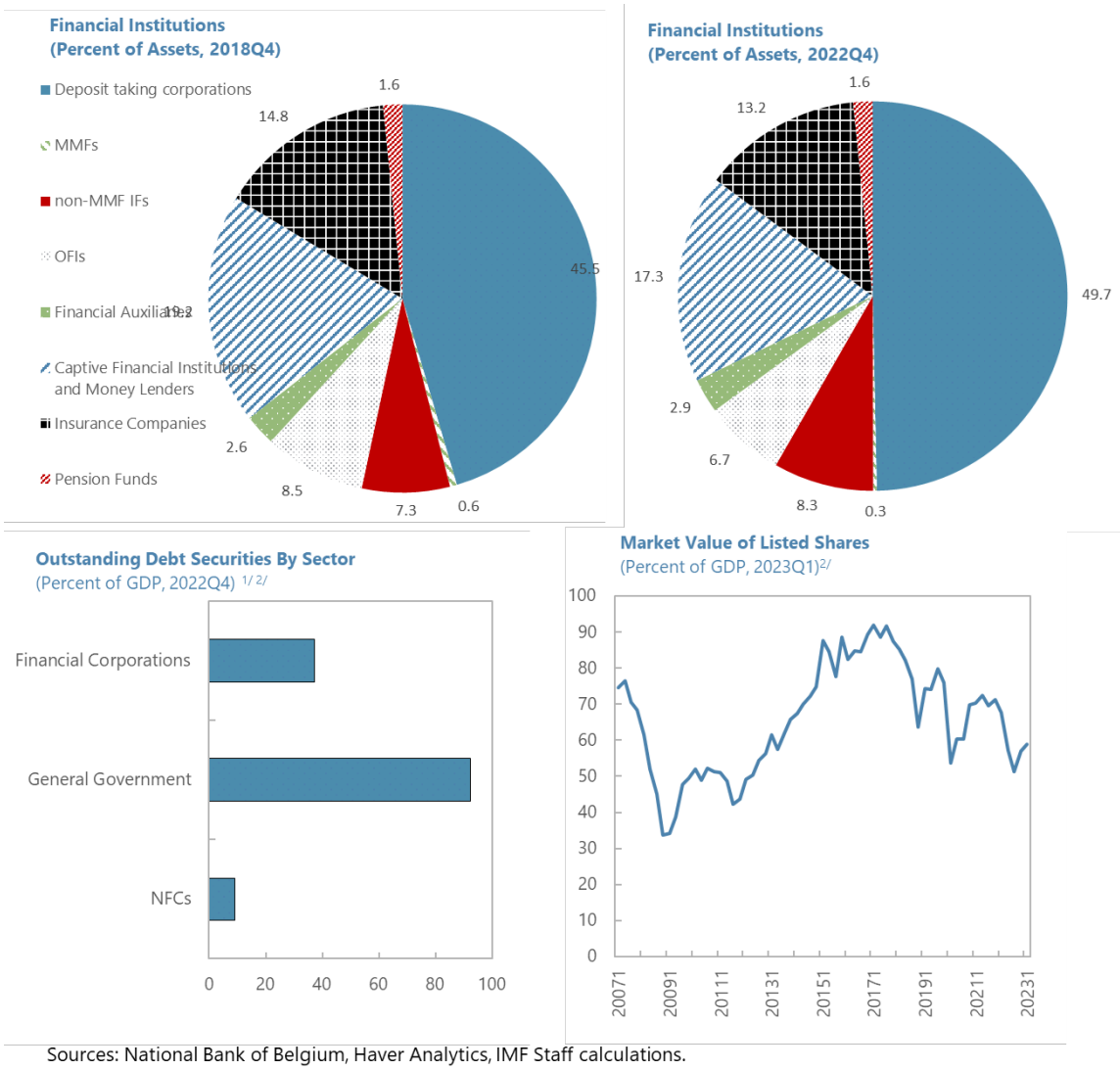
Source: MSCI, EBA, NBB, and IMF staff calculation.

B. Financial Sector Landscape

4. The financial sector is dominated by banks. Banks account for 52 percent of financial sector assets at 239 percent of GDP. Insurance companies (59 percent of GDP) and non-money market investment funds are the two largest NBFI sub-sectors. Captive financial institutions[2], although large, (417 billion as of 2022Q2) have limited links with the financial system and their share in the financial system has decreased. However, the overall structure of the financial system since the previous FSAP has not changed materially. Total assets of pension funds are 40 billion at end-2022. Outstanding debt securities (mostly government) are approximately 140 percent of GDP. The market value of listed shares is about 50 percent of GDP (Figure 5).

[2] CFIs (e.g., nonfinancial holding companies, corporate treasury centers) are established by international companies to benefit from tax advantages in Belgium.

Figure 5. Belgium: Structure of Financial Sector



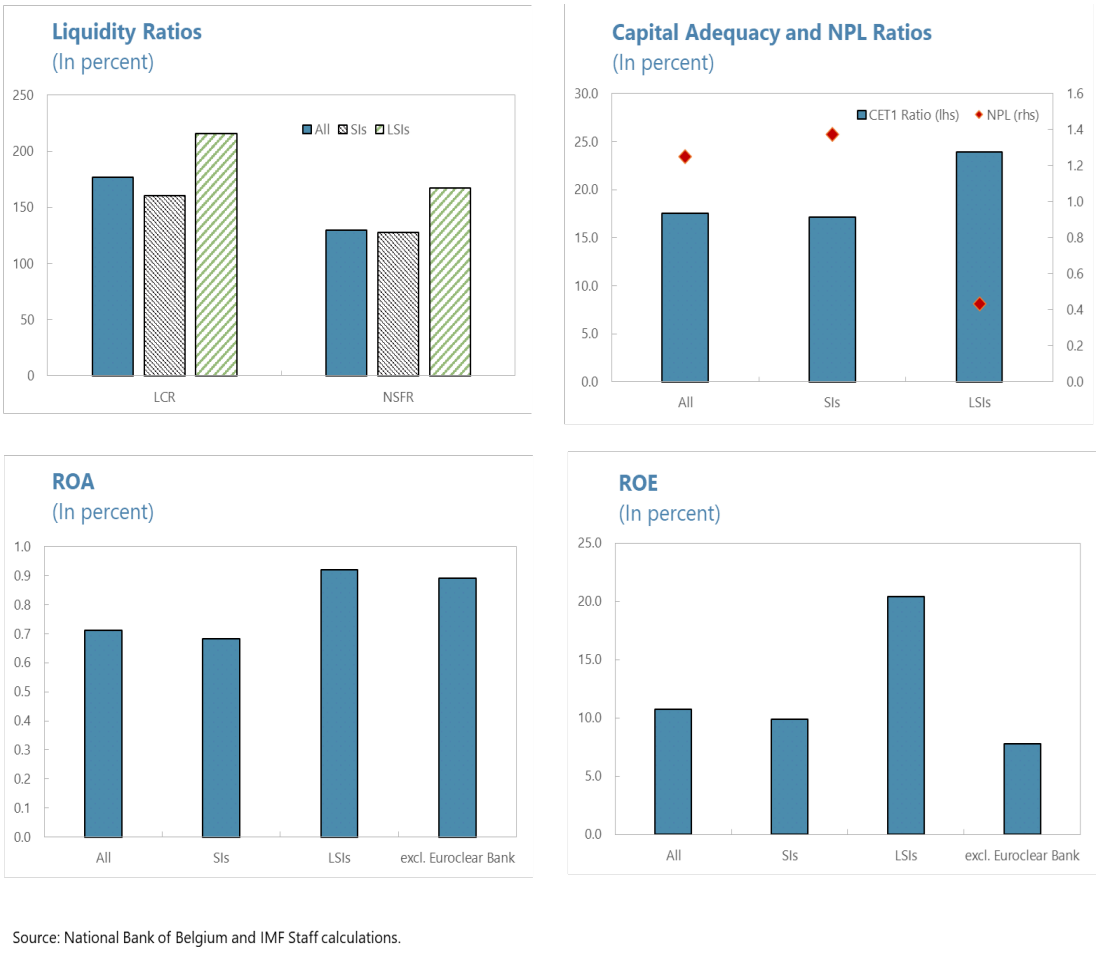
Sources: National Bank of Belgium, Haver Analytics, IMF Staff calculations.
1/ Reflects face value of debt securities.
2/ Nominal GDP reflects rolling sum of 4 quarters.

5. The banking sector is highly concentrated, with high foreign bank presence. Currently, there are 30 domestic licensed credit institutions, 46 European Economic Area (EEA) and five non-EEA branches in Belgium. The four largest banks account for 73 percent of assets, and foreign ownership is 48 percent.[3] Ten banks with 78 percent market share are identified as Significant Institutions (SIs)[4] and are supervised by the Single Supervisory Mechanism (SSM). 16 Less Significant Institutions (LSIs), with a 3 percent market share excluding Euroclear Bank (EB), are supervised by the

[3] Includes foreign branches and subsidiaries.
[4] Excluding foreign branches, SIs' market share is 88 percent.

NBB with European Central Bank (ECB) oversight. While on average LSIs' capital adequacy and liquidity ratios stood higher than SIs at the end of year 2022, the group constitutes diverse banks with different business models (Figure 6). Generally, LSIs' profitability levels are higher compared to SIs. A few digital-only banks are small. Incumbents SIs' digitalization level is strong. New players in fintech emerged mostly in the payments area.

Figure 6. Belgium: Financial Indicators for SIs and LSIs, 2022 Q4



Source: National Bank of Belgium and IMF Staff calculations.

6. Some large banks are connected to insurers. Large banks offer insurance products through subsidiaries or within-group insurance companies, with a market share of 17 percent. The top ten insurers account for nearly 70 percent of premium income. The number of insurers has been declining mainly due to mergers and acquisitions. The market is dominated by composite insurers, complemented by some smaller specialized insurers. Derivatives exposures are concentrated among a few insurers. In general, duration gaps between assets and liabilities are small.

7. The investment funds with characteristics that might make them susceptible to runs[5], have assets of about 28 percent of GDP.[6] This sector is dominated by mixed funds exposed to several asset classes. Public open-ended investment funds (OEFs) are almost entirely plain Undertakings for Collective Investment in Transferable Securities (UCITS) sold to retail investors, with low leverage as well as limited exposure to derivatives and off-balance sheet activities. Non-public alternative investment funds are sold to institutional investors and non-financial corporations (NFCs). The sector has undergone consolidation and appears highly concentrated. Overall, there are signs of potential liquidity mismatches, as the liquidity offered to investors may be greater than the liquidity of the assets held, especially in the short term. Following the pandemic, almost all publicly offered OEFs have adopted liquidity management tools (LMTs).

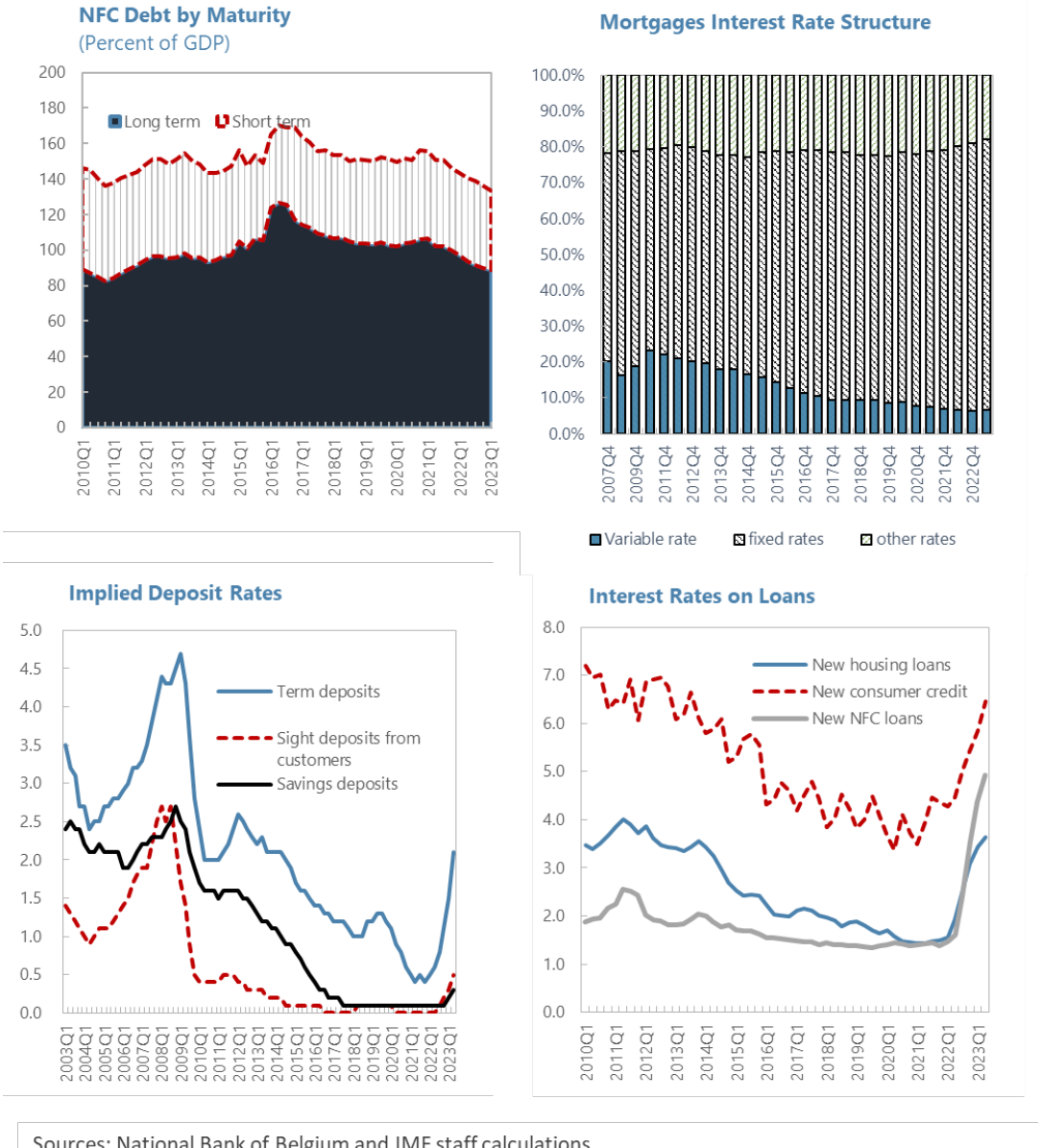
C. Financial Sector Vulnerabilities and Risks

8. Rapidly rising interest rates may pose financial sector challenges (Figure 7). Following the rise of monetary policy rates by the ECB, assets of banks have begun to reprice slowly as a considerable part of bank assets are in long-term fixed rate mortgages. Increases in deposit rates have remained rather modest, improving net interest margins. Pressure to raise the remuneration of deposits, the most important funding source of banks, will mount if depositors start searching for higher yields. Higher deposit rates would raise the funding costs of banks which are also being affected by the phase-out of the ECB's favorably priced liquidity facilities in June 2023. Available-for-sale and held-to-maturity (HTM) bonds are only a small share of total assets, curbing risks for the solvency position of banks. For insurers, investment in government (40 percent) and corporate (20 percent) bonds outside their unit-linked business are large, yet with limited exposure to interest rate risk due to small duration gaps. Holdings of loans, including long-duration mortgages, have risen, accounting for around twelve percent of total assets.

[5] These are Belgian funds that are included in the Economic Function 1 (EF1) based on the FSB classification.

[6] The asset under management (AuM) of Belgian investment funds susceptible to run risks and included in the stress testing exercise was approximately 153 EUR bn at end-2022. Non-Belgian investment funds are offered in Belgium, but those are not covered in the FSAP.

Figure 7. Belgium: Interest Rate Risks



Sources: National Bank of Belgium and IMF staff calculations.

9. Rising household debt is a key concern, also due to its links with housing market developments and substantial financial sector mortgage exposures. Household debt has risen from less than 40 percent to more than 60 percent of GDP over the past two decades, as mortgage lending has expanded. Residential mortgages feature prominently on the balance sheets of banks (a fifth of total assets, 55 percent of GDP) and, to a lesser extent, insurers (5 percent of investments). Riskier segments of mortgage lending with elevated loan-to-value (LTV) and debt service to income (DSTI) ratios may become vulnerable should the macro-financial environment deteriorate, particularly if unemployment rises steeply or the cooling of the housing market turns into a sharper correction. Several characteristics of housing and mortgage markets offer comfort. Real estate valuations remain lower than in peer economies, fixed-rate and fully amortizing mortgages are

widespread, and household financial positions appear strong due to a robust labor market, automatic wage indexation, pandemic excess savings and financial assets far surpassing liabilities. The NBB's prudential guidelines imposing tighter LTV and DS(T)I limits on housing loans originated by banks and insurances since 2020 and additional bank capital required against residential mortgage lending since 2013 have contributed to reduce financial sector risks from housing-related exposures.

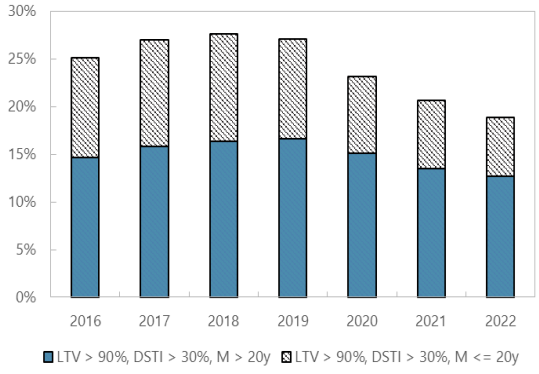
10. Corporate debt has remained comparatively stable, but pockets of vulnerability may emerge. Aggregate NFC debt, at more than 140 percent of GDP, is dominated by company-to-company lending, accounting for nearly 60 percent of the total.[7] The remainder has increased modestly over the past two decades and is characterized by a strengthening of credit quality since end-2019 despite a series of economic shocks (Figure 8). However, cost pressures from commodity market gyrations and automatic wage indexation have weighed on businesses while rising interest rates have raised the financing costs of firms, rekindling credit risk concerns, especially for corporates with weaker profitability and debt servicing capacity.

11. Banks and insurers are vulnerable to a turn in the CRE cycle. CRE markets in Belgium have shown less dynamism than in neighboring economies, as the rather steady prices of the (dominant) office segment have precluded a larger rise, yielding comparatively attractive valuations helped by comparatively low vacancy rates. However, within the euro area, the loan portfolio of Belgian banks is among the most exposed to CRE collateralized NFC lending, at 15 percent of GDP or more than a fourth of total NFC credit. While nearly three quarters of the outstanding stock of CRE exposures show LTV ratios of less than 60 percent, for more than a tenth they maintain a level of 80 percent and beyond. Among insurers, CRE accounts for 12 percent of the investment portfolio. A worsening of CRE market dynamics, driven by weaker economic activity and/or structural changes, may put some strain on the financial sector. Falling operating incomes of CRE may undermine the debt servicing capacity of borrowers and erode recoverable collateral values in case of default.

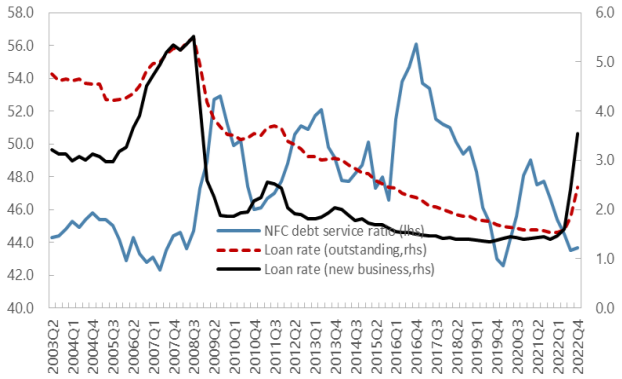
[7] The NBB considers that company-to-company lending has implied little to no macro-financial risks. Lending between entities of the same firm (intra-company) and by captive financial institutions is unlikely to be cut off as it would undermine parts of one and the same enterprise. At the same time, such activities are interacting with Belgian financial intermediaries only at the margin. Loans granted by the non-bank foreign sector may entail some refinancing risk.

Figure 8. Belgium: Households and Non-Financial Corporate Vulnerabilities

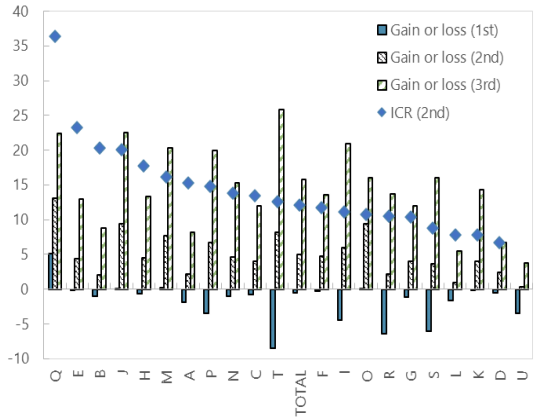
Mortgage Loan Stock at High LTV, DSTI, and Maturity at Origination
(In percent)



NFC Debt Service Ratio[1/] and Interest Rate
(In percent)



NFC Gain or Loss[2/] and ICR[3/] by Sector[5/]
(Quartile; 2021)



NFC Interest Payment to Income Ratio[4/]
(In percent)

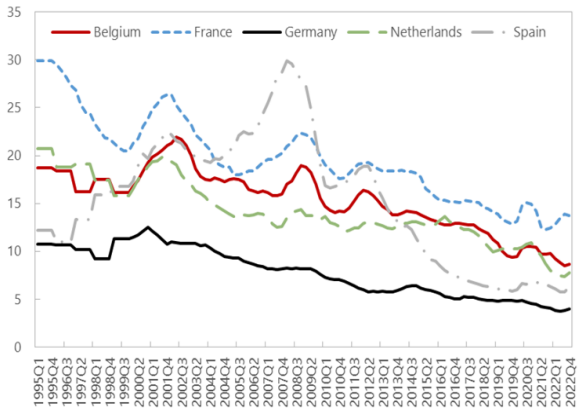
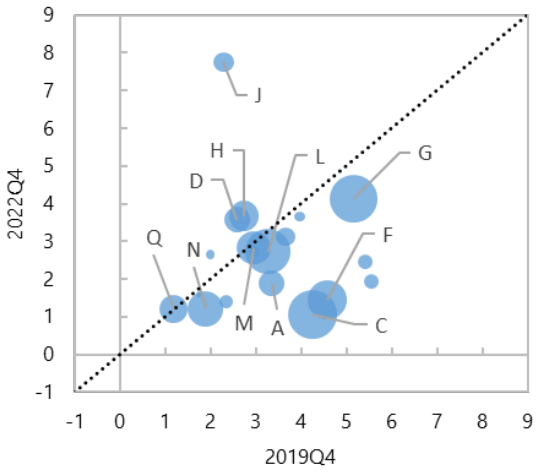


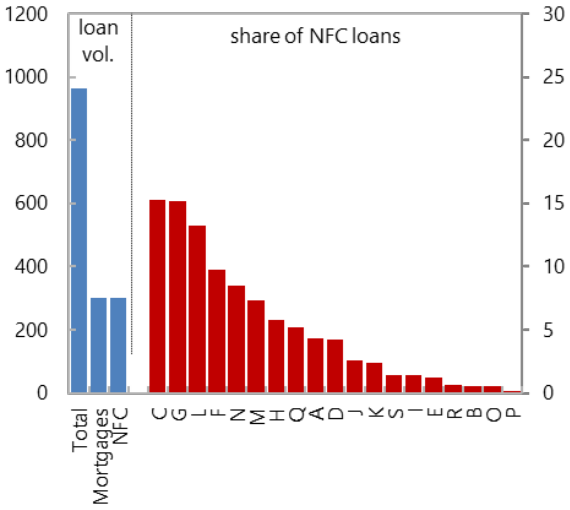
Figure 8. Belgium: Households and Non-Financial Corporate Vulnerabilities (Concluded)

NPL Ratios and Asset Exposures
(Axes: percentage points; bubble size: percent of total loans)



Source: EBA.
Notes: residential mortgages (RM), agriculture (A), manufacturing (C), construction (F), trade (G), transport and storage (H), hospitality (I), finance (K), real estate activites (L), professions (M), administrative and support services (N), health and social services (Q), entertainment (R).

Bank Loan Volumes and Sectoral Exposures
(2022Q4; LHS: EUR bn; RHS: percent)



Sources: EBA.
Notes: manufacturing (C), trade (G), real estate activities (L), construction (F), administrative and support services (N), professions (M), transport and storage (H), health and social services (Q), electricity and heating (D), agriculture (A), ICT (J), finance (K), other services (S), hospitality (I), water supply (E), entertainment (R), mining (B), public sector (O), education (P).

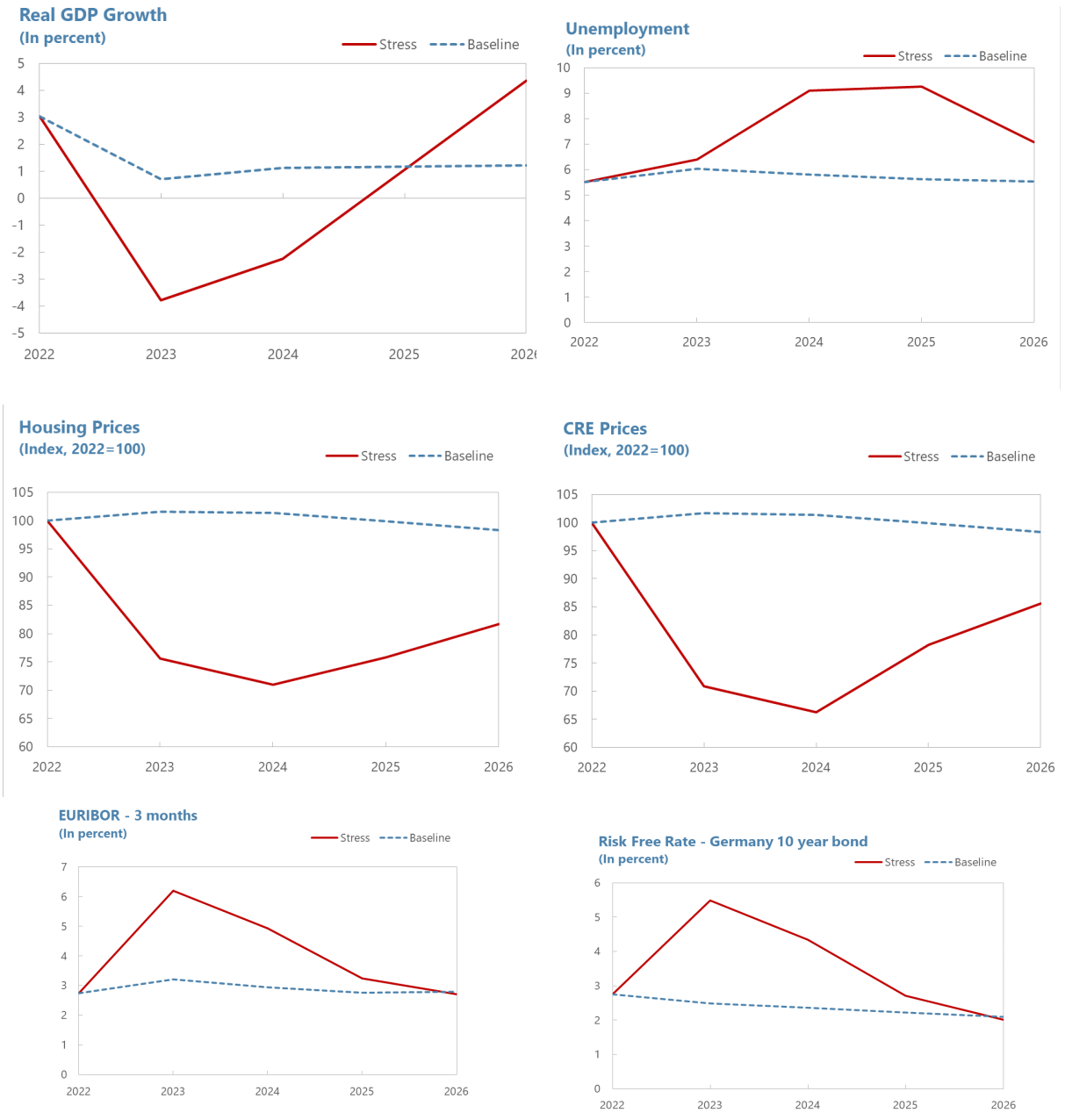
Source: NBB, BIS, IMF Systemic Risk Tracker, and IMF staff calculation.
Notes:
[1/] Debt service ratio is defined by debt service costs (interest payments and debt amortizations) as a proportion of income.
[2/] Gain or loss refers to gains or losses recorded in the accounting period, in % of total assets.
[3/] Interest coverage ratio is calculated as the EBITDA divided by financial charges
[4/] The ratio is defined by interest before FISIM Allocation over augmented gross disposable income
[5/] Manufacturing (C), trade (G), real estate activities (L), construction (F), administrative and support services (N), professions (M), transport and storage (H), health and social services (Q), electricity and heating (D), agriculture (A), ICT (J), finance (K), other services (S), hospitality (I), water supply (E), entertainment (R), mining (B), public sector (O), education (P), activities of households as employer (T).

D. Scenarios

12. The adverse scenario features the major risks in GRAM and some Belgium specific layers (Appendix I). A combination of global and idiosyncratic risk factors results in a significant economic downturn, with negative spillover effects across trade, financial channels, and markets. The intensifying repercussions of the Ukraine war exacerbate the energy crisis, disrupt supply chains, resulting in persistent inflation, and lead to subsequent monetary tightening (Figure 9, Table 2). These factors cause sharp fluctuations in real interest rates, risk premiums, and asset repricing, and lead to insolvency in weaker financial institutions, causing market dislocations and adverse cross-border spillovers. Despite some mitigation through fiscal support in advanced economies, the

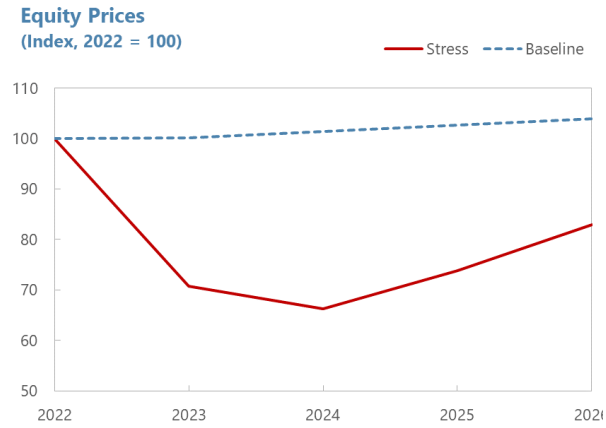
impacts remain significant. The scenario is simulated using the Global Macrofinancial Model (GMM), a structural macro-econometric model of the 40 largest economies (Vitek, 2018).[8]

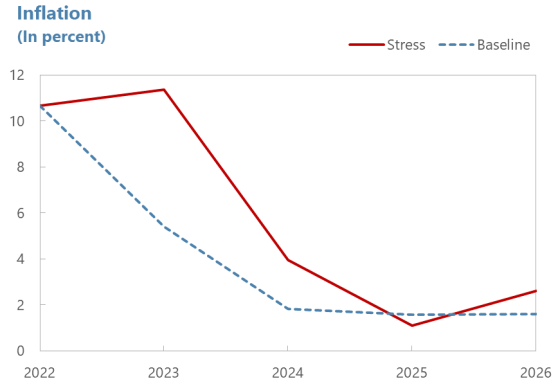
Figure 9. Belgium: Macroeconomic Scenario

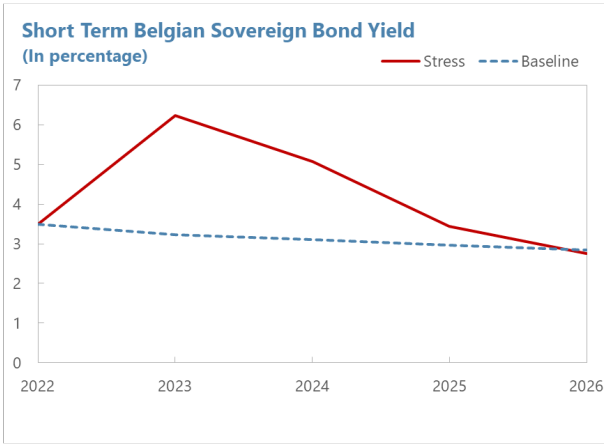


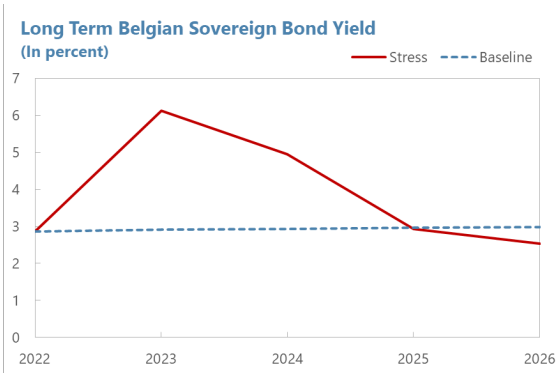
[8] Vitek, F. (2018), The Global Macrofinancial Model, *International Monetary Fund Working Paper*, 81.

Figure 9. Belgium: Macroeconomic Scenario (Concluded)









Source: IMF staff calculations.

Table 2. Belgium: Macroeconomic Scenarios

		2022	2023	2024	2025	2026
Real GDP growth (percentage)	Baseline	3.1	0.7	1.1	1.2	1.2
	Stress	3.1	-3.8	-2.2	1.1	4.4
Unemployment (percentage)	Baseline	5.5	6.0	6.0	5.6	5.5
	Stress	5.5	6.4	9.1	9.3	7.1
Inflation (percentage)	Baseline	10.3	4.7	2.1	1.7	1.8
	Stress	10.3	11.4	3.9	1.1	2.6
3 months EURIBOR (percentage, year average)	Baseline	2.8	3.2	2.9	2.8	2.8
	Stress	2.8	6.2	4.9	3.2	2.7
House Price Index (2022=100)	Baseline	100.0	101.6	101.4	99.9	98.3
	Stress	100.0	75.6	71.0	75.8	81.7
CRE Price Index (2022=100)	Baseline	100.0	101.6	101.4	99.9	98.3
	Stress	100.0	70.9	66.3	78.2	85.6
Equity prices (Index, 2022=100)	Baseline	100.0	100.7	101.8	103.0	104.3
	Stress	100.0	71.2	66.4	74.1	83.2
10-year German Sovereign Bond Yield (percentage)	Baseline	2.1	2.2	2.2	2.2	2.2
	Stress	2.1	5.4	4.2	2.2	1.8
10-year Belgian Sovereign Bond Yield (percentage)	Baseline	2.9	2.9	2.9	3.0	3.0
	Stress	2.9	6.1	5.0	2.9	2.5
1-year Belgian Sovereign Bond Yield (percentage)	Baseline	3.5	3.2	3.1	3.0	2.8
	Stress	3.5	6.2	5.1	3.4	2.8

Source: IMF staff calculations. The baseline numbers correspond to the April 2023 World Economic Outlook projections.

BANK SOLVENCY STRESS TEST

A. Overview

13. The FSAP solvency stress test is a top-down exercise that covers all seven SIs that cover over 90 percent of the banking sector assets. Five are domestic banking groups and two subsidiaries of large foreign banking groups. The exercise is based on the IMF's internally developed solvency stress-testing framework (see Appendix II for methodology). The stress test includes a comprehensive set of risks, including, market risk (equity, foreign exchange (FX), commodities, and interest rate risk), and income projections. The stress test was conducted using supervisory data for Q4 2022 provided by the SSM. Satellite models were estimated using aggregate data provided by the National Bank of Belgium.

B. Balance Sheet Projections

14. A quasi-static approach is used for the growth of banking and trading books over the scenario horizon. Asset allocation and the composition of funding remain the same, while balance sheets, which are based on total net assets, grow in line with the nominal GDP path specified in the scenario. To prevent banks from deleveraging, a floor on the rate of change in the balance sheet is

set at zero percent. Balance sheet growth is estimated at a bank specific level, using the weighted average GDP growth of all countries where the bank has significant exposure. Other factors affecting balance sheet growth are the revaluation of assets in accordance with foreign exchange movements, and the conversion of a proportion of off-balance sheet items (i.e., credit lines and guaranties) to the balance sheet.

C. Credit Risk

15. Credit risk is an important component of solvency stress testing. It is associated with domestic and cross-border household lending, corporate lending, sovereign lending, corporate bonds, financial institution bonds and sovereign bonds in the banking book (measured at amortized cost (AC)), and corporate bonds, financial institution bonds, and sovereign bonds in the trading book, measured at fair value through other comprehensive income (FVOCI).

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

Probabilities of Default Estimation

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

18. NPL ratios have been projected using an econometric model (Appendix III). NPL ratio is projected in quarterly frequency and the projections are annualized (Figure 10). The macrofinancial variables that provided the best fit are unemployment, property prices, and real GDP growth. Historical NPL ratios are available at an aggregate level only (without a separation between mortgage lending, other consumer lending, corporate lending etc.); and so, an adjustment of aggregate NPL ratios to different banks and different types of lending is implemented through the Bayesian rule. Specifically, when NPL_t is the NPL ratio at time t of the scenario, LE^A_0 is the proportion of the lending exposures of bank A over the total lending exposures of the banking sector at time 0, and $NPLE^A_0$ is the proportion of non-performing lending exposures of bank A over the total non-performing lending exposures of the banking sector at time 0, then the NPL ratio for bank A at time t is:

$$NPL_t^A = NPL_t \frac{NPLE_0^A}{LE_0^A} \quad (1)$$

Likewise, from equation (1), when $LE^{A,M}{}_0$ is the proportion of the mortgage lending exposures of bank *A* over the total lending exposures of the bank *A* at time 0, and $NPLE^{A,M}{}_0$ is the proportion of non-performing mortgage exposures of bank *A* over the total non-performing lending exposures of bank *A* at time 0, then the mortgages NPL ratio for bank *A* at time *t* is:

$$NPL_t^{A,M} = NPL_t^{A,M} \frac{NPLE_0^{A,M}}{LE_0^{A,M}} \quad \textbf{(2)}$$

19. NPL ratios for other types of lending are estimated in the same way. A separation of NPLs between secured lending and unsecured lending is not available neither historically, nor at time 0, so a distinction between secured and unsecured credit provision is derived through LGD modelling.

Figure 10. Belgium: Annual NPL Projections

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

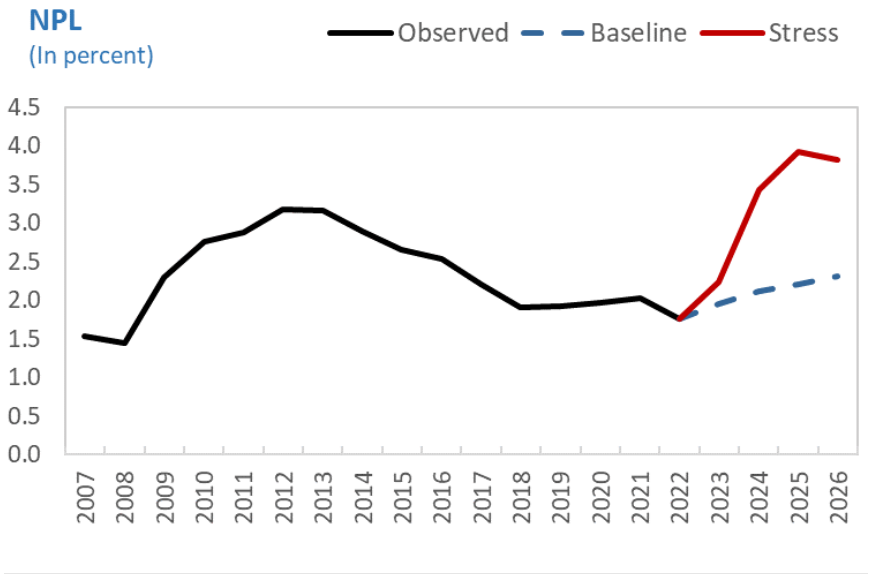
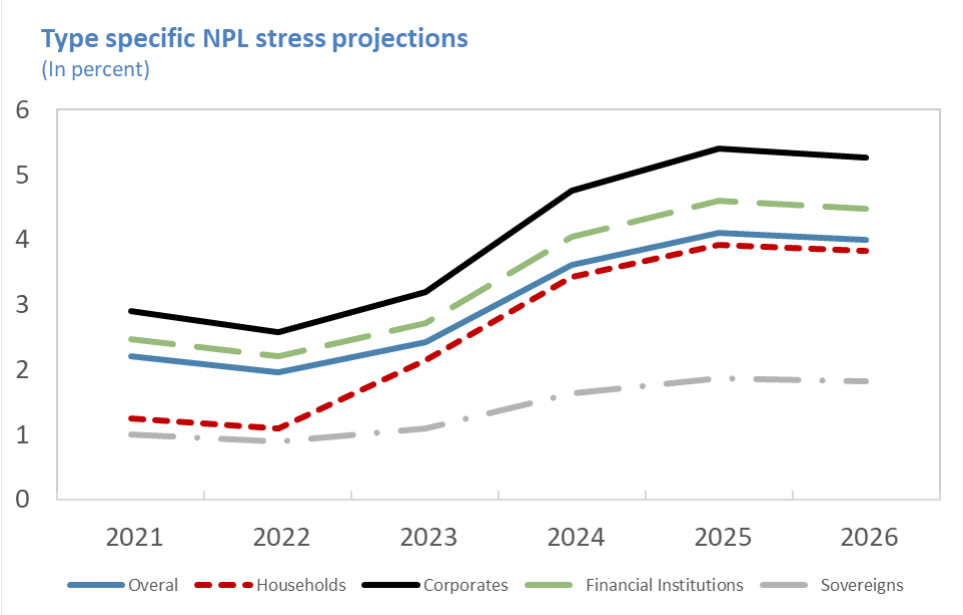


Figure 10. Belgium: Annual NPL Projections (Concluded)



Source: IMF staff calculations.

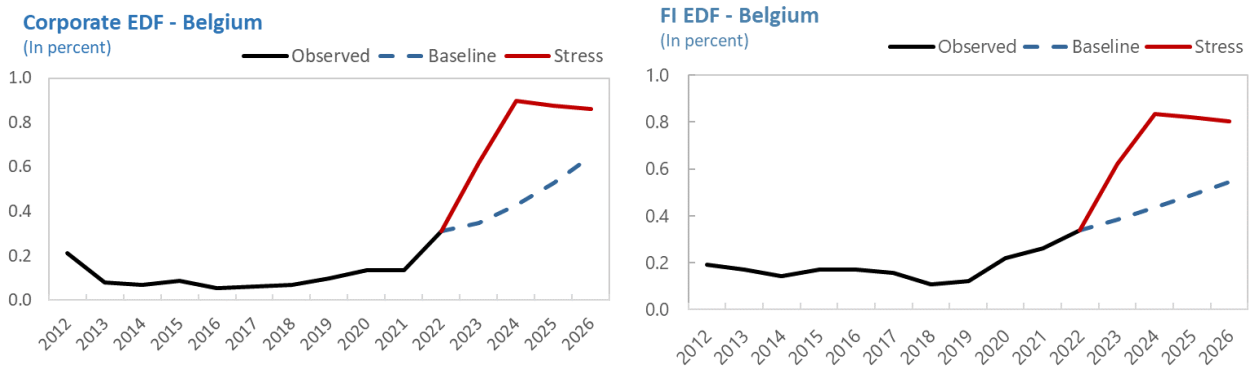
20. Lending probabilities of default (PD) are derived through the respective NPL ratio projection (Serwa, 2016). The cross-border household NPL ratio is assumed to follow the same growth path as the domestic NPL ratio. For small and medium enterprise (SME) lending, PDs are derived through the corporate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

21. For large domestic corporate lending, and lending to financial institutions, two independent PD paths are projected (Figure 11). The first path is informed by the NPL ratio projections outlined earlier. The second path uses a panel model, integrating average expected-default-frequency (EDF) data obtained from Moody's. This model is sensitive to country-specific macro-financial variables, namely real GDP growth and sovereign spreads (Appendix IV). The latter technique provides average corporate EDF projections for Belgium and ten other countries where Belgian banks have notable exposures. These countries include the Czech Republic, France, Germany, Italy, Luxembourg, Netherlands, Slovakia, Türkiye, UK, and USA. Following the individual derivation of the two PD paths—the NPL-based PDs and EDF-based PDs—we then integrate them into a singular PD using linear programming (referencing methodologies from Reeves and Lawrence, 1991; Lam et al., 2001; Panagiotopoulos, 2012).

22. For lending to financial institutions, both domestic and cross-border, a similar strategy is utilized. PDs are projected via a panel model using the average EDF for financial institutions, with the output gap as the defining macro-financial explanatory variable. We also extend the use of these EDF-based PD projections to all debt securities classified as amortized cost (AC) and fair value through other comprehensive income (FVOCI). Lastly, for sovereign debt securities, we derive probabilities of default from the respective spread paths of sovereign bonds under the baseline and stress scenarios. This approach aligns PDs with potential future economic conditions.

Figure 11. Belgium: Annual EDF Projections

Similar projections have been estimated for Czech Republic, France, Germany, Italy, Luxembourg, Netherlands, Slovakia, Türkiye, UK, and USA. Satellite models and projections are estimated on a quarterly basis. Charts are presented on an annual basis, as implemented in the stress test exercise.



Source: IMF staff calculations.

23. All PD paths, which are not derived from NPL ratios, are estimated on aggregate level, and they are adapted to bank specific PDs through formula (3):

$$PD_{it} = N\big(G(PD_{i0}) + G(aPD_t) - G(aPD_0)\big) \quad (3)$$

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

Loss Given Default Estimation

24. Loss given default (LGD) rates for collateralized lending are calibrated through structural modelling. It uses reported information on the value of collateral (loan to value, (LTV)), starting point reported LGDs, and property price paths. LGD for unsecured lending is calibrated through the Frye-Jacobs method (Frye and Jacobs, 2012). Both secured and unsecured LGDs have been calibrated at the bank-specific portfolio level. Notably, under the adverse scenario, the substantial decline in property values materially affects the LGD of secured lending. This, in turn, has a consequential impact on the credit risk charges associated with mortgage lending.

Risk Weighted Assets Estimation

25. In the calibration of risk weighted assets (RWAs), standardized (STA) and internal ratings-based (IRB) portfolios have been differentiated. RWAs change due to balance sheet growth, new provisions for credit losses, exchange rate movements, and the triggered portion of off-balance sheet items. For IRB portfolios, the Asymptotic Single Risk Factor (ASRF) model for

unexpected losses is implemented for different types of exposures (according to Basel III). Regulatory through-the-cycle (TTC) Probabilities of Default (PD) are calibrated through the scenario point-in-time (PiT) projections, using a smoothing parameter recommended by the Belgian authorities, and regulatory downturn (DT) LGD is considered as the maximum between the reported DT LGD at period 0 and the estimated PiT LGD.

D. Market Risk

26. Solvency stress tests assess the resilience of banks when facing different sources of market risk, specifically, interest rates, exchange rates, and equity prices. The assessment of market gains and losses pertaining to the derivatives portfolio is not adequately calibrated due to a deficiency in access to detailed data. Consequently, this limits the precise valuation and risk assessment of the derivatives, thus precluding a substantial stress testing of the derivatives portfolio. Market risk losses have an impact on both capital resources, either via profit and loss or via other comprehensive income, and capital requirements. The impact on capital resources will include positions in the trading book as well as other fair valued items in the banking book. The impact on RWAs for market risk evolves with balance sheet assumptions.

27. Market valuation losses correspond to holdings of debt securities (sovereigns, financial institutions, and large corporates) are estimated using a modified duration approach. The current average modified duration of the debt portfolio has been provided by the EBA transparency exercise. The analysis focuses on trading book debt securities measured at fair value, with the change in fair value recognized either in FVPL or in FVOCI. The HTM portfolio (AC) has been stressed in the same manner, but the resulting estimated unrealized losses were not integrated into the solvency stress test; instead, they have been utilized in the forthcoming solvency-liquidity interaction analysis.

28. Debt securities are subject to three shocks: yield shocks, FX position, and risk-free rate. Modified duration for every year of the scenario is estimated through formula (4):

$$MD_t = \frac{MD_{t-1}}{1 + \Delta spread_t + \Delta risk\_free_t} \quad \textbf{(4)}$$

The change in the value of a security is calculated through formulae (6), (7), and (8)

$$percent\Delta FV_t^{credit\ spread} = -MD_t \times \Delta spread_t \quad \textbf{(5)}$$

$$percent\Delta FV_t^{risk\ free} = -MD_t \times \Delta risk\_free_t \quad \textbf{(6)}$$

$$FV_t = FV_{t-1}\left(1 + percent\Delta FV_t^{credit\ spread} + percent\Delta FV_t^{risk\ free}\right) \quad \textbf{(7)}$$

where, percentΔFV$^{\text{credit spread}}$ and percentΔFV$^{\text{risk free}}$ are the percentage changes in FV due to credit spread and risk-free shocks respectively.

29. Spreads are projected through satellite models that are constructed on aggregate historical data on debt securities held by Belgian banks, provided by the NBB (Figure 12). Despite efforts to link the average spreads for different types of debt securities with the scenario's macrofinancial variables, such a connection proved elusive. Thus, we resorted to employing linear autoregression time-series models to simulate potential paths under multiple scenarios. The outputs of these simulations serve as the basis for the spread projections. Within these simulations, the average path is taken as the baseline projection, offering a representative view of potential outcomes. The stress projection, designed to provide insight into the impact of adverse conditions, is represented by the 85th percentile of the simulation results. The risk-free rate employed in the analysis is derived from the scenario (10-year Germany bond rate).

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

31. Market valuation losses for commodity, FX, and equity securities are estimated as the starting position of the securities multiplied by the change in the respective commodity prices, FX, and equity prices paths of the scenario. Specifically, the market impact from full revaluation of equity holdings was subject to a floor constraint in formula (8):

$$\Delta Eq = -0.3\ percent(Eq^{Long} + Eq^{Short}) \quad \textbf{(8)}$$

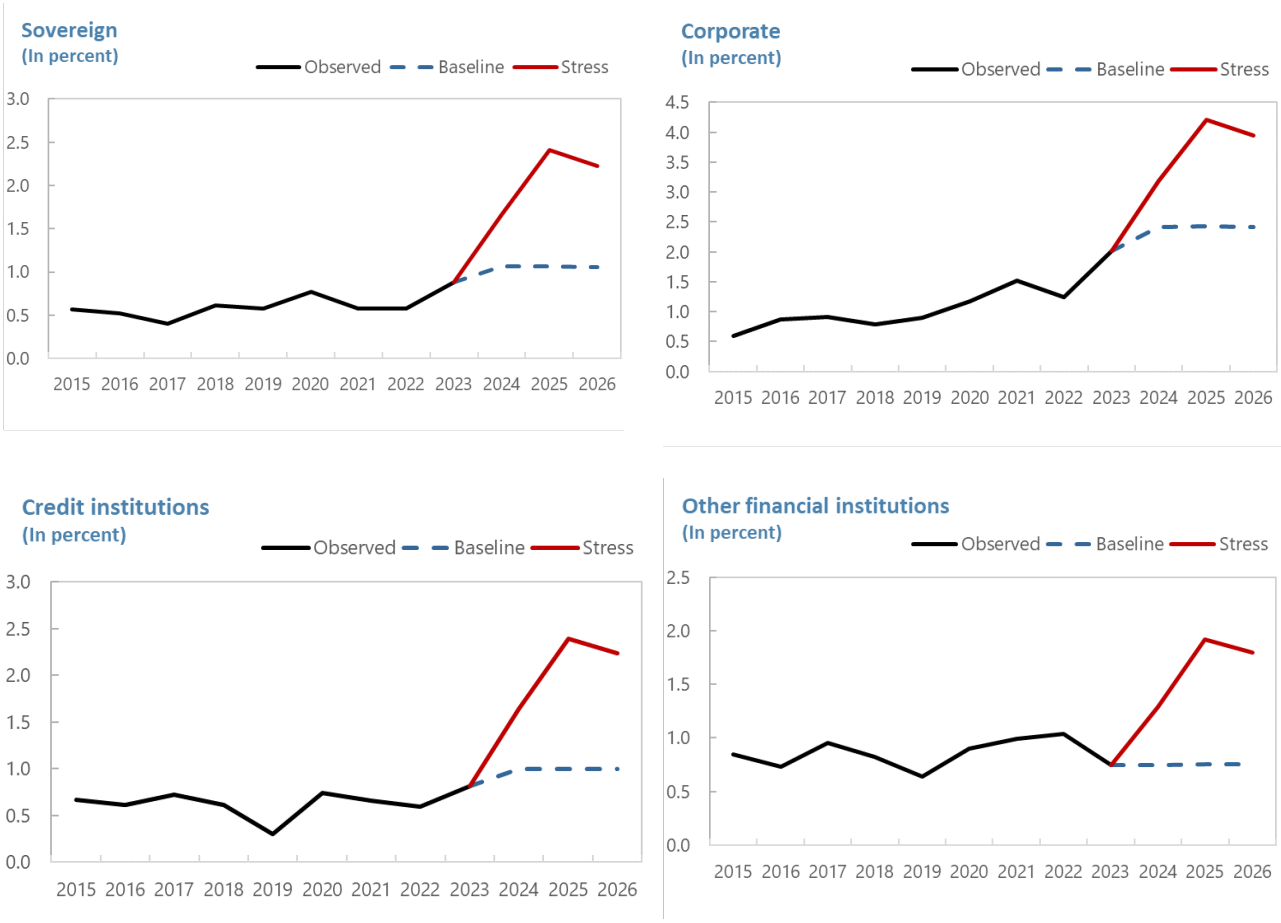
E. Net Interest Income

32. Bank interest rates on new business were estimated and used as the input for interest rate risk in the banking book (IRRBB). Time-series regressions, based on data provided by the NBB, are used to project aggregate funding and lending rates on new and variable-rate business (Appendix V).

33. Within these projections, historical interest rates for residential mortgages, unsecured consumer lending, and corporate lending are co-integrated. They are modeled via a Vector Error Correction Model (VECM), with EURIBOR operating as an exogenous variable (Figure 13).

Figure 12. Belgium: Annual Spreads Projection

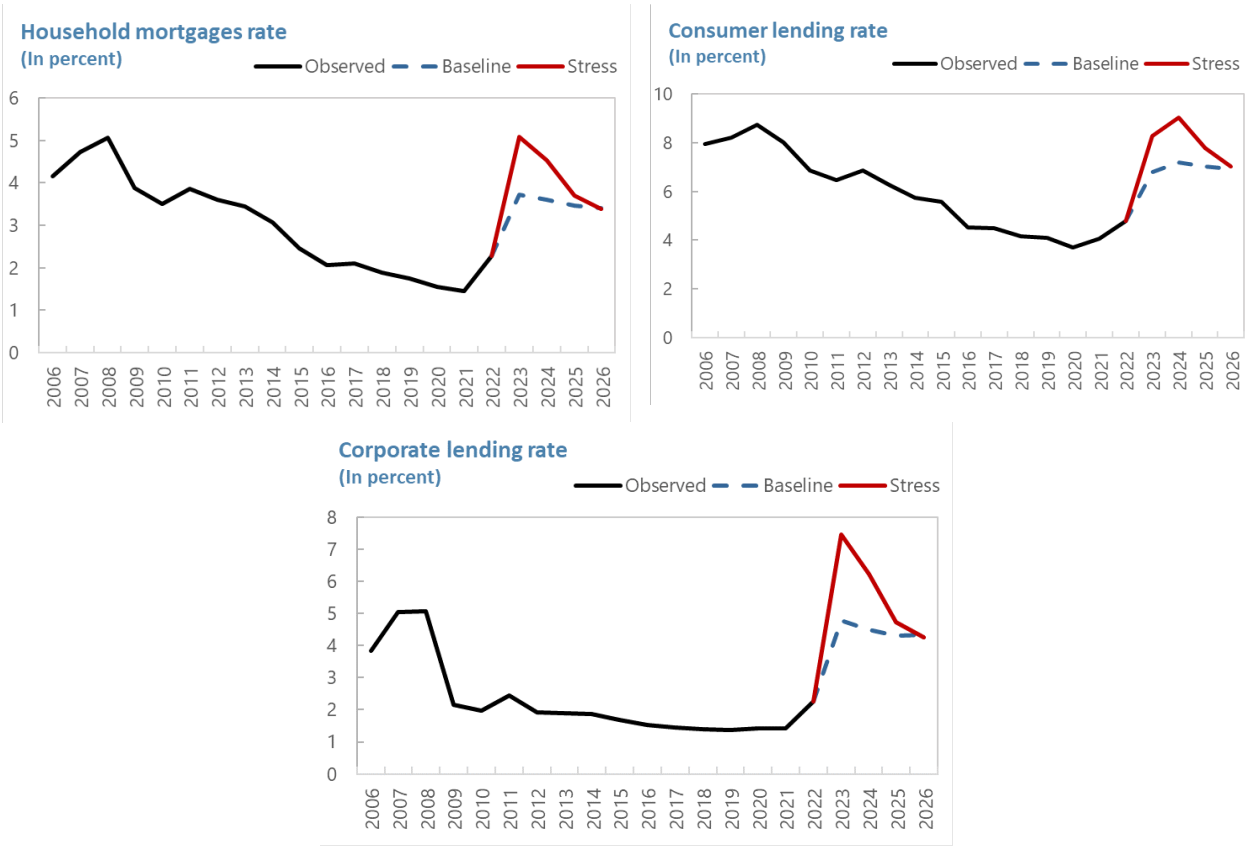
Actual satellite models and projections are estimated on a quarterly basis. Charts are presented on an annual basis, as implemented in the stress test exercise.



Source: IMF staff calculations.

Figure 13. Belgium: Annual Asset Rates Projections

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



Source: IMF staff calculations.

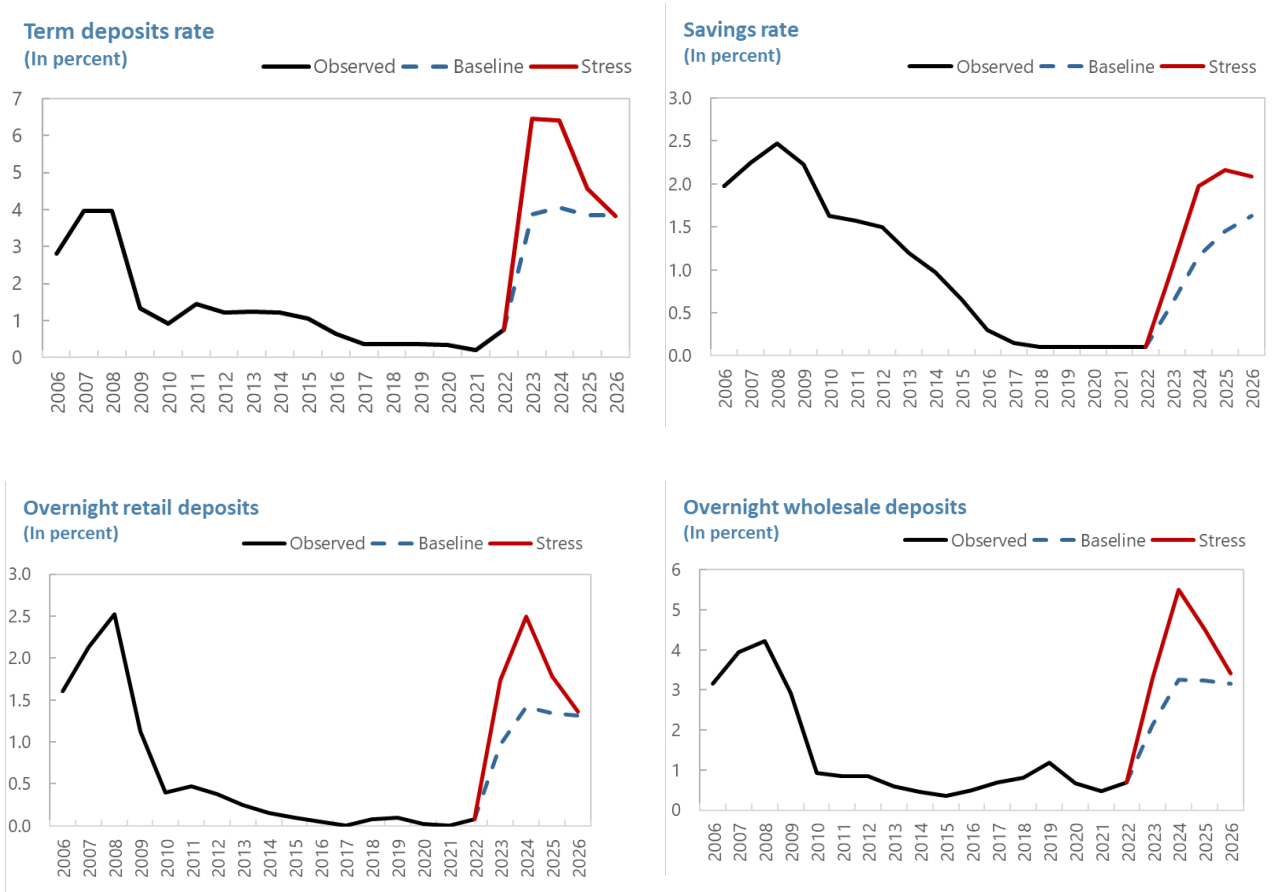
34. Simultaneously, single equation time-series estimations model interest rates for term deposits, retail overnight deposits, corporate overnight deposits, and savings, using EURIBOR as an independent variable (Figure 14). The results of these models enable us to project bank-specific interest rate paths, by appending the period changes of the aggregate rates in the forecast horizon to the bank-specific starting points.

35. These projected funding and lending rates are then mapped to banks' financial assets and liabilities. This is categorized by product and counterparty, employing the Short-Term Exercise (STE) IRRBB template. This template provides a bank-specific maturity ladder for fixed-rate instruments and repricing dates for floating rate instruments at the portfolio level for both assets and liabilities. The categories include generic products related to debt securities and performing loans and advances on the asset side. On the liabilities side, they encompass retail and wholesale overnight and term deposits, repos, and debt securities.

36. The effective funding costs, covering all types of liabilities and integrating a repricing structure, are also considered. The pricing of repos, for instance, aligns with changes to the EURIBOR. Interest rate projections are associated with both the baseline and adverse scenario. Retail and wholesale deposit funding is repriced in accordance with the satellite models' output. Derivatives can be both net interest receivers and payers. However, their proportion to the total interest bearing assets and liabilities is small, and they do not play a pivotal role in adjusting interest income and expense in response to scenario-driven yield shifts. Finally, the yields of new debt securities evolve based on the scenario projections of the risk-free rate (10-year Germany bond).

Figure 14. Belgium: Annual Liabilities Rates Projections

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



Source: IMF staff calculations.

37. On the interest income side, effective lending rates are applied for the entire range of interest-bearing assets, keeping in mind the repricing structure. Only performing loans are considered. The weighted average of lending rates is used to project interest rates on these

performing loans. Lending rates on consumer loans, mortgages, and non-financial corporates are weighted by their respective notional amounts as of December 2022 to produce the forward paths. Like liabilities, the yields of debt securities evolve following the scenario projections of the risk-free rate.

F. Non-Interest Income and Other Projections

38. Non-interest income (non-II) is projected based on a Monte Carlo simulation (Figure 15). This is because non-II includes many components that are not dependent on macro-financial variables. The parameters of the Monte-Carlo simulation are based on the observed historical trend and volatility of bank specific non-II data. 10,000 alternative non-II paths are projected. The average of the paths is used as a projection for the baseline, and the path in the 10th percentile is used for the adverse scenario to provide a more conservative estimate for the stress. Finally, both the baseline and stressed non-II projections have been adapted to nominal GDP growth, in line with the balance-sheet growth rule.

39. Other expenses in Profit and Loss and the rest of Other Comprehensive Income (OCI) that is not derived from the market risk analysis — rest Other Comprehensive Income (rOCI) — are projected as an average of the last 10 years (excluding 2020 due to the pandemic), weighted by total assets. Other expenses are -79 bps of total assets, and rOCI -10 bps of total assets.

40. Income tax is estimated at a fixed rate when profit before tax (PBT) is positive (without counting OCI). The tax rate is set at 25 percent. The expected rate of dividends for each bank has been assigned according to the information provided by the NBB. A rule has assigned that fixed rate of dividends is distributed if both profit after tax (PAT) and total comprehensive income (TCI) are positive. An upper threshold has been assigned, where total dividends cannot be greater than the TCI of the bank in the same year.

G. Results

41. Banks appear to be resilient to severe macrofinancial shocks. All banks meet the Pillar I capital adequacy requirements over the stress testing horizon. In the baseline, the aggregate CET1 capital ratio is on an upward trajectory due to banks' revenue-generating capacity from the gradual increase in base rate, as well as low credit impairments. The system's aggregate CET1 capital ratio would increase from 18.3 to 22.4 percent between 2022–26.[9]

42. In the adverse scenario, the aggregate CET1 capital ratio declines by 4.3 percentage points to 14 percent at end-2026. Banks record weakened profits in the first year of the scenario on average (ROA drops from 58bps in year 0 to 28bps in year 1), but they record losses in the rest three years of the scenario. The decline in the capital ratio is mainly a result of credit impairments. All banks meet the minimum capital requirements, but one bank does not meet their Capital Conservation Buffer/Other Systemically Important Institutions Buffer (CcoB/O-SIIB).

[9] The dividend ratio in banks that record profits is assumed constant, i.e., the bank-specific historical average dividend ratio; however, in cases were banks record higher profits, a higher dividend ratio could have been considered, which would have resulted more moderate increase in regulatory capital over the course of the baseline scenario.

43. Credit impairments and provisions in Profit and Loss (PnL) are key factors underpinning profitability depreciation in the adverse scenario (Figure 15). Four-year cumulative credit impairments are 108.3 percent of starting CET1 capital by end-2026. Under the baseline scenario, cumulative four-year impairments are 48.9 percent of starting capital. Most credit risk impairments are recorded during the last three years of the scenario. The bulk of these impairments originates from mortgage lending, which constitutes the largest lending category in the system. This is compounded by the considerable shock in property prices depicted in the scenario, exacerbating the impact on this specific sector.

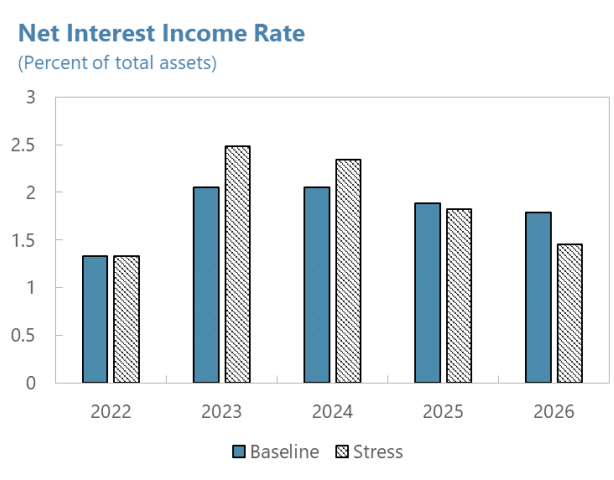
44. The sharp increase in the interest rates in the adverse scenario allows banks to compensate with high net interest income (NII) (Figure 15). The average NII over total assets in the adverse scenario rises to 2.4 percent by end-2023 when the average 3-months EURIBOR in the scenario increases to 6.2 percent. In the baseline, it is 2.1 percent at end-2023, where the average 3-months EURIBOR during the year is 3.2 percent. NII increase is not uniform across banks and largely depends on the Asset and Liability Mismatch. The average annual risk-free rate increases from 2.1 to 5.4 percent in 2023 and it drops to 1.8 percent at the end of the stress scenario. The average NII ratio in the adverse scenario drops to 1.5 percent at end-2025 due to the decrease in the base rate and the risk-free rate remains high.

45. Market risk losses are high during the first year of the adverse scenario, but they fall during the other years of the scenario (Figure 16). While they contribute negatively to profitability and capital, they are not the main drivers of the results of the bank solvency analysis. Four-year cumulative losses are 0.9 percent of starting CET1 under stress, versus losses of 0.2 percent in the baseline. Stressed non-interest income is lower than in baseline, but it remains positive on average.

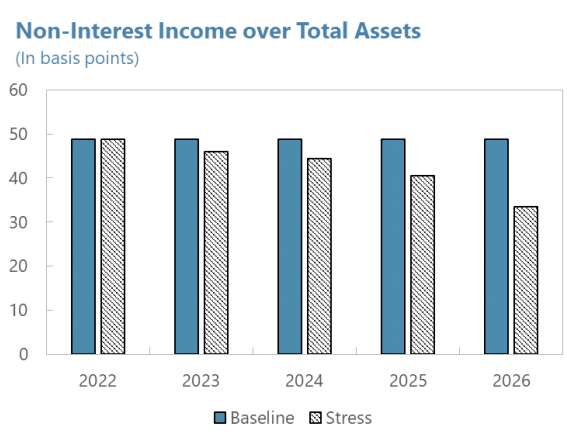
46. The elevation in credit provisions and impairments across the seven banks is not entirely homogeneous. The extent of variability appears to hinge on the average LTV ratio pertinent to each bank's secured lending, and the specific composition of their lending portfolios. Contrastingly, market losses exhibit a more consistent pattern across the banks, with limited divergence noted in this regard.

Figure 15. Belgium: Risk Projections

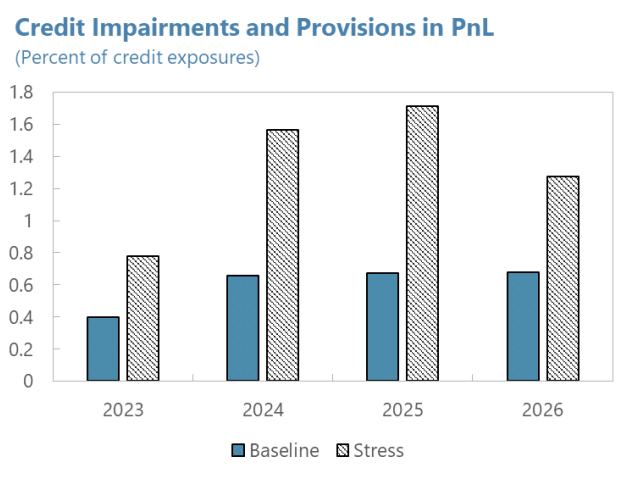
The sharp increase in the interest rates in the adverse scenario allows banks to compensate with high NII. NII to total assets peaks in 2023 at 2.4 percent in the stress scenario.



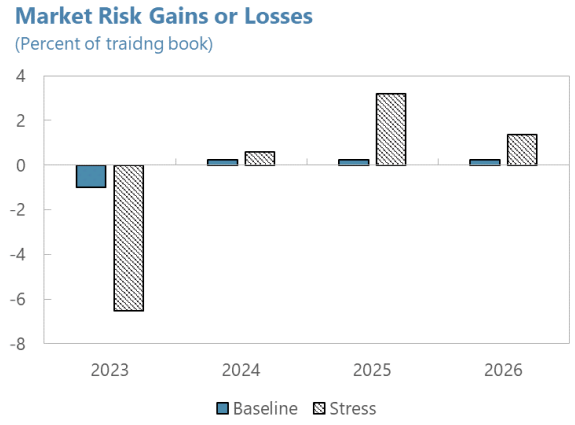
Aggregate Non-II follows a slight decreasing trend. Although, its impact on the results is low.



Credit impairments and provisions in the PnL are a key factor underpinning the profitability depreciation in the adverse scenario. Impairments to credit exposures peaks in 2025 at 1.7 percent.



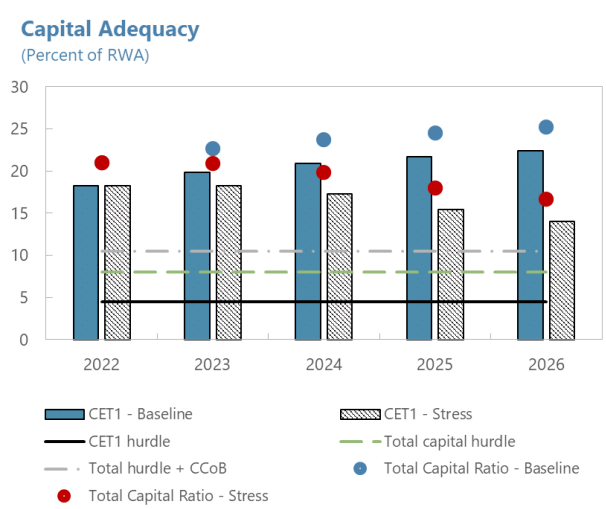
Market risk losses are low. Losses over total trading book peak in 2023 at 0.9 percent under the baseline scenario, but they slightly recover during the course of the scenario..

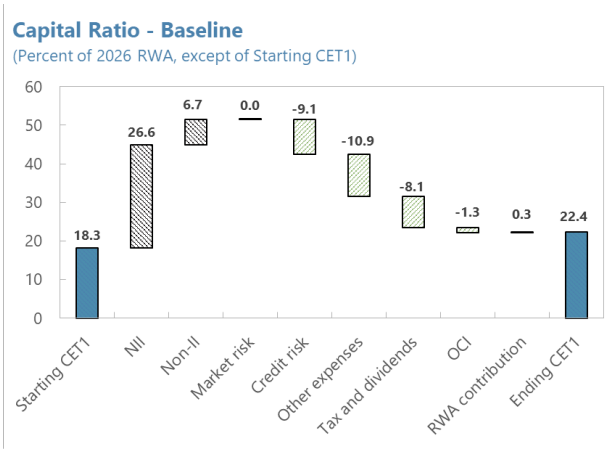


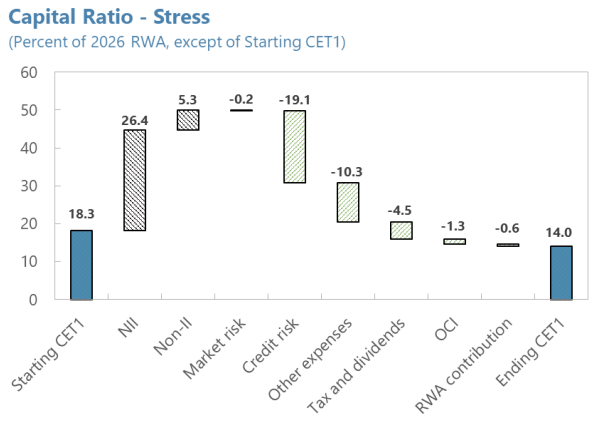
Source: IMF staff calculations.

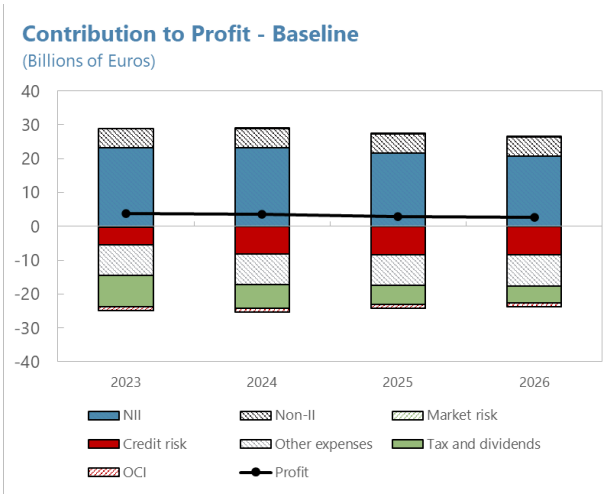
Figure 16. Belgium: Solvency Stress Test Results

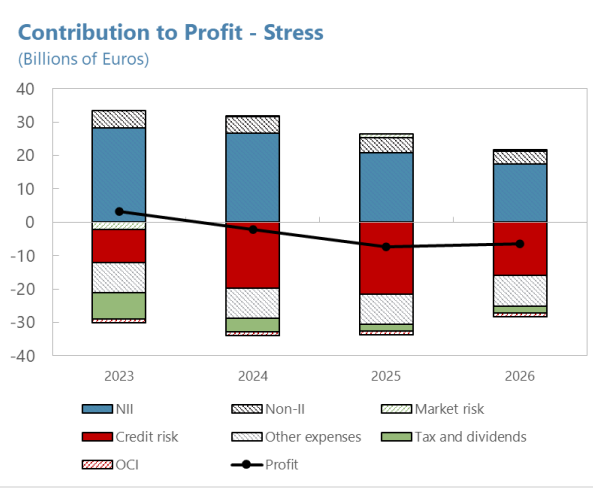
- ***Capital adequacy:*** *All banks have been highly capitalized at the start of the stress test. CET1 sufficiently covers the minimum capital requirements, and it continues to be sufficient during both scenarios. In the adverse scenario, capital decreases until 2026.*
- ***Capital flow:*** *During the stress scenario, the most important factor that contributes to the overall decrease of the capital ratios is credit impairments.*
- ***Contribution to profit:*** *The main factor that weakens profitability during the stress is the increase in credit impairments. This is counterbalanced by the increase in the NII.*











Source: IMF staff calculations.

H. Sensitivity Analysis

Scope

47. The solvency stress test analysis projections indicate a significant increase in NII during the stress scenario, primarily driven by a sharp rise in interest rates. To further investigate this, a sensitivity analysis has been conducted. This analysis introduces two specific scenarios: the "20 percent transition" and the "50 percent transition". These scenarios, that add an additional layer on top of the adverse scenario, are designed to explore the potential effects of different depositor responses to the climbing interest rates in the stress-induced environment.[10] For this analysis, identical pass-through rates as utilized in the NII projection of the primary solvency exercise have been employed.

48. In the "20 percent transition" scenario, we postulate a condition where 20 percent of the bank's non-term deposits migrate to term deposit accounts. This situation seeks to offer insights into the resilience of the banking sector and the potential shifts in NII and capital adequacy measures when a moderate proportion of depositors choose to relocate their holdings to term deposit accounts.

49. Conversely, the "50 percent transition" scenario models a more extreme circumstance, wherein half of the non-term deposits transition to term deposit accounts. By simulating this significant shift in depositor behavior, we aim to understand how the banking system would react and how its financial situation might be impacted in response to these changes.

50. For both scenarios, we maintain the same credit losses and market losses as observed in the main stress scenario. This approach ensures that the comparative implications of the transitions are clearly discernible, isolating the effects of potential changes in depositor behavior on the financial soundness of the banks. The conclusions drawn from this sensitivity analysis aim to supplement our understanding of the banks' potential responses under different stress conditions, ultimately informing our regulatory recommendations and strategies for the supervision of the banking sector.

Results

51. In the "20 percent transition" scenario, the CET1 ratio follows a downward trend over the four years of the stress scenario, decreasing to 13.1 percent in the final year (Figure 17). Simultaneously, the NII over total assets shows a decreasing trajectory from 2.3 percent in year one to 1.4 percent in year four. The return on assets (ROA) similarly shows a reduction, moving from 0.3 percent in the first year to -0.6 percent by the fourth year. It's important to note that under this scenario, one bank was unable to meet the minimum CET1 requirements by the fourth year.

52. The cause for this shortfall can be primarily attributed to the significantly elevated rates observed for term deposits in year zero, which continue to rise throughout the stress period. However, non-term deposits, despite being the primary source of funding for Belgian banks, recorded rates that were essentially null in the initial year. The escalation of their rates during the

[10] The March 2023 episode of banking sector turmoil saw increased mobility of bank deposits.

stress scenario was not commensurate with the rates observed for term deposits, thereby contributing to the declining trends mentioned above.

53. In the "50 percent transition" scenario, the CET1 ratio experiences a more substantial decrease over the four years, declining to 11.5 percent in the final year (Figure 17). NII over total assets shows a decrease from 2.0 percent in the first year to 1.4 percent in the fourth year. The ROA turns negative from the second year onwards, with the values ranging from -0.1 percent to -0.6 percent in the fourth year. Like the "20 percent transition", the same bank was unable to meet the minimum CET1 requirements by the fourth year.

54. The sensitivity analysis results depict a clear trend of decreasing profitability and capital adequacy ratios in both transition scenarios (Figure 17). This signals the significant impact of deposit behavior change and the consequent shifts in the banks' asset-liability management structures, demonstrating the necessity of incorporating such depositor behavior considerations into stress testing exercises. The observations further underline the importance of supervising and managing such risk factors to ensure the continued stability of the banking sector.

Figure 17. Belgium: Sensitivity Analysis Results

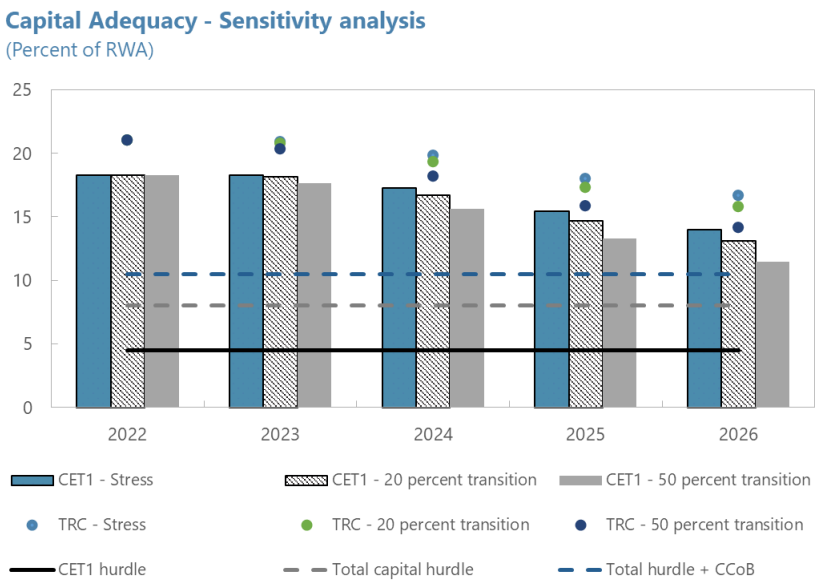
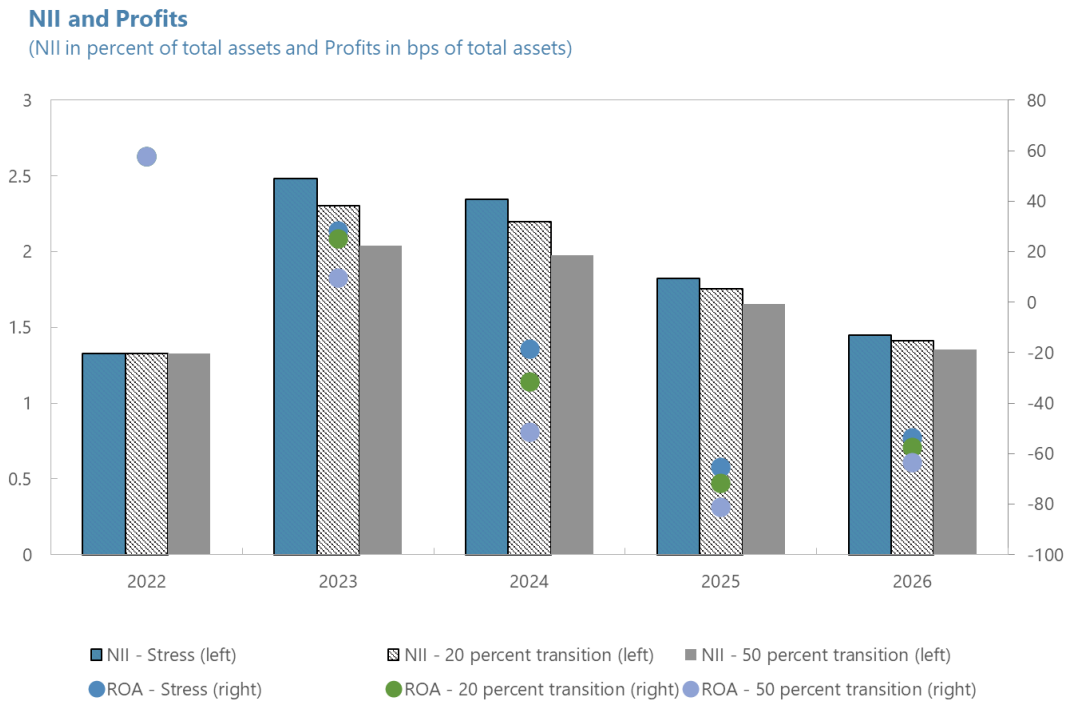


Figure 17. Belgium: Sensitivity Analysis Results (Concluded)



Source: IMF staff calculations.

I. Recommendations

55. Based on the banking solvency analysis, the FSAP makes the following recommendations to the NBB:

- **Strengthen the General Stress Testing Framework:** The primary recommendation is to augment the current stress testing framework to better integrate all the distinct models, focus on different areas of risk (e.g., credit risk, NII), thereby providing a more holistic understanding of their cumulative impact on banks' profitability and capital adequacy. This comprehensive approach should account for a diverse range of factors, from macroeconomic conditions to specific banking operations, allowing for a more robust and insightful stress test analysis. Such an approach would promote a comprehensive view of potential vulnerabilities and better inform decision-making.

- **Incorporate IFRS 9 Approach into Credit Risk Modelling:** As a specific upgrade to the current credit risk model, it is recommended to integrate an IFRS 9-based approach. IFRS 9 introduces a more forward-looking assessment of credit losses. Incorporating IFRS 9 would allow for a more proactive assessment of credit risk, considering not only current financial conditions but also future expectations, hence allowing a more accurate estimation of potential credit losses during stress scenarios.

- **Utilize Advanced Tools for Assets and Liabilities Management (ALM):** Finally, to better manage ALM risks, it is recommended to NBB continuing to incorporate more advanced tools such as dynamic simulation models and stochastic modelling in their top-down stress testing exercises. These techniques offer a more sophisticated analysis of ALM risks under various scenarios, allowing the capturing of complex behaviours and relationships, and the examination of potential outcomes across a broad spectrum of possibilities. A more granular understanding of ALM risks, as facilitated by these advanced tools, would equip banks to develop more effective risk management strategies, ultimately bolstering their resilience under stress scenarios.

BANK LIQUIDITY STRESS TEST

56. Liquidity risk was evaluated through three types of analyses: LCR stress tests, cash flow-based analysis, and descriptive analysis of the NSFR. The LCR stress test measures banks' ability to cover their 30-day liquidity needs with high-quality liquid assets. This analysis employs six scenarios calibrated to replicate stress in retail and/or wholesale funding and market dislocations. The cash flow-based analysis examines banks' ability to meet cash outflows under stress over various timeframes, assessing cash inflows and outflows across different maturity buckets. It also evaluates if banks can address liquidity shortages using their unencumbered assets. The NSFR analysis qualitatively assesses banks' ability to fund their long-term activities with stable funding sources.

A. LCR Stress Testing Exercise

57. The LCR exercise was based on scenarios obtained by recalibrating Basel weights. The LCR scenarios do not rely on macroeconomic assumptions but instead utilize "stressed" Basel coefficients on liquid assets, inflows, and outflows, to simulate stress. Starting from the baseline LCR, computed using the coefficients on inflows, outflows and liquid assets as prescribed by the Basel III standards, we calibrated six stress scenarios, simulating mild and severe stress on asset values, inflows, and outflows. The coefficients under stress scenarios have been calibrated by applying proportional changes across all categories. Under "aggressive" scenarios the changes correspond roughly to a doubling/halving of the Basel coefficients. This is broadly consistent with other FSAP exercises. Detailed coefficients can be found in Appendix VI.

58. The calibrated scenarios affect several components of the LCR and aim to capture stress in different funding and asset market segments. Stressing coefficients on liquid assets impacts both the numerator of LCR—because they affect the calculation of weighted inflows and outflows from collateralized transactions—and the denominator of the LCR—because they affect the weighted value of high-quality liquid assets (HQLA). Instead, stressing coefficients applied to borrowing and lending transactions affect the numerator of LCR by modifying the weighted value of the relevant inflows and/or outflows. The first two scenarios ("Retail" and "Wholesale") represent stress on retail or wholesale customers, with larger coefficients applied on retail/wholesale deposit outflows and lower coefficients applied on inflows from loans. The changes in coefficients applied to asset values are minimal in these scenarios. The third scenario ("Wholesale and Retail") combines the first two. The fourth scenario ("Market") is meant to capture the effect of market dislocations, by applying larger haircuts on asset values and lower coefficients on inflows and outflows from the wholesale and retail segments. The fifth scenario ("Wholesale Total") simulates stress in the wholesale market, with larger haircuts on asset values and higher stress on wholesale loans and

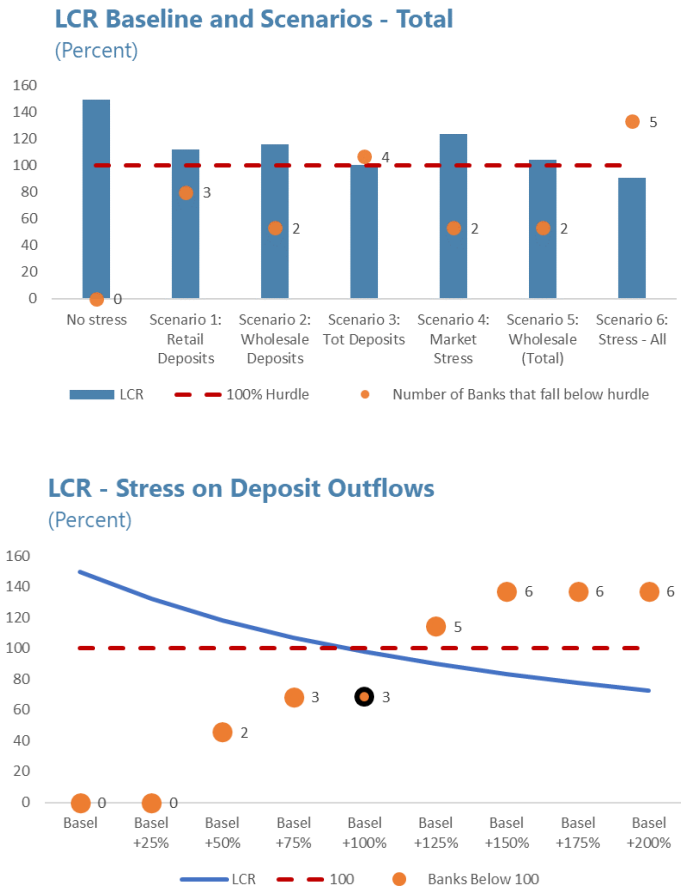
deposits. Lastly, the last scenario assumes simultaneous stress in the retail, wholesale sectors, and market prices (Table 3).

Table 3. Belgium: LCR Scenarios

	OUTFLOWS				INFLOWS				ASSETS	
	Retail Dep.	Wholesale Dep.	Whol. Mkt Funding (Mild)	Whol. Mkt Funding (Aggressive)	Sec.Funding Haircut (Mild)	Sec.Funding Haircut (Aggressive)	Retail Loans	Wholesale Loans	Mild Haircut	Aggressive Haircut
1) Retail	x		x		x		x		x	
2) Wholesale		x	x		x			x	x	
3) Retail & Wholesale	x	x	x		x		x	x	x	
4) Market				x		x				x
5) Wholesale Total		x		x		x		x		x
6) Total Stress	x	x		x		x	x	x		x

59. The overall system is largely insulated from market-driven stress, but the initial liquidity position of banks is crucial. With a starting LCR around 150 percent, the system possesses a comfortable level of liquidity and remains generally liquid in all scenarios except the last one. However, there is variation among banks: two out of seven banks consistently fall below the regulatory hurdle of 100 percent in most scenarios, and in the most severe scenario only two banks remain above the regulatory hurdle. In general, however, Belgian banks are found to be more susceptible to stress originating from the retail and wholesale sectors, while they are relatively insulated from market-driven stress (Figure 18). This is explained by the funding structure, which relies more on wholesale and retail deposits and less on market funding. In general, the initial LCR position helps banks withstand shocks in every scenario. To further analyze this, a sensitivity analysis on LCR coefficients applied to wholesale and retail deposits was conducted. The results reveal that the system-wide LCR falls below the regulatory threshold when Basel coefficients are doubled, and while no banks fall below the regulatory hurdle for mild changes in the coefficients, an increasing number of banks exhibit LCR below 100 percent when coefficients are increased by 50 percent (Figure 18).

Figure 18. Belgium: LCR Results



Source: IMF staff calculations

B. Cash Flow Stress Testing Exercise

60. The cash flow analysis evaluates banks' capacity to handle cash outflows over a 12-month period under three stress scenarios. It utilizes asset and liability management data to track cash inflows and outflows based on contractual maturity and categorizes them into different maturity buckets. The data follows double-entry bookkeeping, where cash inflows contribute to the initial counterbalancing capacity, while cash outflows deplete it. A liquidity gap arises when the bank exhausts its counterbalancing capacity to fulfill net cash outflows. The analysis was conducted calibrating three stress scenarios. Like the LCR analysis, these scenarios aim to capture: (i) stress from asset market dislocations—mostly affecting the value of the counterbalancing capacity, (ii) stress from retail and wholesale markets generating higher deposit outflows and lower inflows, and (iii) a combination of both.

61. The scenarios vary in terms of runoff rates, rollover rates of maturing obligations, and haircuts on counterbalancing capacity (Table 4). The "market stress" scenario involves significant haircuts on assets, while retail and wholesale inflows and outflows experience low levels of stress (i.e., low runoff rates). The second scenario is the exact opposite of the first, while the third scenario combines both sources of stress (see Appendix VII for details).

Table 4. Belgium: Cash Flow Analysis, Scenarios

	Haircuts	Inflows & Outflows
1. Market Stress	High	Low
2. Retail and Wholesale Stress	Low	High
3. Combined Stress	High	High

62. Runoff rates for deposits, credit, and liquidity facilities are calibrated using similar daily rates as the ECB (2019).[11] Total outflows are calculated by compounding these daily rates over relevant days assuming outflows occur over the initial three-month period. The profile of deposit outflows is assumed to be relatively smooth over the first 2-3 days, then gather speed between day 4 and two months, and then phase out. Runoff rates are differentiated across types of deposits. Stable retail deposits are assumed to be the "stickiest" so even under a high stress

Table 5. Belgium: Outflows from Deposit, Liquidity, and Credit Lines
(Cumulative over Three Months, Percent)

	Low	High
Stable retail deposits	5	10
Other retail deposits	20	25
Operational deposits	25	40
Non-operational deposits from central banks	0	0
Non-operational deposits from fin. customers	30	50
Non-operational deposits from non-fin. & other customers	30	50
Committed credit facilities	60	12
Liquidity facilities	75	75

Source: staff calculation.

[11] ECB (2019), "ECB Sensitivity analysis of Liquidity Risk – Stress Test 2019 Methodological note".

scenario only about 10 percent of the total are assumed to run off over the three months period. Non-operational deposits from financial and non-financial customers are supposed to be the most sensitive, with total outflows ranging between 30 percent (in the low stress scenario) and 50 percent (in the high stress scenario) (Table 5). These runoff rates are broadly consistent with the evidence of liquidity crises but are lower than what was experienced in the recent episodes of bank runs. Arguably though, cases like Silicon Valley Bank, First Republic, and Silver gate are poor comparators for Belgian banks, which have more diversified asset positions, as well as diversified and stable depositors' base.

63. Haircuts on assets are calibrated starting from the haircuts applied by the ECB in its collateral framework.[12] For each asset in the COREP C66 template, haircuts are computed based on quantiles of a lognormal distribution centered around the haircut applied by the ECB for comparable types of assets. In particular, haircuts under the "low stress" scenario correspond to the 95th percentile of the distribution, while the haircuts under "high stress" scenario correspond to the 99.5th percentile. Depending on the type of asset, the computed haircuts vary between 7 and 30 percent in the "low stress" scenario and 15 and 40 percent under the "high stress" scenario. (Table 6).

Table 6. Belgium: Haircuts on Counterbalancing Capacity
(Percent)

	Low	HIgh
Event Probability (cumulated)	95%	99.50%
Level 1 tradable assets		
Level 1 central bank	7.0	15.0
Level 1 covered bonds (CQS1)	8.5	16.5
Level 1 (CQS2, CQS3, CQS4+)	11.0-15.0	19.0-23.0
Level 2A tradable assets	9	17
Level 2B tradable assets		
Level 2B ABS (CQS1-CQS2, covered bonds)	8.0	16.0
Level 2B (CQS 3-5)	18.0	26.0
other tradable assets		
central government (CQS1)	19.0	27.0
central government (CQS 2 & 3)	30.5	38.5
other tradable assets	30.5	38.5
non tradable assets eligible for central banks	30.5	38.5

Source: IMF staff calculations.

64. Some assumptions are common across all scenarios. Consistently with the ECB (2019) and other FSAP liquidity stress tests, we assume also: (i) no rollover of maturing assets and liabilities related to secured lending and other collateralized transactions; (ii) no rollover of maturing FX swaps and derivatives; (iii) no rollover of loans and advances to credit institutions and other financial customers; and (iv) full rollover of non-operational deposits from the Central Bank. Finally, we also

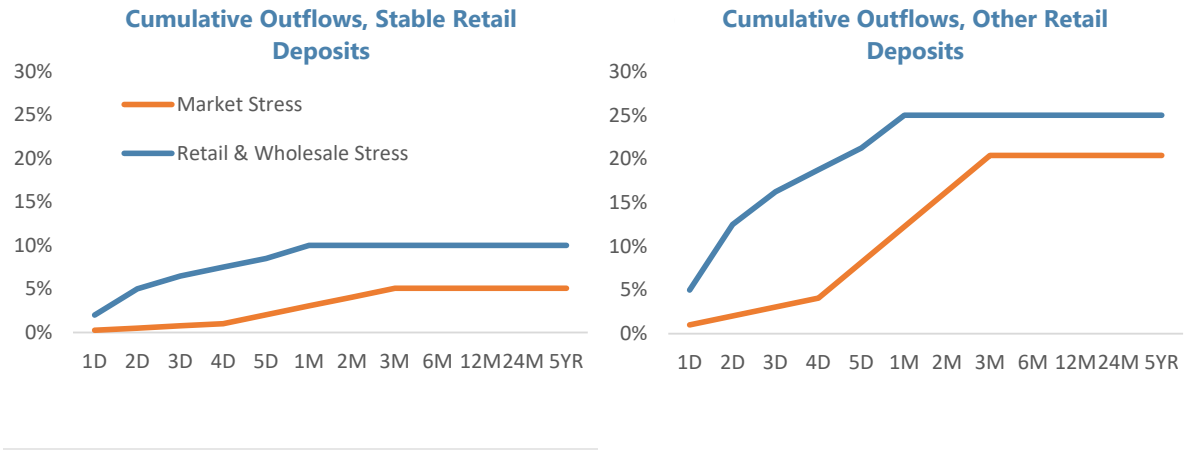
[12] Guideline ECB/2022/49 amending Guideline (EU) 2016/65 on the valuation haircuts applied in the implementation of the Eurosystem monetary policy framework (europa.eu).

assume that in the second and third scenarios inflows from maturing loans are more heavily affected, while in the first and third scenarios, the decline in rollover rate for maturing securities issued is more pronounced, thus generating larger outflows.

65. The cash flow analysis demonstrates that even in the most extreme scenario, the system maintains an adequate level of counterbalancing capacity. Initially, the "Market Stress" scenario causes a more rapid erosion of counterbalancing capacity due to the immediate impact of higher haircuts. However, as time passes, the "Retail and Wholesale Stress" scenario leads to a faster decline in counterbalancing capacity as deposit outflows unfold. After 12 months, the counterbalancing capacity diminishes by a factor of four, but the overall system remains liquid. This is primarily attributed to the banking system starting from a comfortable liquidity position, with an initial counterbalancing capacity of approximately 24 percent of total bank assets, primarily comprising high-quality liquid assets that experience mild haircuts even under stress conditions.

66. Two out of seven banks encounter a liquidity gap mostly because of deposit outflows. Consistent with the findings from the LCR analysis, while banks appear well protected against market-induced stress, some of them are vulnerable to liquidity strains caused by deposit outflows. Liquidity shortages emerge after about two months (Figure 20). Higher initial counterbalancing capacity functions as effective protection against liquidity outflows in our scenarios. As a sensitivity test, we repeated the analysis by assuming the deposit run to be more heavily frontloaded, with all the outflows shown in Table 5 to take place over the first month (see Figure 19) for an example of the path of deposit outflow). The profile of the deposit outflow, however, does not change the number of banks that suffer from liquidity shortages, but under this scenario those banks run out of counterbalancing capacity after only three days (Figure 20).

Figure 19. Belgium: Profile of Deposit Outflows under Alternative Scenario

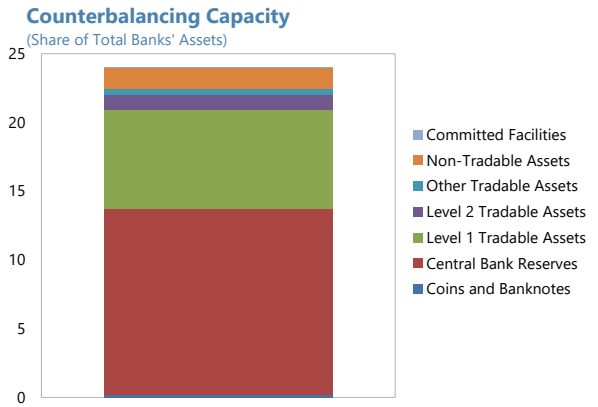


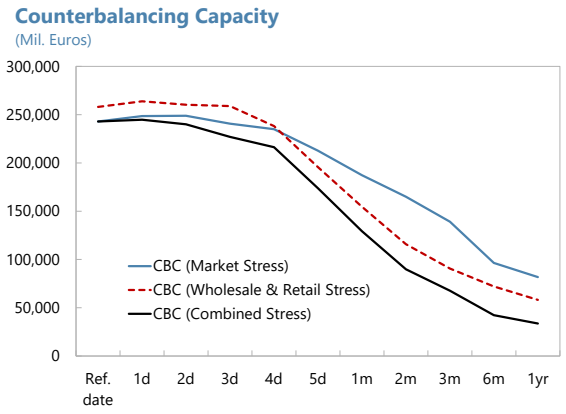
Source: IMF staff calculations.

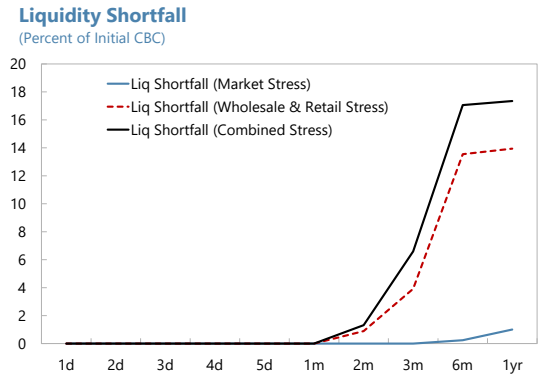
67. Liquidity gaps are more severe if we focus only on US dollars liquidity. Since four of the seven banks in our analysis have exposure to US dollars, we conducted a currency-specific cash flow analysis (Figure 21). We recalibrated the parameters to account for the higher sensitivity of US dollars deposits and assumed higher haircuts on US dollar denominated assets. The initial liquidity position, measured by the US dollars counterbalancing capacity as a percentage of total assets, is

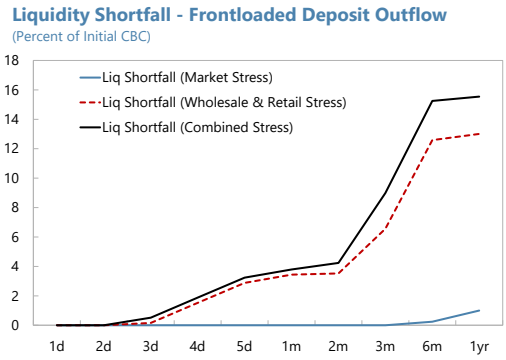
considerably weaker, which is reflected in the liquidity gap generated by the stress scenarios. Out of the four banks analyzed, the same two banks that encountered liquidity shortages in the previous exercise show liquidity shortages in US dollars. The other two have sufficient counterbalancing capacity relative to their US dollars activity to successfully meet net outflows over the 12-month period.

Figure 20. Belgium: Cash Flow Analysis



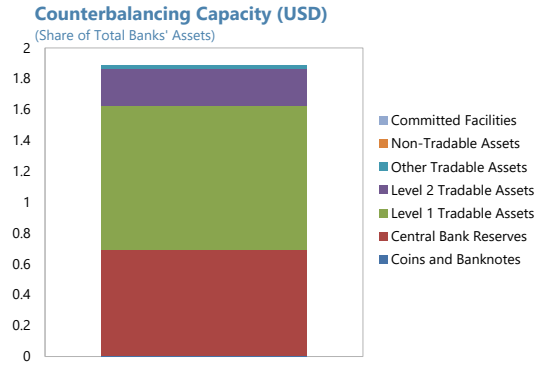


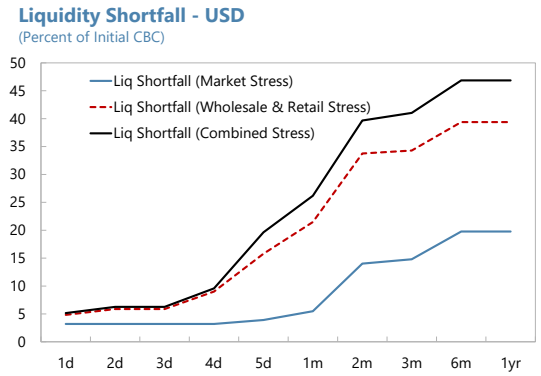




Sources: COREP66, IMF staff calculations.

Figure 21. Belgium: Cash Flow Analysis – US Dollars Proportion

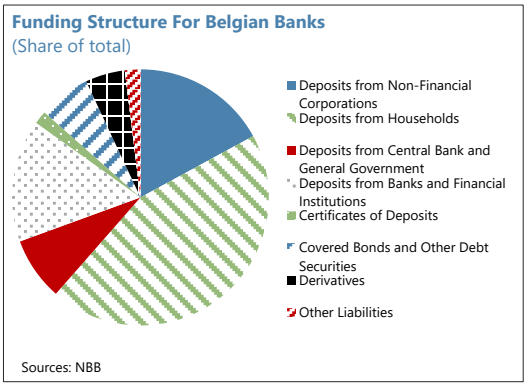




Sources: COREP 66, IMF staff calculations.

C. NSFR Analysis

68. The qualitative NSFR test reveals the heavy reliance of banks stable funding sources, consisting mostly of deposits covered by the public guarantee. By end-2022, deposits from household and non-financial corporations were making up more than half of total banks liabilities. Debt securities (excluding CDs) were only about 6 percent of total liabilities. As a reflection of the solidity of funding, the net stable funding ratio (NSFR) at the end of 2022 stood at 132 percent.



Sources: NBB

BANK SOLVENCY AND LIQUIDITY INTERACTION

A. Scope

69. Leveraging the underpinning macroeconomic scenario, the solvency stress test, and the executed cash-flow stress test, this part delves into the exploration of solvency-liquidity risk interplay under stress conditions. This exercise, albeit not being highly plausible due to real-world banking operations wherein banks utilize their counterbalancing capacity as collateral to procure liquidity from the ECB without incurring actual losses, is nevertheless useful and intriguing to discern whether the banks can withstand the potential losses emanating from forced liquidation.

70. The HTM securities portfolio is a small share of bank assets (7.8 percent, approximately 73 percent of the total debt securities hold by the banking sector). Consequently, potential losses from forced liquidation are expected to be small. Breaking down the HTM portfolio, sovereign debt accounts for 65.5 percent. This is followed by debt from credit institutions at 20.6 percent, corporate debt at 7.4 percent, non-bank financial institutions at 6.1 percent, and central banks constituting a 0.4 percent. These proportions serve as the backdrop against which the solvency-liquidity stress scenarios are assessed.

71. The essence of this analysis lies in the hypothesis that banks, when confronted with acute liquidity stress, may opt to divest assets from their HTM portfolio in the banking book, a recourse generally considered a last resort. In this hypothetical situation, the HTM portfolio is sold at market value, denoting a devaluation against its book value. This devaluation, estimated from 2022 (when interest rates started increasing) through to the end of either year 1 or year 3 of the scenario (as per the variant of the exercise), follows the risk-free rate trajectory within the adverse scenario. It's critical to note that the banks would tap into their HTM portfolio only post exhausting their tradable counterbalancing capacity. Furthermore, no additional haircuts are assumed in this scenario, given that the HTM portfolio primarily comprises HQLA, mainly low yield sovereign bonds, which can be liquidated at their market value.

72. The financial dent inflicted by forced liquidation is calculated as the disparity between the market and book values of the fraction of the HTM portfolio sold, with these losses directly impinging on banks' PnL statements. Simultaneously, RWAs corresponding to the total utilized counterbalancing capacity (not only HTM sales) are eradicated from the banks' balance sheets. All provisions held against the sold HTM portfolio are rescinded and recognized as income, which is reflected in the PnL statement, thereby mitigating the detrimental impact of the forced liquidation losses.

73. Four different scenarios are contemplated for this analysis, determined by the proportion of the HTM portfolio that is divested. In the initial three scenarios, the proportions are guided by the outcomes of the three cash-flow stress test scenarios (“Market”, “Outflow”, and “Combined”), resulting in an aggregate of 47.4 percent, 66.6 percent, and 86.6 percent of the HTM portfolio being sold respectively. The individual banks' proportions vary, dictated by their unique liquidity situations. As an added exercise, a fourth scenario is simulated envisioning a complete liquidation (100 percent) of the HTM portfolio.

74. Each scenario is considered as a standalone event, implying that the forced liquidation does not trigger a wholesale transformation of the HTM portfolio into a Fair Value Through Profit and Loss (FVTPL) portfolio. The repercussions of these forced liquidations are evaluated within two timeframes of the solvency stress test: Year 1, characterized by the highest risk-free rates, and Year 3, aligning with the pinnacle of the banks' credit losses.

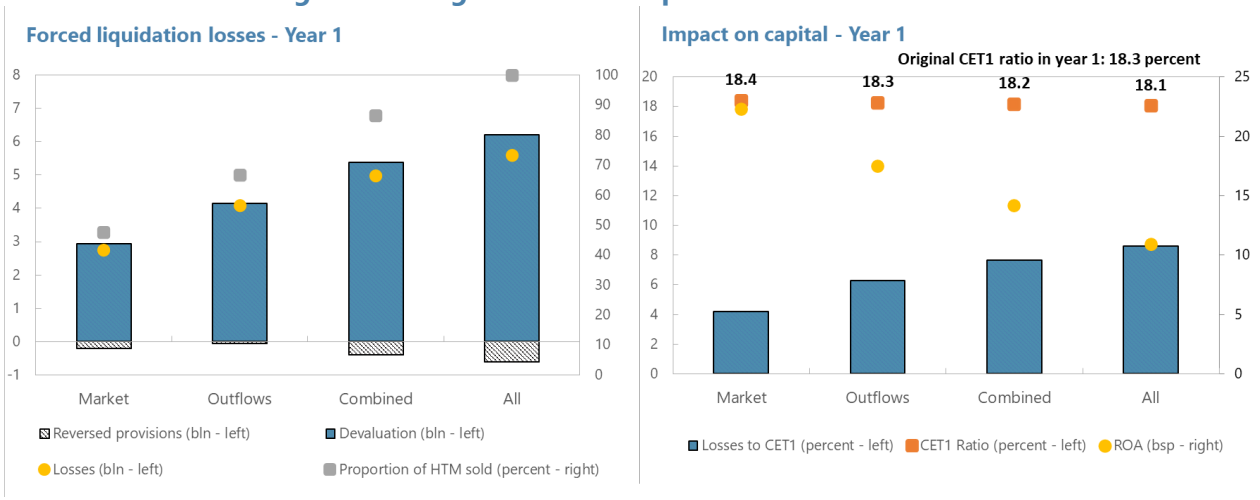
75. Due to the complex nature of the analysis and to maintain manageability, our solvency-liquidity interaction exercise is confined to the year when the forced liquidation transpires. To extend the analysis beyond this point would necessitate modeling the influence of deposit outflows from the liquidity stress test on net interest income in subsequent years, thereby introducing significant additional complexity. Consequently, this analysis should be viewed as a complementary tool to the longer-term solvency stress testing and cash-flow stress testing previously delineated, offering insights into the immediate impact of liquidity stress on solvency.

B. Results

76. For the Year 1 scenario, the analysis began with a solid average CET1 ratio of 18.3 percent and a return on assets of 28bps (Figure 22). In the event of forced liquidation, a total devaluation of 7 percent of the portfolio ensued. This led to respective losses as a proportion of CET1 of 453bps, 636bps, 826bps, and 955bps under the "Market", "Outflow", "Combined", and "Complete liquidation" scenarios. However, these losses were tempered by the reversal of provisions, which brought in gains ranging from 31bps to 95bps across the four scenarios. Factoring these in, the net losses over the pre-liquidation CET1 ratio were computed as 421bps, 626bps, 766bps, and 860bps. Despite these losses, a 2 percent reduction RWAs due to the forced liquidation sets the post-liquidation CET1 ratios to 18.4 percent, 18.3 percent, 18.2 percent, and 18.1 percent across the respective scenarios. Notably, all banks managed to uphold their minimum capital requirements under these circumstances.

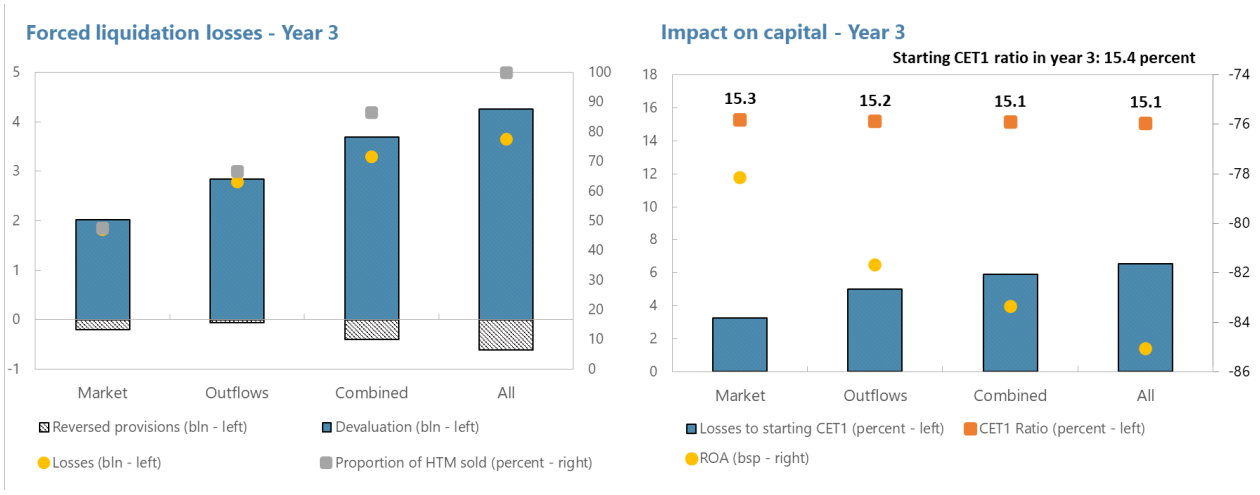
77. Transitioning to the Year 3 scenario, the average CET1 ratio before forced liquidation was marked at 15.4 percent, with return on assets at -65bps (Figure 23). A 4.8 percent devaluation of the portfolio under forced liquidation led to losses amounting to 364bps, 511bps, 663bps, and 766bps of the CET1 ratio across the four scenarios. After accounting for the reversal of provisions, which added gains of 37bps to 111bps, the net losses over the initial CET1 were 328bps, 500bps, 592bps, and 655bps. A similar 2 percent drop in RWAs led to post-liquidation CET1 ratios of 15.3 percent, 15.2 percent, 15.1 percent, and 15 percent under the respective scenarios. Although the return on assets declined to -78bps, -82bps, -83bps, and -85bps in these scenarios, all banks were able to maintain their minimum capital requirements. Despite the increasing losses, all banks continued to meet their minimum capital requirements.

Figure 22. Belgium: Forced Liquidation Results – Year 1



Source: IMF staff calculations.

Figure 23. Belgium: Forced Liquidation Results – Year 3



Source: IMF staff calculations.

78. This detailed examination highlights the ability of the banking sector to uphold regulatory capital requirements in stringent conditions. The impact of forced liquidation on the sector's solvency is significant but manageable, courtesy of the RWA reduction which counterbalances the losses. While a decline in CET1 ratios due to lower profits and a decrease in the return on assets is observed, the ratios remain robust, showcasing the banking sector's resilience and the effectiveness of its risk management strategies. This analysis, serves as a supplementary tool, enhancing our understanding of the immediate impact of liquidity stress on solvency, alongside the longer-term solvency and cash-flow stress testing exercises.

INSURANCE STRESS TEST

A. Scope of the Solvency Stress Test

79. Eight composite insurers (KBC, Belins, Ethias, Axa, Baloise, AG Insurance, Allianz, and P&V) are included in the stress test, accounting for three quarters of the Belgium insurance market. Six of them (all except Allianz and P&V) participated in the bottom-up exercise. In the Belgian insurance market, which is characterized by high concentration, a coverage of around 76 percent is reached by the inclusion of eight of the largest mixed insurers in the sample. While the importance of the life and non-life segments varies by company, the overall sample has a similarly high representation of both the life and the non-life business. The insurers' aggregated balance sheet assets amount to €231 billion. One firm applies a full internal model and one a partial internal model. All assessed insurers apply the volatility adjustment (VA) but no other long-term guarantees (LTG) measure.

80. The stress test was run at the solo entity level and thereby excluded business performed by foreign subsidiaries of Belgian insurers. Nevertheless, for those few Belgian insurance groups with foreign activities, these are in most cases limited or not consolidated into the group. By focusing on the Belgian entity, a comprehensive view on relevant risks can be achieved.

81. The participating insurers' investments are characterized by a high exposure to fixed income assets and a significant share of direct and indirect real estate investments. Their fixed income investments, more than two thirds of which are government bonds, are generally of good credit quality. Insurers' 87 percent of government bond investments have an A or higher rating. Similarly, their corporate bond investments are of good credit quality (Figure 24). More than half of all investments have a credit rating of A or higher, with the credit quality of financials (representing 38 percent of total corporate bond investments) being significantly higher than those of non-financials. Corporate bond investments in the high yield category cover less than three percent but could increase in times of rating migrations due to the large share of BBB investments.

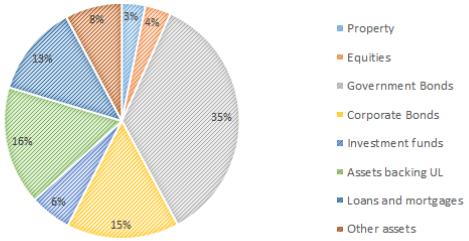
82. The large investment in government bonds and high-quality corporate bonds indicate a good level of asset liquidity, but illiquid investments have increased over the last years. Cash levels (above one percent of total assets) are in line with the European average, bond investments are considerably more pronounced. Direct and indirect real estate investments are high in comparison to most European peers and have been increasing in recent years. Mortgages constitute a significant share of the real estate investments. These loans have weighted average LTV and DSTI ratios of 74 and 34 percent, respectively.

83. The home bias of sovereign bond investments is significant, exposing insurers to rating downgrades of the Belgian sovereign. Around half of all government bonds are held in the Belgian sovereign, followed by government bonds from France, Germany, and Spain, which cover another quarter.

Figure 24. Belgium: Insurers' Balance Sheet Composition and Fixed Income Portfolios

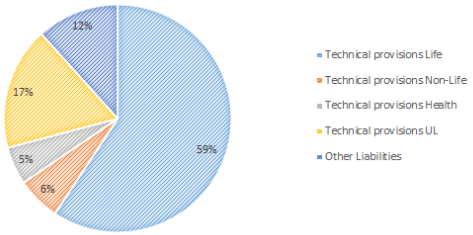
Fixed income assets, including government bonds, corporate bonds and mortgages and loans dominate investments

Breakdown of Assets



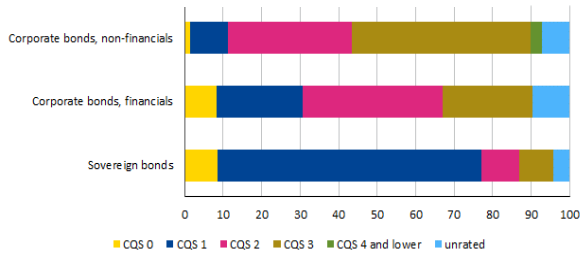
Three quarters of the mixed insurers' liabilities relate to technical provisions of their life business.

Breakdown of Liabilities



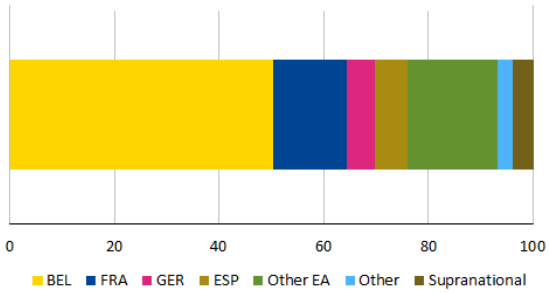
Bond investments are generally of high quality with around 84 percent of sovereign and 50% of corporate bonds being CQS 2 (~ A rating) or better.

Fixed Income Rating Distribution
(In percent)



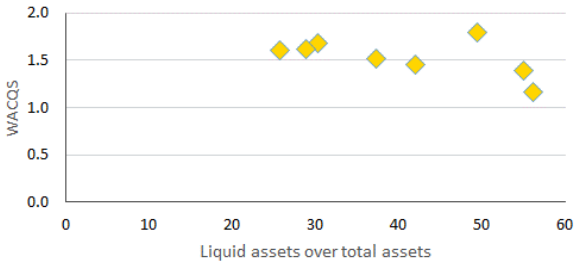
The home bias in sovereign bonds is significant, with BE government bonds covering half of the total exposure.

Sovereign Holdings Breakdown
(In percent)



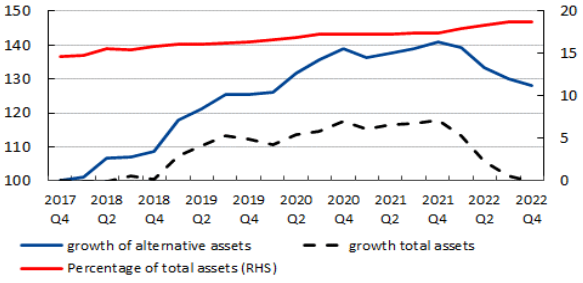
Overall, investments are of fair quality and generally liquid

Liquid Assets (In percent) **– Weighted Average Credit Quality Step**



Less liquid assets have grown steadily over the last years; real estate investments in particular.

Asset Growth
(End 2017 = 100)

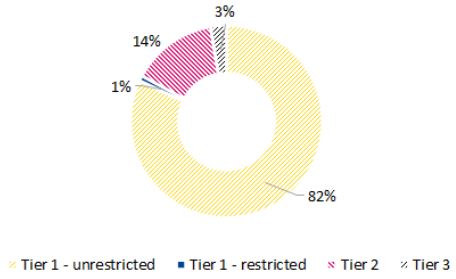


Sources: IMF staff calculations based on NBB data.
Notes: Stress test participants only. The breakdown of assets excludes unit- and index-linked insurance. Haircuts are applied to the liquid assets in line with banking LCR. Alternative assets include property, loans, alternative and infrastructure funds, private equity, and collateralized securities. The right-hand chart of the lower panel covers the entire Belgian insurance sector.

Figure 25. Belgium: Own Funds and Solvency Capital Requirements

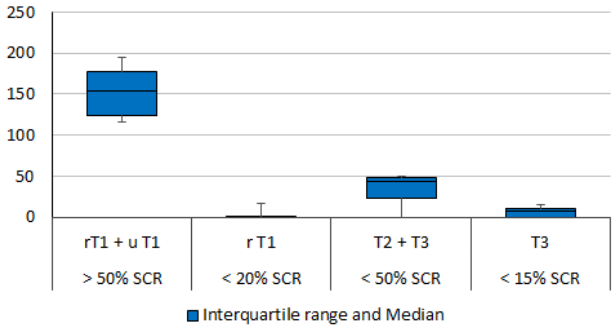
Although unrestricted tier 1 capital dominates insurers' own funds….

Composition of Eligible Funds



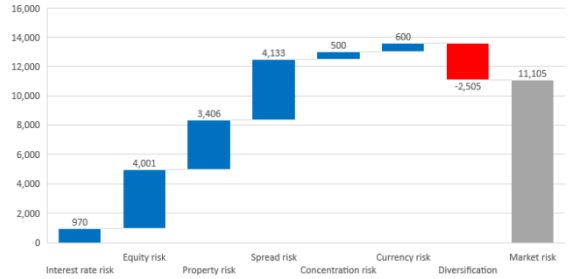
…..tier 2 and 3 are significant for some insurers and close to the regulatory limit

EOF in Percent of SCR and Tiering Limits



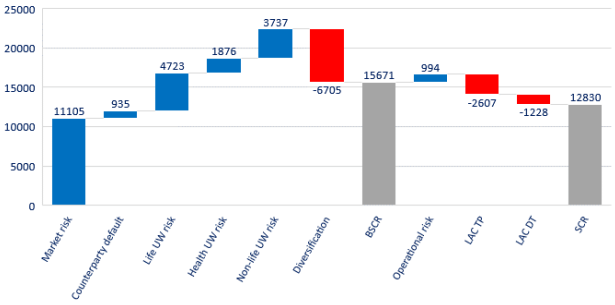
While assets and liabilities are generally well matched, the market risk capital requirements highlight the significant exposure to fixed income investments (bonds and loans)

Market Risk (In EUR Min)



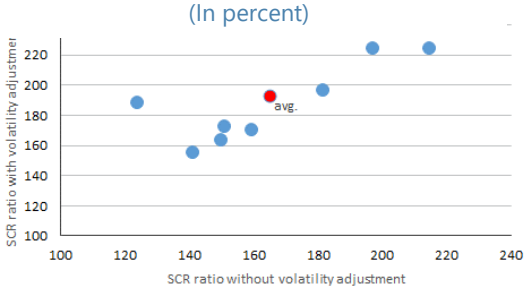
Market risks dominate the solvency capital requirements, and diversification at the level of the BSCR is significant.

Solvency Capital Requirement (in EUR Min)



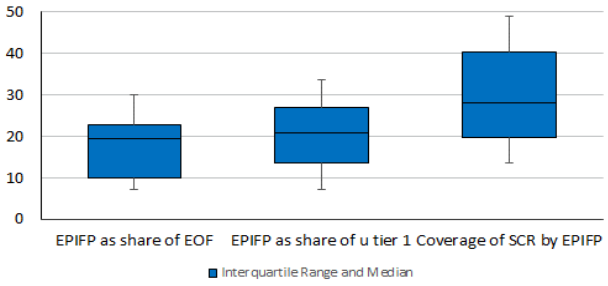
The VA, the impact of which varies across insurers, further increases generally solid solvency ratios.

Impact of VA on Solvency Ratio
(In percent)



The sample shows a large dispersion of expected profits in future premiums as a share of insurers' own funds.

Importance of EPIFP in Insurers' Own Funds
(In percent)



Sources: IMF staff calculations based on NBB data.
Notes: Stress test participants only. The middle panels also include partial and full internal model users. The scope of their SCR modules can deviate from the standard formula.

84. Belgian insurers have healthy solvency ratios, even without VA. Market risk is the main contributor to the insurers' capital requirements (Figure 25). It covers about 70 percent of the basic Solvency Capital Requirements (SCR). Given the investment exposure, the main drivers are spread risk, property risk and equity risk. Assets and liabilities are generally well matched and duration gaps are small, thus explaining the comparatively small contribution of interest rate risk to capital requirements. Unrestricted tier 1 capital represents around 80 percent of Belgian insurers' eligible own funds. Unrestricted tier 1 capital alone easily covers the SCR, but some insurers' debt leverage may become a constraint in stressed periods as their holdings of eligible tier 2 and 3 capitals are close to the limit.

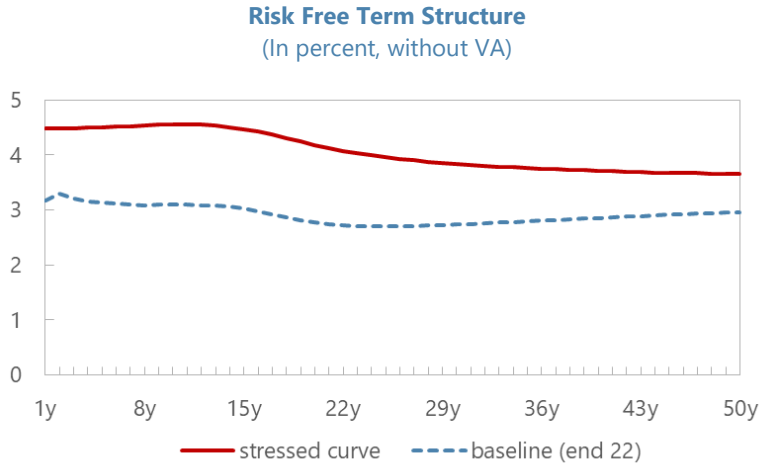
B. Scenarios

85. The macrofinancial scenarios specified by the IMF for the banking sector stress test also serve as the basis for the insurance stress test. While all scenario assumptions are highly relevant for the insurance sector, in some instances slight adjustments were made for the purpose of the insurance stress test. These adjustments intend to make the scenario directly applicable to an insurer's balance sheet. While the scenario includes a four year ahead projection of macrofinancial variables, for the insurance stress test all shocks were assumed to occur at the beginning of the first year (instantaneous shock approach). Market shocks have therefore been front-loaded so that the maximum drawdown during the project horizon of the scenario is already realized immediately after the reference date (31 December 2022). Furthermore, the risk-free rate term structure was adjusted to take account of the significant downward reversal of risk-free rates in the scenario after 2023 (Figure 26).

86. To cover the most relevant risk factors for an insurer's balance sheet, the market risk stresses have been defined more granularly. The scenario includes shocks to the risk-free interest rate, equity, and property prices, default rates of mortgage loans, as well as credit spreads of corporate and sovereign bonds. Given the increase of credit spreads in the scenario, also the volatility adjustment (VA) increases, following the Solvency II calculation method. For insurers applying this measure, the result is a higher risk-free rate, which offsets to a large degree the impact of the credit spread shock.[13]

[13] The VA in its current design can create periods of overshooting effects, i.e. insurers get overcompensated for an increase in volatility in the market. This can happen because of duration mismatches or in case of an insurer having fixed income assets that experience a lower spread increase than the European representative portfolio used for the calculation of the VA. This is not the case in this stress test due to the assumption of a considerable increase in sovereign risk.

Figure 26. Belgium: Interest Rate Shock



Sources: IMF staff calculations.

87. In the bottom-up (BU) exercise, insurers were also requested to calculate the impact of a mass lapse and inflation on their own funds and solvency ratio. The (30 percent) mass lapse shock assumes a sudden non-permanent discontinuance of the in-force insurance policies after the materialization of the market shocks. It applies to non-mandatory insurance of the in-force life policies and is inclusive of normal lapsation assumptions. The inflation shock follows the scenario path for the consumer price index (CPI) and wage inflation of the macrofinancial model. After the five-year model period, it is assumed that the CPI gradually returns to a two-percent inflation assumption until 2032 and remains constant afterwards. Wage inflation is assumed to increase at the same pace as the CPI after 2027, the end of the modelled four-year period (detailed specifications of the stress test can be found in Appendix VIII).

C. Capital Standard and Modeling Assumptions

88. Solvency II serves as 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, specifically about the discount rate, which can incorporate LTG measures and transitional measures. In Belgium, the use of LTG measures is mainly restricted to the volatility adjustment. Only one insurer, which is not included in the stress test sample, applies the transitional measure for technical provisions.

89. The main output of the stress test calculations is the effect on own funds, eligible for the coverage of the solvency capital requirement (SCR). As the stresses also affect the capital requirement, the SCR was partially recalculated after stress. The BU stress test also allowed a more granular assessment of the own funds' composition.

90. To benchmark the results of the bottom-up stress test and assess sensitivities to variations of the shocks, a top-down (TD) stress test was run by the FSAP team. The top-down analysis is based on data received from the NBB and insurance undertakings. It includes a granular breakdown of investment assets, government, and corporate bond holdings, as well as maturities and coupon rates of fixed income investments. In addition, a detailed maturity breakdown on cash flow projections was requested. In the TD analysis, the focus is predominantly on the impact of financial shocks. It includes assessments related to rating migrations of insurers' corporate bond portfolio and their exposure to the Belgium sovereign as well as an assessment of the real estate exposure.

91. Data were gathered in line with the Solvency II quantitative reporting templates. Solvency II has introduced very granular supervisory reporting, especially on the asset side. For the solvency stress test exercise, the following templates were used for the solvency and liquidity assessments:

- Balance sheet (S.02.01),
- Open derivatives (S.08.01)
- Securities lending and repos (S.10.01)
- Asset-by-asset investment holdings (S.06.02),
- Cash-flow projections (S.13.01, S.18.01)
- Impact of LTG measures and transitionals (S.22.01)
- Own funds (S.23.01)
- Calculation of the Solvency Capital Requirement (S.25.01 – S.25.03, S.26.01)

Besides the Solvency II quantitative reporting templates, the stress test also made use of national specific reporting templates, such as those related to the NBB "liquidity reporting" and, which the collection of which collect the standard formula calculation of the SCR by full and partial internal model users.

92. For the TD stress test, the shocks specified in the scenario were applied to the investment assets and insurance liabilities. Haircuts in line with scenarios were applied to the market values of assets, and a revaluation of fixed income assets was undertaken with the stressed term structure. Similarly, technical provisions (except for unit linked business) were approximated with the stressed term structure including the volatility adjustment.

93. The re-calculation of the SCR in the TD stress test was limited to selected risk modules within the market risk component. 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 adjustment, which changes to -10 percentage points after the fall in equity prices. All other components of the basic SCR were not modelled by the TD stress test but derived from the BU exercise.

94. Reactive management actions are not modeled in the TD stress test but are an integral part of the BU exercise. In times of financial stress, insurers have several options to restore their capital adequacy and/or profitability, including changes in underwriting standards, in the reinsurance program or by withholding profits. In addition, they may improve their solvency position by de-risking the balance sheet, for instance by changing their asset allocation towards less risky assets and applying hedging strategies, such as forward bonds and spread locks to address falling bond values and increasing spreads. Dividend retentions and intra-group capital management actions are additional ways to bolster own funds and thus improve solvency ratios. This is not modelled in the TD stress test. However, as part of the BU stress test, participating insurers were requested to show results with and without reactive management actions. Furthermore, insurers were asked to provide additional details on embedded management actions and their corresponding impact. In that way, by accounting for behavioral adjustments, the BU stress test includes some features of a multi-period perspective.

D. Results of the Solvency Stress Test

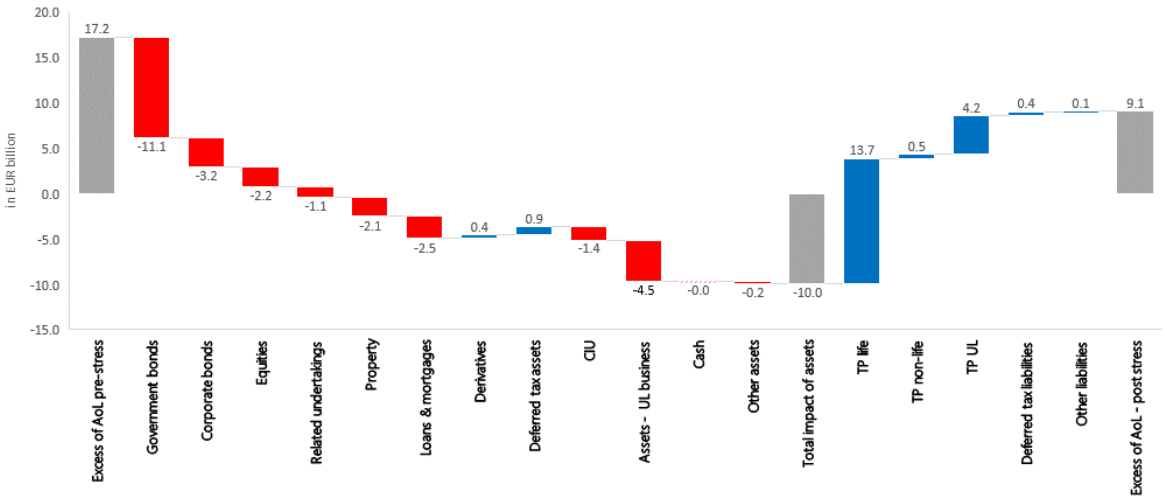
95. Industry can withstand severe price shocks, despite vulnerabilities on the asset side (Figure 27). According to the BU calculations, the median solvency ratio drops from 192 percent before stress to 113 percent after stress (Figure 28). Including reactive management actions, the new median solvency ratio is 142 percent.[14] The aggregated solvency surplus amounts to €9.1 billion before stress and falls to €1.8 billion after stress, or €3.3 billion when reactive management actions are included. The insurers benefit substantially from the assumed increase in the VA in the stress scenario. By mitigating the effect of short-term volatility of bond spreads on the solvency position, the VA immunizes the insurers against the spikes in credit spreads, which are not purely driven by a deterioration in underlying credit risk. The impact on the solvency ratio, however, varies considerably across companies but can be substantial. Without its application, most insurers' solvency ratio would have fallen below 100 percent.

96. The combination of valuation losses and a severe mass lapse shock had a significant impact on insurers' own funds. For the whole sample, the solvency ratio fell almost 80 percentage points, from a baseline of almost 200 percent. This decrease is mostly due to a significant fall in eligible own funds (EOF) by 43 percent. The significant fall of assets due to financial shocks is only partially compensated by a corresponding fall in technical provisions. The SCR falls by around seven percent due to the lower asset and liability exposures post stress. The assets over liabilities ratio falls from 110 percent to 107 percent, which leads to a reduction of assets over liabilities (eAoL) by more than eight billion euro, almost halving the year-end 2022 figure. One insurer would fall below a solvency ratio of 100 percent before the application of reactive management actions.

[14] This figure also includes those insurers that did not apply reactive management actions.

Figure 27. Belgium: Decomposition of Excess of Assets over Liabilities

Belgian insurers excess of assets over liabilities is significantly affected by a drop in asset values. This is partially compensated by a fall in technical provisions.



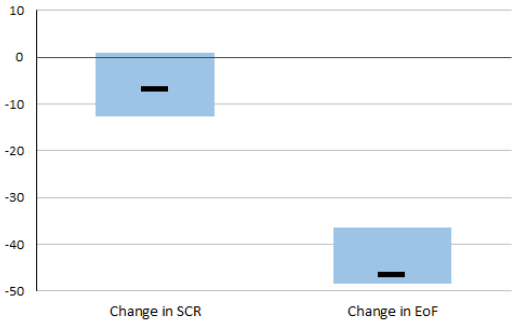
IMF Staff calculation based on company submissions.

Figure 28. Belgium: Impact of Shocks on Own Funds and Solvency Capital Requirements

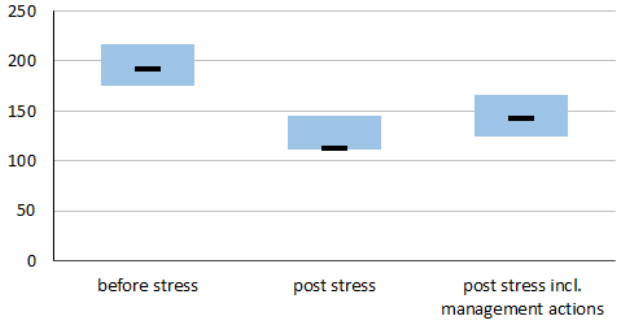
The financial shocks have a significant impact on EOF, and capital requirements fall due to lower exposures post stress.

The changes in EOF and SCR lead to a median reduction by 80 percentage points of the solvency position (50 percentage points with management actions

Change in Eligible Own Funds and SCR
(In percent)



Solvency Ratios
(In percent)



Source: IMF Staff calculations based on company submissions. Not all insurers applied management actions.

97. The high corporate bond exposure makes Belgian insurers vulnerable to spread increases and rating migrations. Corporate bond holdings represent 15 percent of total assets and are almost entirely of investment-grade quality. Nevertheless, a significant share of corporate bonds is held in BBB grade. A downgrade would lead to significant valuation losses due to higher spreads.

The increase in capital requirements, as assets move into non-investment grade territory partially cancels out due to lower exposure following the revaluation. A rating migration scenario, like the 2008 experience, combined with the assumed increases in bond spreads would lead to an average reduction of the solvency ratio of 14 percentage points.[15,16] Differences across companies are mainly driven by the quality of the bond portfolio and the duration of the assets. Although rating migrations have an impact on required capital, this potential increase in SCR is more than offset by the fall in exposure due to valuation losses. The change in the solvency ratio is, hence, almost entirely driven by the change in own funds.

98. A downgrade of the Belgian sovereign would have a marked impact on Belgian insurers' solvency.[17] The impact on the solvency ratio reflects the significance of the Belgian sovereign on the insurers' balance sheet. Belgian sovereigns represent 18 percent of the balance sheet or 50 percent of the government bond exposure. Even assuming an increase of only 30 basis points (i.e., the difference between the shock on Belgian sovereign and the shock for non-AAA or AA rated EA countries in the model specifications), the solvency ratio would see a further decline of nine percentage points or a loss in valuation of around one billion euros (Figure 29). This comes in addition to the original spread shock on government bonds, which reduces the sample's solvency ratio by 28 percentage points. In line with the standard formula of Solvency II, no capital requirements for government bonds have been assumed.

99. Insurers' real estate exposure is a significant driver of insurers' fall in own funds and consequently their solvency ratio. A shock to real estate can propagate through several channels or asset types, thus increasing the sector's overall exposure. Real estate investments represent about ten percent of Belgian insurers' balance sheets, consisting in direct investments in property, real estate funds, loans and mortgages, bonds, and equity of real estate related corporations. The importance of the different asset categories differs markedly across companies. Property (excluding own use) and mortgages and loans are the main real estate exposures. Real estate related equity investments are significant as well. It is notable that it is the dominant equity exposure for several insurers, representing a third of total equity exposure for the total sample (with a maximum of almost three quarters). Real estate funds represent nine percent of total fund investments, with several insurers not having any exposure and some with exposure of more than a quarter of their total fund holdings. Six percent of corporate bonds are allocated to real estate corporations. To identify the impact of a real estate shock, we stress all real estate related exposures, i.e., bonds, equities, loans, direct property and real estate funds, according to the stress test scenario. All else equal, with a considerable dispersion across insurers, excess of assets over liabilities (proxy for own funds) falls by 19 percent and leads to a similar impact on the solvency ratio.

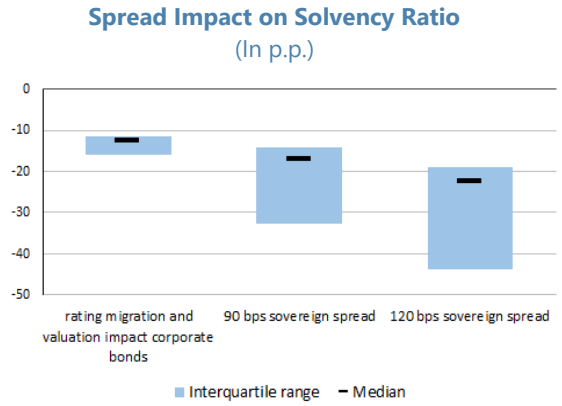
[15] The 2008 Fitch one-year transition rates for global corporate bonds were used. Adjustments were made by assuming only one-notch downgrade and no upgrades, unrated bonds were treated like BBB-rate bonds.

[16] Management actions and potential portfolio reallocations because of or ahead of a rating downgrade are ignored.

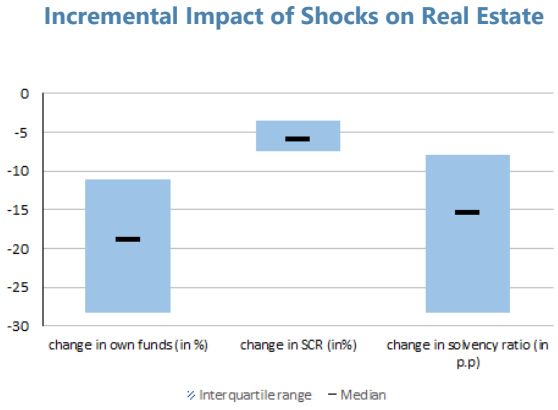
[17] We assess the incremental impact of increasing sovereign bond exposures. The potential impact on corporate bonds from a sovereign rating downgrade are ignored, given the small share of Belgian corporate bonds in insurers portfolios. Technical provisions have been left unchanged.

Figure 29. Belgium: Sensitivity Analysis for Specific Exposures

High exposures to the BE sovereign and a large share of BBB corporate bond investments increase the impact of potential rating migrations.



Real estate exposure is a major driver for stress test impact.



Source: IMF Staff calculations based on the NBB data. Only asset side adjustments included in real estate sensitivity analysis. Due to data limitations non-mortgage loans to real estate sector have not been included. Based on the data available, the impact of the exclusion is unlikely to have a significant impact on the results.

100. The impact of the inflation stress scenario is small as end 2022 balance sheets already reflect insurers' own projections of the inflation trajectory. The inflation shock, driven by an increase in claims and expenses, leads to an increase of around five percent in non-life best estimates liabilities but is negligible for life business. The main affected line of business is the long-tailed workers compensation insurance, which accounts for six percent of the non-life business. On the asset side, some insurers benefit from the increase in value of their inflation-linked bond holdings, which can partially offset the increases in best estimate liabilities. Part of the impact of the inflation shock is implicitly assumed in the interest rate shock. In addition, the end of the year baseline liability cashflow projections already incorporate insurers' own expectations' regarding the inflation trajectory, which is generally more severe in the long run but less in the very short term.

101. Both embedded and reactive management actions have a significant impact on the insurers' solvency ratio. Belgian insurers apply a variety of the management actions mentioned above. Some of those measures have an immediate effect, such as dividend retentions, hedging derivatives or intra-group transactions. Asset sales largely depend on the liquidity of the assets, while liability portfolio de-risking may need to be executed over a longer time horizon. Reactive management actions are largely informed by the companies' own risk appetite with respect to the targeted solvency ratio. The main impact comes from an improvement in the own funds, mitigating the impact of the stress scenario on the solvency ratio by 20 percentage points. The overall solvency ratio after reactive management action would be at 140 percent.[18]

[18] Not all insurers applied reactive management actions.

102. While Belgian insurers' tier 1 capital is generally sufficient to cover the SCR, tiering limits can become a constraint under stress. Even in the baseline, some insurers' eligible tier 2 and tier 3 capital is close to the limits set by Solvency II regulation.[19] As the analysis showed, in a stressed environment, these limits can become a binding constraint and affect insurers' risk management options.

103. In addition, expected profits in future premiums (EPIFP) represent a significant share of unrestricted tier 1 capital for several insurers, and as such cover a large share of the SCR. On the one hand, this can raise a concern regarding loss absorbency. It is not evident, how EPIFP can be readily available to absorb losses under stress. In case of high EPIFP supervisors are also warranted to be vigilant about the adequate application of contract boundaries in the calculation of the technical provisions.

E. Liquidity Risks

104. Using the scenario narrative of the solvency stress test as a reference, the liquidity analysis focused on two aspects: liquidity risk from mass lapses and variation margin calls. Lapsation may be motivated by an increase in the need for financial resources of policyholders due to a shock to income, such as an increase in cost of living, inflation in general, unemployment, etc. Alternatively, as interest rates rise, other investment opportunities may become more attractive. Empirical evidence also indicates that the type of distribution channels used may have an impact on lapsations.

105. Insurers' interest rate swap (IRS) exposure may lead to liquidity risk from variation margin calls. Derivatives and in particular IRS are an important risk mitigation tool for insurers' long-term business. Insurers may use IRS – as a floating rate payer and fixed rate receiver - to extend the duration of their assets and thus improve the matching with their liabilities. This reduces the exposure to a fall in interest rates but makes them more vulnerable to increases. When the market value of the insurer's derivative portfolios falls, they will be required to pay variation margins. In case of a long position, on the other hand, they receive margin payments, when interest rates increase, allowing for some netting where the transaction is with the same counterparty.

106. The IRS exposure in Belgium is concentrated among very few insurers with significant holdings. Those insurers hold IRS in both directions, fixed for floating and floating for fixed and adjust their positions dynamically as the considerable number of off-setting transactions suggests. It also implies that they have a small number of counterparties, which would allow netting of margin payments.[20] The weighted average remaining time to maturity for the sample is 12.6 years for floating for fixed IRS and 13.8 years for fixed for floating. The number of open positions is 181 and 519 respectively, with the former, however, having a higher total notional value. Most of the derivatives outstanding have been traded over the counter and are not centrally cleared in Belgium.

[19] The sum of eligible tier 2 and tier 3 capital can only cover less than 50% of the SCR. Eligible tier 3 capital needs to be less than 15% of SCR. Restricted tier 1 capital can only cover 20% of the SCR.

[20] In the results no netting positions were considered, except for transactions that provide a perfect offset in terms of notional amount and maturity date.

107. Data were gathered from the NBB in line with Solvency II quantitative reporting templates. This includes S.08.01 derivative positions and S.06.02 asset by asset investment holdings. The latter focused on those items relevant in the assessment of available liquid assets in a stressed environment, excluding assets pledged as collateral.

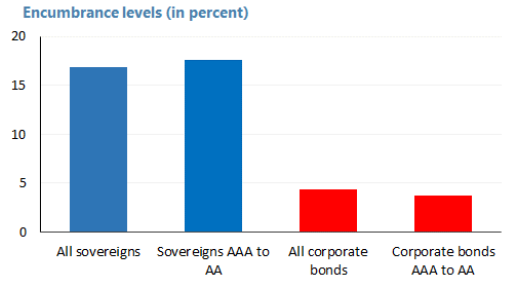
108. The scenario for the analysis of liquidity risk from variation margin calls assumes very severe interest rate increases of up to 100 basis points within a five-day period. Three interest rate shocks were modeled over two different time horizons: A 25 basis point (bp) increase (parallel shift of the interest rate term structure) 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. The other two scenarios, interest rate increases of 50 and 100bps, 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, thus enlarging the pool of available liquid assets. The margin calls could be met with cash deposits plus unencumbered sovereign bonds with high credit quality rating (AAA to AA), revalued after the interest rate increase.

109. Encumbrance levels of high-quality assets are generally low but vary significantly among the insurers in the sample. While for most insurers, pledged government bonds account for ten percent or less of their total government bond exposure, for some insurers asset encumbrance levels are considerably higher (Figure 30). Encumbered assets mostly comprise Belgian government bonds, which represent two thirds of all pledged sovereign bonds. Only a small share of corporate bonds is encumbered.

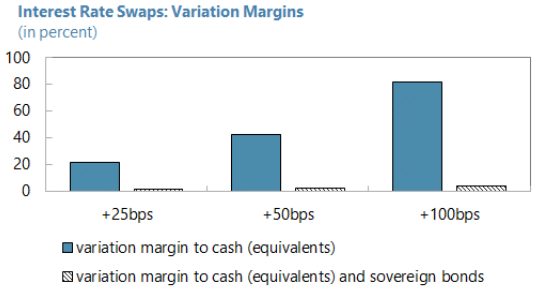
110. Variation margin calls from sudden and strong interest rate increases are a manageable exposure for the Belgian insurance sector. Low exposures for most insurers make the sector largely resilient to margin calls following steep interest rate hikes. Cash buffers vary significantly across firms, however, and can become stretched for some insurers with larger exposures under a narrow definition of cash. For two insurers, cash may not be sufficient to service margin calls, and they may have to engage in forced liquidation of other liquid assets, such as high-quality government bonds in the pre-scribed scenarios. Insurers have access to repo facilities and money market funds, but these sources may not be available, or dry up in a crisis. Overall, other liquid assets are sufficient if the interest rate increase unfolds over a longer period.

Figure 30. Belgium: Liquidity Stress Test Results from Variation Margin Calls

Asset encumbrance levels vary considerably but are low for most companies. Two thirds of encumbered sovereign bonds are Belgian sovereigns.



Overall, cash margin calls on interest rate swaps following a 25-bps interest rate increase could be met by drawing on 22 percent of cash equivalents. It would require 82 percent if interest rates were to increase by more than 100bps.



Source: IMF staff calculation based on NBB data. Assets that are pledged as collateral as part of intra-group reinsurance but remain on the insurer's balance sheet and can be invested to its own investment policy are included in the denominator for the purpose of calculating asset encumbrance.

111. We assess the insurers' robustness against different lapse scenarios given a stressed balance sheet. Four different scenarios are applied: A 30 percent lapsation event, for all lapsable contracts, in line with the solvency stress test, and three more nuanced approaches. Two scenarios only involve "high-risk contracts", i.e., it only involves contracts without fiscal or contractual penalties. These contracts account, on average, for about 14 percent of lapsable surrender values (with considerable variation across insurers and a range between four and 39 percent). In one scenario, we assume a complete wipe-out of such products[21], in the other case a 30 percent lapse scenario is applied. Such a scenario, where policyholders only redeem a particular type of product is consistent with the "run" on Ethias in October 2008. In that example policy redemptions were essentially restricted to its pension plan without surrender penalties. Another scenario is a combination of a 10 percent withdrawal assumption for products with some form of penalty and a 30 percent lapse scenario for high-risk products. The argument for different lapse rates is that contractual and tax penalties reduce the likelihood of early surrenders. The market stresses affecting the insurers' liquid assets are assumed to take place before the lapsations.

112. Pay-outs are not immediate. Although, there is no legal provision, payments generally occur one month after the demand for lapse for individual contracts and two to three months for occupational contracts. This allows the insurer more time to sell assets in case cash is insufficient to honor the pay-outs. We hence allow for a broader set of liquid, non-pledged, assets but apply haircuts to the amounts after applying the stress assumptions for financial risks. The financial shocks are like those used in the solvency stress test, in terms of the fall in equity and spread assumptions for corporate and sovereign bonds. A parallel shift of 25, 50, and 100 basis points for the risk-free term structure is assumed.

[21] These are severe scenarios and ignore any interventions by the supervisor. Article 508/1, introduced in 2019 in the Belgian law, gives the NBB the power to temporarily prevent surrenders in case of a run on an insurer.

113. The deferred pay-outs allow the inclusion of a broader set of liquid assets subject to haircuts. In addition to cash and sovereign bonds, it includes high quality corporate bonds (excluding financials) and covered bonds, listed equities of non-financials, and money market, equity, and debt funds. The haircuts increase with the riskiness of the asset and are broadly aligned with the banking sector LCR.

114. Results show that the insurers have sufficient liquid funds to withstand significant redemptions, but also identify high levels of dispersion. Cash plus sovereign bonds generally suffice to service pay-outs even in stressed market conditions. Including all liquid assets, most insurers in this exercise would be able to withstand a complete wipe-out of all products without penalties and on average a further surrender of two thirds of their contracts with penalties. These figures vary significantly, however, as Figure 31 indicates, it is noticeable that some of the companies with high levels of products without penalties, also have comparatively lower liquid to total asset ratios. It should be noted that some of the insurers more vulnerable to lapse risk also have a higher exposure to variation margin calls.

115. The analysis is done on a stock basis, but investment income can mitigate the liquidity shock.[22] The non-immediate pay-out of the surrender values also means that a large share can be serviced through regular cash-flows from investment income and premiums. Around seven percent of their fixed income assets mature within a year. Assuming a quarter of these assets maturing within the first trimester, provides a cash inflow of around € 2 billion.[23] Furthermore, insurers have an average coupon rate of around three percent on their fixed income investments. If the same timing of coupon payments applies and assuming that assets are only sold after the coupon payment, this would add another € 900 million. These investment inflows represent about 20 percent of the contracts without penalty and 2.5 percent of total surrender values.

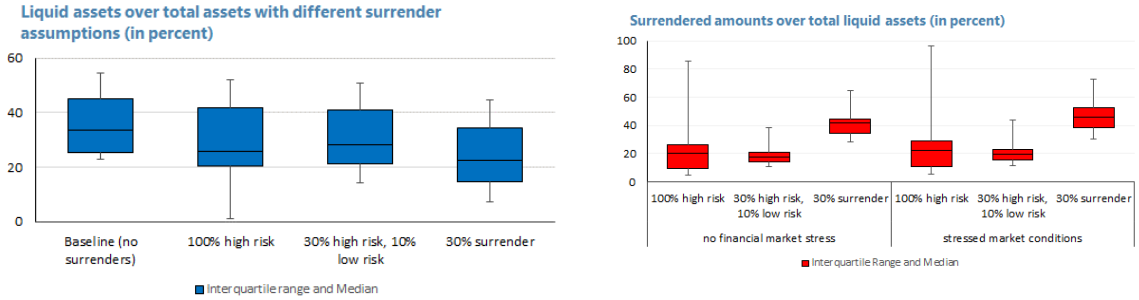
[22] Based on quarterly claims and expense ratios for both the non-life and the life business over time, net cash flows from premiums were assumed to be zero.

[23] This figure is based on the eight institutions that were included in the solvency stress test and for which detailed asset data were collected.

Figure 31. Belgium: Liquidity Strains from Policy Lapsations

The stock of liquid assets is generally sufficient to cover for the mass lapse events in an environment of stressed financial markets, but figures show high dispersion.

Some insurers, however, have a significant exposure to products that can be redeemed without penalty ("high risk" products).



Source: IMF Staff calculations based on NBB data. The boxes represent the interquartile range and the median. Different stress assumptions are applied in accordance with assumptions described in paragraph 113. High risk refers to products without market value adjustment, tax or any other penalty. The left-hand chart shows the liquid asset ratio after application of the different surrender shocks. The right hand chart shows amount surrendered relative to total liquid assets (post stress).

F. Recommendations

116. The NBB is recommended to implement liquidity stress tests and liquidity scenarios to identify potential sources of stress. Supervisors should challenge the assumptions insurers apply to the availability of liquid assets in a stressed environment, including what is considered as cash equivalent. The share of life insurance products without penalty is high in some cases, heightening the risk of surrenders in times of increasing interest rates and a weak economy. To support internal analyses, the NBB should collect surrender/lapse data by type of insurance product.

117. The NBB should engage with the industry to reduce dependence on lower tier capital as it can become binding in times of stress. While overall solvency ratios have improved over the last years, some insurers still depend on lower quality capital instruments. These instruments, in some instances already close to the regulatory limit in the baseline, can become a constraint in a stressed environment and limit the choices of reactive management actions. While tier 1 capital is generally sufficient to cover the SCR, this may not be the case in a stressed environment, when the tiering limits start to become binding.

118. The NBB should run a detailed assessment of the impact of the use of the VA on the solvency ratio in a changing interest rate environment. Numbers in the quantitative reporting templates, show that the VA has a profound impact on the solvency ratio. The NBB analyzed the impact of the VA previously and assessed that its impact did not distort the level playing field in the low yield environment. The NBB should assess whether the improvement of the solvency ratio due to the VA can lead to an unlevel playing field considering the differences that exist between undertakings. It is recommendable to continue to collect figures on the impact of the VA on the solvency ratio.

INVESTMENT FUNDS STRESS TEST

A. Objective and Scope

119. The FSAP assessed the resilience of Belgian open-end investment funds through a liquidity stress-testing approach. The objective is threefold: (i) assess the ability of investment funds to withstand severe but plausible redemption shocks, (ii) identify the types of funds that are potentially more vulnerable to liquidity risk, and (iii) estimate and the sector's capacity to transmit shocks to the rest of the financial system. Of note is that the stress test does not consider the use of liquidity management tools (LMTs), and the results should be interpreted keeping in mind that LMTs could mitigate shocks to some extent.

120. The analysis focuses on investment funds with characteristics that make them susceptible to run.[24] This segment comprises funds of funds (FoFs), mixed vehicles and fixed income funds, that may present liquidity/maturity transformation risk. The presence of potential liquidity mismatches is the fundamental premise of the stress test. While open-ended investment fund liabilities are highly liquid, with most funds – and UCITS in particular –providing daily dealings to their investors, the assets of certain types of investment funds might be less liquid.

121. A comprehensive set of regulatory and supervisory data have been used to assess the exposure of collective investment undertakings and their characteristics. Based on end-2022 data, the sample comprises 435 funds for a total net asset value (NAV) of around €136 billion (Figure 32) The categories are the following: bond funds, funds of funds, non-public alternative investment funds that pursue their strategies with more limited regulatory constraints, and a residual heterogeneous group of 'Other' funds.

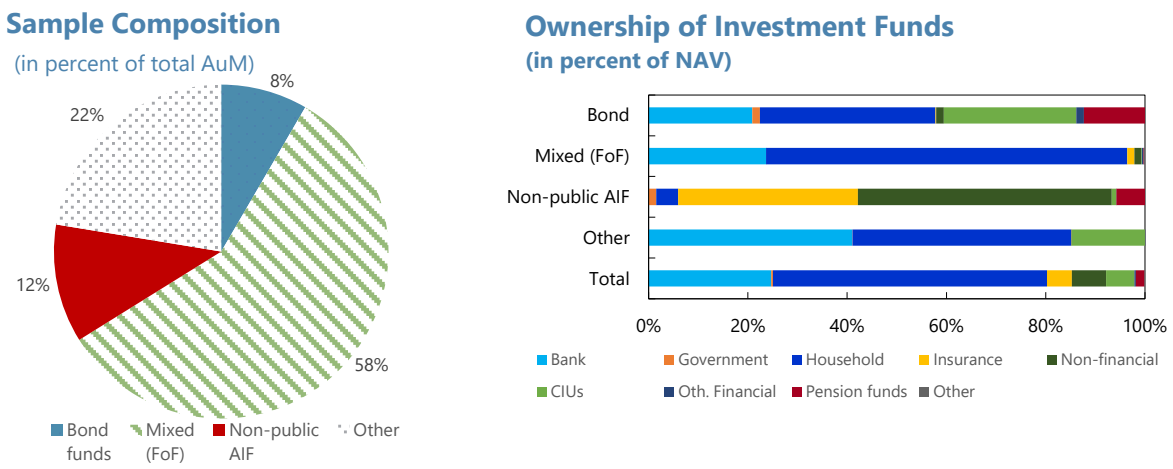
122. Belgian investment funds are historically oriented toward retail investors. Households hold more than 55 percent of public open-ended investment vehicles exposed to liquidity transformation risk, with a preference for FoFs (Figure 32). Publicly distributed funds appear diversified and benefit from the possibility to activate liquidity management tools (LMTs). Shares of non-publicly distributed alternative funds that present higher but still contained levels of leverage are generally held by non-financial corporations and institutional investors.

B. Methodology

123. The stress test has three main components: calibration of the redemption shock, composition of asset sales and the price impact of sales. For each fund in scope, the analysis compares the level of redemptions requests with the level of highly liquid assets (HQLA) that management companies can dispose. After a redemption shock, it is assumed that the manager will sell part of the assets in the fund's portfolio according to a set of liquidation strategies. When assets are sold, sales are assumed to have a negative price impact on the market, the extent of which depends on the amounts of sales and on the absorption capacity of the market (see Appendix IX). The liquidation of securities by funds constitutes one channel through which funds can transmit shocks to the rest of the financial system.

[24] These are Belgian funds that are included in the Economic Function 1 (EF1) based on the FSB taxonomy.

Figure 32. Belgium: Belgian Investment Funds in EF1 Group



Sources: Lipper, and IMF staff calculations.

124. Different levels of redemption shocks are tested based on historical data. First, for each fund, historical data are used to calibrate the redemption shocks, defined in percentage of total net assets, based on the most extreme outflows observed by funds in the same category. Funds of the same type and with a similar geographical focus face the same shock ('homogeneity assumption'), calibrated based on the average of the worst 3 percent net flows observed by funds in each category.[25] Funds of funds with a global focus tend to have a higher returns' sensitivity to redemptions. Depending on the funds' type and geographical focus, the resulting levels of redemptions range between 4 percent and 9 percent of the net asset value for mixed-FoFs, and between 14 percent and 18 percent for non-public alternative investment funds (Table 7). A second set of historical redemption shocks is then calibrated at fund-level ('heterogeneity assumption') to account for idiosyncratic shocks based on individual fund net outflow. The vehicles in the residual 'Other' category present a high degree of variation in their shocks when looking both at fund level than within their specific common strategies.

125. Redemptions are compared to funds' HQLA to assess their ability to withstand shocks. The redemption coverage ratio (RCR) measures the amount of liquidity that funds have compared to the size of the shock, both expressed in percent of NAV, and is used to estimate the ability of funds to meet redemptions without resorting to the sale of less liquid assets in their portfolio:[26]

[25] 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. As a robustness check, other thresholds and methods are used, resulting in twelve different redemptions shocks.

[26] 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.

$$RCR = \frac{HQLA}{Redemption\ shock} \quad (9)$$

Highly liquid assets are estimated at fund-level using the composition of the portfolio and applying liquidity weights derived from Basel III framework for the calculation of HQLAs. The liquidity shortfall is computed as the difference between the redemption shock and the available highly liquid assets when a fund presents an RCR below one.

126. Fund managers can use different liquidation approaches when facing redemptions. Sales of securities are conservatively assumed to occur in a pro-rata fashion (vertical slicing) or alternatively according to the waterfall approach (horizontal slicing). When liquidating pro-rata manager sells assets proportionally to their weight in the portfolio without distorting its composition. This may be preferable for managers pursuing liquidity management practices that preserve fundamental allocation decisions, as opposed to divesting most liquid securities first, as would instead be the case under the waterfall liquidation strategy.

127. The sales of securities by funds to meet redemption requests can have an impact on markets. Given a redemption shock and a liquidation strategy, funds have to sell a given number of securities across different asset classes. To estimate the price impact of the sales, the volume of sales is compared to the liquidity of the underlying market. Liquidity is measured by market depth which is positively related to the ratio of average daily trading volumes to asset volatility. Market depth is measured both under normal trading conditions and during stress periods (see Appendix IX.).

C. Results

128. Within the different fund categories, funds appear to have similar portfolio compositions. FoFs hold more than 40 percent of total NAV and, while aiming at diversifying their exposure across different asset classes, are largely invested in other collective investment undertakings (CIUs) including exchange traded funds (ETFs) domiciled in other European jurisdictions (Figure 33).

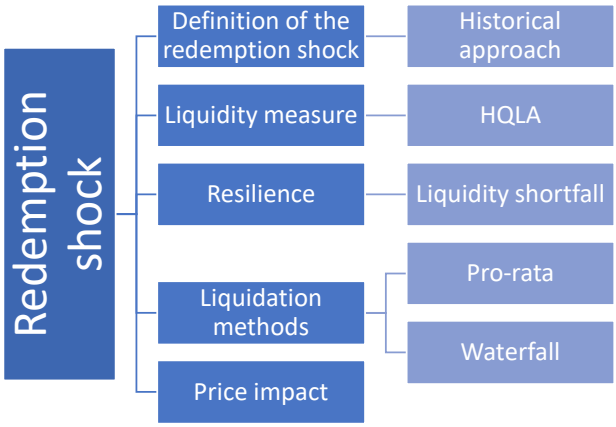
129. Funds with a global focus present a high degree of diversification through their investment in foreign assets. Vehicles with a mandate to focus on European markets maintain some domestic and other European sovereign instruments to reduce their liquidity and counterparty credit risks. Unencumbered cash amounts overall to 2 percent of the total asset under management.

130. For limited number of funds, the liquidity offered to investors may be greater than the liquidity of the assets held, especially in the short term. Public open-ended investment funds are almost entirely UCITS attaining low levels of leverage, with no engagement in off-balance sheet activities and very limited exposure to derivative instruments. When liquidating its assets, it is assumed that a fund targets its leverage and adjusts the sales proportionately.

131. The liquidity buffers display significant variation across fund categories. Bond funds and mixed investment vehicles have a level of HQLA ranging between 40 percent and 60 percent. Only non-public alternative investment funds, which are sold to professional investors display a weighted average level of liquid assets of around 30 percent. Exposure to fixed income instruments amounts overall to €34 billion, which is equally split between sovereign and corporate bonds. More than 80 percent of corporate bond exposure is to investment grade instruments.

Table 7. Belgium: Investment Funds Stress Test—Sample and Approach

Components of the Stress Test Framework



Sample of investment funds in EF1 group

Fund category	Composition	
	NAV (EUR bn)	Number of funds
Bond funds	10.6	46
Mixed (FoFs)	77.8	215
Non-public alternative funds	15.8	38
Other	31.6	136
Total	*135.8*	*435*

Sources: FSMA, NBB, IMF staff calculation

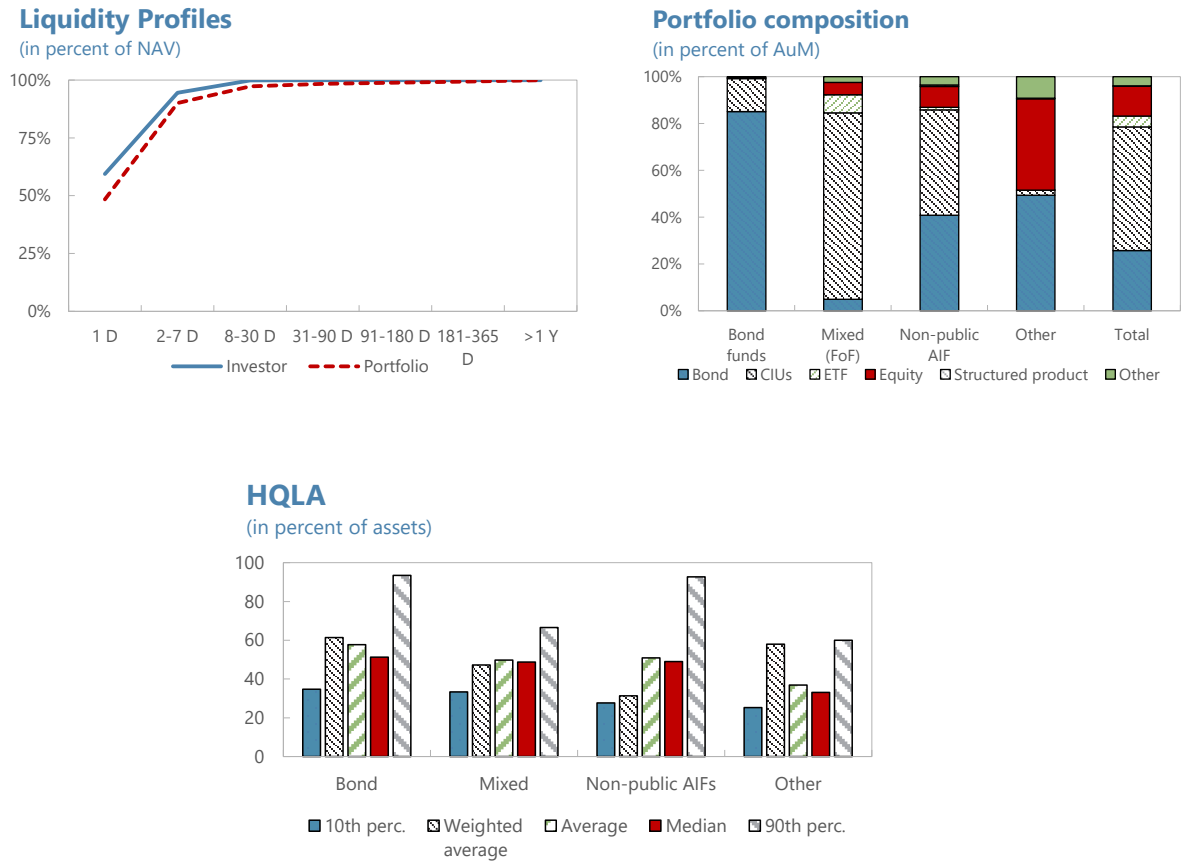
Redemption shocks by fund category

Fund category	Homogeneity		Heterogeneity
	EU focus	***Global focus***	
Bond funds	15%	14%	12%
Mixed (FoFs)	4%	9%	5%
Non-public alternative funds	18%	14%	15%
Other	1%-30%	2%-32%	2%-33%
Total	*11%*		*7%*

Monthly redemption shocks in % of NAV. Median outflow indicated under the heterogeneity approach. Totals refer to the aggregate pure redemption shock to the sector.

Sources: Lipper, IMF staff calculation

Figure 33. Belgium: Liquidity Profiles and Portfolio Composition



Source: FSMA, Lipper, NBB, IMF staff calculations.

Funds' Ability to Withstand Severe Redemption Shocks

132. The Belgian investment funds sector would be able to withstand severe but plausible redemption shocks, however a few non-public alternative funds could run into difficulties. Less than 2 percent of the investment funds (6.7 percent of NAV) analyzed would not have enough highly liquid assets to meet investors' redemption requests in a market stress situation and thus present liquidity shortfalls (Table 8).

133. Limited pockets of vulnerabilities can be identified in those portfolios either with a concentrated exposure to other non-domestic CIUs or whose risk exposure might be not sufficiently diversified. While the mixed funds presenting a potential liquidity shortfall could activate and use some LMTs, non-public alternative investment funds, which sold to professional investors may not have this possibility. Non-domestic funds in which non-public alternative funds invest might not benefit from deep liquidity on their side and thus may not be able to promptly provide liquidity in a stressed market situation. This may be further exacerbated if the underlying funds engage into leveraged activities.

Table 8. Belgium: Results of the Liquidity Stress Test for the Historical Approach

Category	Homogeneity (ES 3%)			Heterogeneity (ES 3%)		
	Funds with RCR < 1	% Funds with RCR < 1	% NAV with RCR < 1	Funds with RCR < 1	% Funds with RCR < 1	% NAV with RCR < 1
Bond funds	0	-	-	0	-	-
Mixed (FoFs)	1	>1%	0.0%	1	>1%	0.1%
Non-public alternative funds	5	13%	46.3%	6	16%	57.1%
Other	0	-	-	0	-	-
Total	6	1.1%	5.4%	7	1.6%	6.7%

Note: RCR is the Redemption Coverage Ratio (Highly Liquid Assets/Redemption shock).
Source: FSMA, NBB, Lipper, IMF staff calculations.

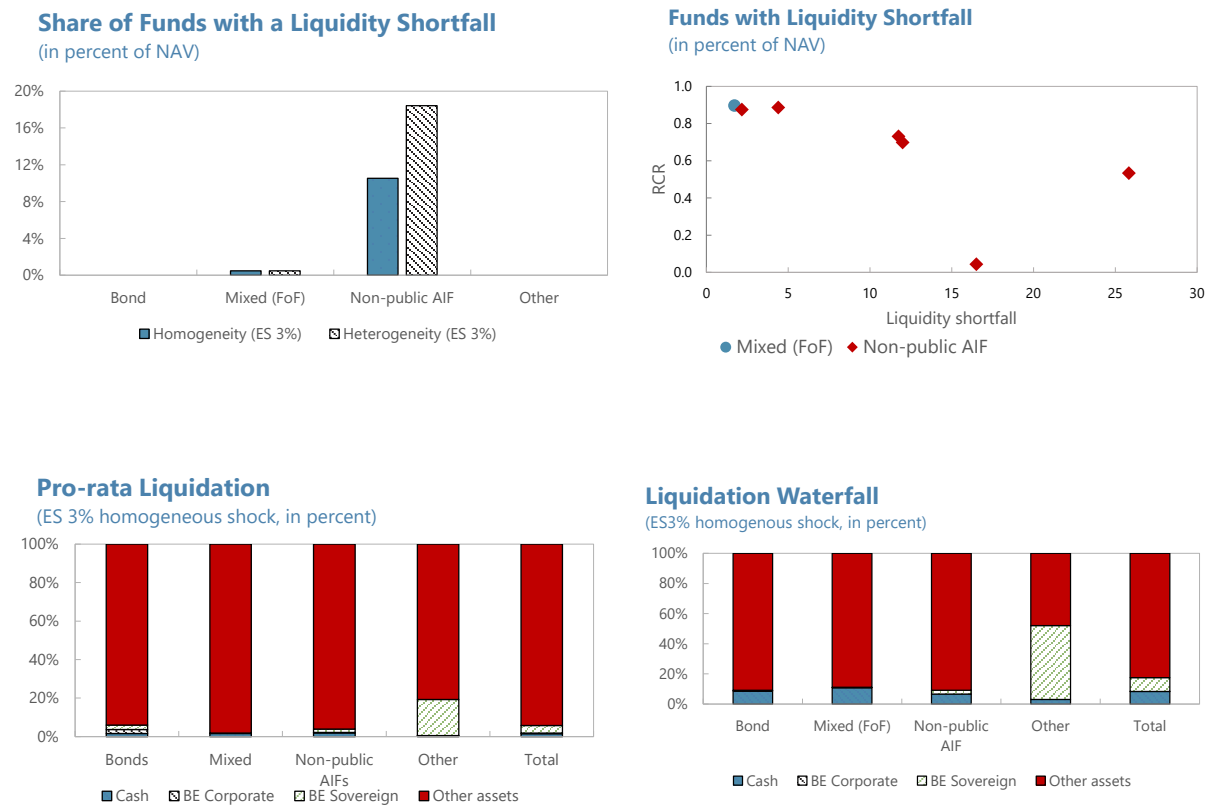
134. The redemption shock does not result in significant market price impact. In the reference scenarios, the liquidation of domestic sovereign bonds would amount to 10-13 percent of the assets liquidated by investment funds (Figure 34). Benefitting from a sufficiently large market depth, under the different liquidation strategies, there would not be any relevant price impact from the funds' sales.

Complementary market-based contagion analysis

135. A market-based analysis is performed to assess indirect spillover risks originating in specific markets in distress or transmitted by other investment funds due to co-movement in asset prices. The analysis of investment funds vulnerability to volatility shocks is based on the Diebold and Yilmaz (2009, 2012) connectedness framework (Appendix IX). Equity, bond, and mixed fund indices are built based on funds' weekly performances and are used to estimate spillovers from each fund category as well as from domestic and foreign markets.

136. Belgian investment funds are exposed to volatility spillovers from foreign markets. The market-based interconnectedness analysis indicates that bond, equity, and mixed funds are more vulnerable to volatility shocks originating in other European jurisdictions and global markets than to spillovers from the domestic market. Market-based contagion between domestic funds appears overall limited to equity funds and mixed vehicles exhibit stronger co-movements and similar inward spillovers from foreign markets (Figure 35).

Figure 34. Belgium: Liquidity Shortfall and Asset Liquidation



D. Recommendations

137. The NBB and the FSMA should establish a formal agreement for sharing investment funds data. The FSMA collects a broad set of supervisory data as the European data collection established under the AIFM Directive has been extended also to UCITS funds. This information should be complemented with data investment funds' portfolios collected by the NBB. The FSMA should further develop and improve the effectiveness of their data driven risk-based supervisory framework by including this enhanced information set in their monitoring tool.

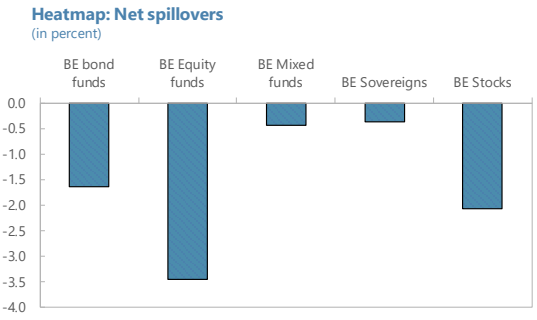
138. The FSMA should develop and adapt their stress test framework for conducting market wide liquidity risk analysis. Using detailed information collected by the NBB together with the other available supervisory data, the authority should complete their analytical framework to assess structural vulnerabilities in the sector. This assessment can form part of the systemic risk assessment of the NBB. The FSMA should further develop and improve the effectiveness of their data driven risk-based supervisory framework by including this enhanced information set in in their monitoring tool.

139. Based on the investment fund liquidity analysis, the FSAP also makes the following recommendations:

- The FSMA should monitor more closely Belgian managers of non-public open-ended AIFs, to enhance their liquidity management including by recommending the availability and use of LMTs where necessary and propose possible amendments to the legislation considering European framework on this point.
- The FSMA and the NBB should continue common reporting on asset management & NBFI, including a cooperation between FSMA and NBB to monitor relevant transfers between credit institutions and investment funds managed by affiliated managers.
- Given its advanced framework regarding LMTs, the FSMA should monitor and assess the use of LMTs by IFs within the European framework and should consider issuing guidance on their use, taking into account international developments.

Figure 35. Belgium: Market-Based Contagion Analysis

Heatmap: Net spillovers



Heatmap: Volatility spillover

		FROM:					
		Own variance	Other BE Funds	BE Sovereigns	BE Stock market	EU markets	Global markets
TO:	BE bond funds						
	BE Equity funds						
	BE Mixed funds						

INTERCONNECTEDNESS ANALYSIS

A. Domestic Interbank Contagion and Interconnectedness Analysis

140. The contagion analysis relies on the methodology developed by Espinoza and Sole (2010), which captures the propagation of a credit and funding shock throughout the banking system. [27] The analysis is based on large exposures data for nine banks from COREP, reported by end of December 2022. An initial credit shock is assumed to affect one bank, leading to their default on debt obligations to their creditors. Subsequently, the capital of the creditor banks is used to absorb these unexpected losses. If insufficient, they would default on their creditors. Funding shock, on the other hand, is simulated through failure of a bank and its impact on its debtor banks, who are forced to find alternative funding sources. Debtor institutions absorb funding shortfall-induced losses using their capital. If insufficient, they default. Simulations stop when no banks default.

141. Two spillover scenarios are conducted: i) a credit shock scenario; and ii) a credit and funding shock scenario. The model requires a set of predetermined parameters:

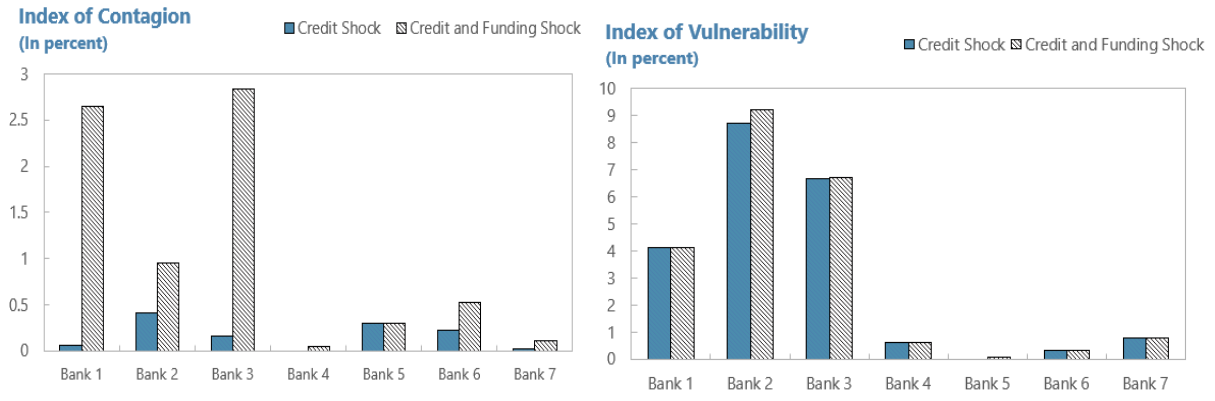
- *Lambda* (credit shock): The portion of LGD. It is set to 65 percent.
- *Delta* (funding shock): The loss factor due to funding shortfall. It is set to 50 percent.
- *Rho* (funding shock): The fraction of lost funding that is not replaceable. It is set to 35 percent.

142. Analysis of domestic interbank exposures indicates low contagion risks for Belgian banks (Figure 36).[28] The finding shows that the failure of a single domestic bank would not trigger the failure of another bank. Additionally, no bank falls below its regulatory minimum capital requirement after experiencing shocks to one/ several of its interbank exposures. Overall, the vulnerability to spillover effects remains low across banks, albeit with some variation. However, specific institutions contribute to the high vulnerability index observed for certain banks.

[27] Espinosa-Vega, M., & Sole, J. (2010). Cross-Border Financial Surveillance: A Network Perspective. IMF Working Paper.

[28] For the analysis, the FSAP team has incorporated two additional institutions that exhibit significant exposure from most banks. However, these institutions are not depicted in the interbank exposures' charts.

Figure 36. Belgium: Interbank Exposures

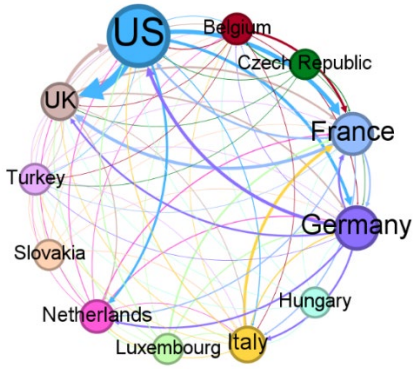


Sources: IMF staff calculations.
Notes: Index of contagion (of index of outward spillover risks): the average loss of other banks due to the failure of a bank *i*; Index of vulnerability (or index of inward spillover risks): the average loss of a bank *i* due to the failure of all other banks.

B. Cross-Border Contagion and Interconnectedness Analysis

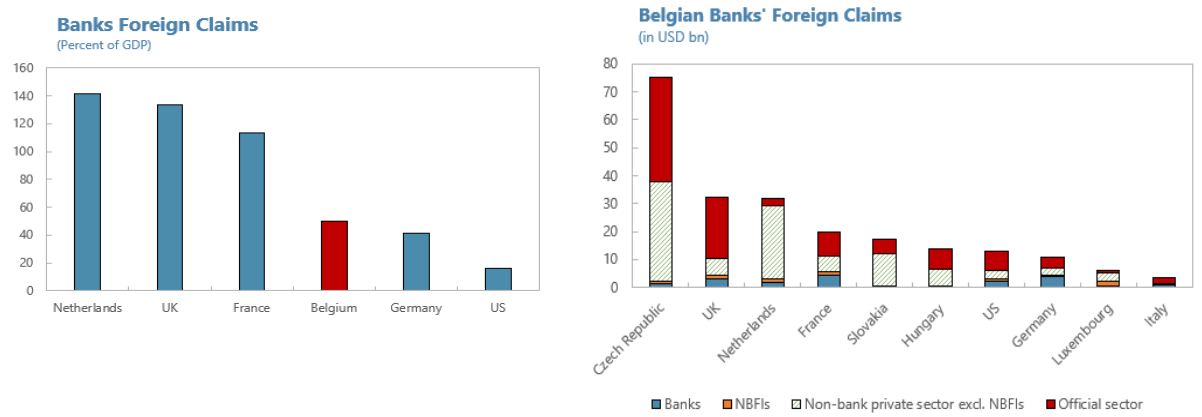
143. Belgian banks exhibit a moderate degree of interconnectedness with rest of the world, with foreign claims of 50 percent of GDP (Figure 37). Among its cross-border exposures, a predominant concentration of over 60 percent is directed towards the Czech Republic, the United Kingdom, the Netherlands, France, and Slovakia, with a primary focus on non-financial sectors.[29] Domestic exposures of Belgian banks are concentrated in the household, government, and NFC sectors, making up 61 percent of total domestic exposures.

Figure 37. Belgium: Cross-Border Exposures[1/ 2/]



[29] Non-financial sectors here refer to official sector, NFCs, and households.

Figure 37. Belgium: Cross-Border Exposures (Concluded)



Sources: BIS Consolidated Banking Statistics, ECB, NBB, IMF staff estimates.

Notes:

1/ The arrow points to the country/ sector that is exposed to; Greater funding flows between two countries/sectors are represented by thicker lines. Node size proportionally represents domestic banks' domestic positions/ intra-sectoral connections.

2/ For the cross-border interconnectedness chart, Czech Republic, Luxemburg, Hungary, and Slovakia's domestic positions are not included. The exposures of the Belgian subsidiaries of two institutions headquartered outside Belgium are accounted for as Belgium's exposures. These exposures have been excluded from the respective exposures of the countries their headquarters are based.

144. In cross-border analysis, BIS consolidated banking statistics for 2022Q4 data is used, supplemented by the data provided by NBB on the Belgian subsidiaries of two institutions headquartered outside Belgium.[30] The same methodology and parameters are used as in the interbank analysis (lambda is set to 65 percent, delta is 50 percent, and rho is 45 percent). The capital data for each country in this analysis utilizes capital and reserve data from the respective country's MFIs, excluding central banks.[31] Three spillover scenarios are tested: i) a credit shock to cross-border all sectors, ii) a credit shock to cross-border financial sectors, and iii) a credit and funding shock to cross-border financial sectors.

145. The simulation reveals that Belgium is highly vulnerable to contagion from an external shock. Aside from the US, a default of all exposures in the Czech Republic, Netherlands, France, Luxembourg, and the UK would have a significant adverse impact on banks' capital in Belgium Figure 38.[32] However, the impact on Belgian banks in the occurrence of a default in any financial institution is expected to be marginal. This is because Belgian banks have limited cross-border exposure to the financial sectors, thereby reducing the potential effects of credit and funding shocks.

[30] NBB data on the Belgian subsidiaries are only applied to all exposures analysis.
[31] The capital data for the US only includes commercial banks.
[32] BIS consolidated banking statistics data on guarantor basis is used for analysis, meaning inward and outward risk transfers across countries has been taken into consideration.

Figure 38. Belgium: Cross-Border Contagion Analysis Results

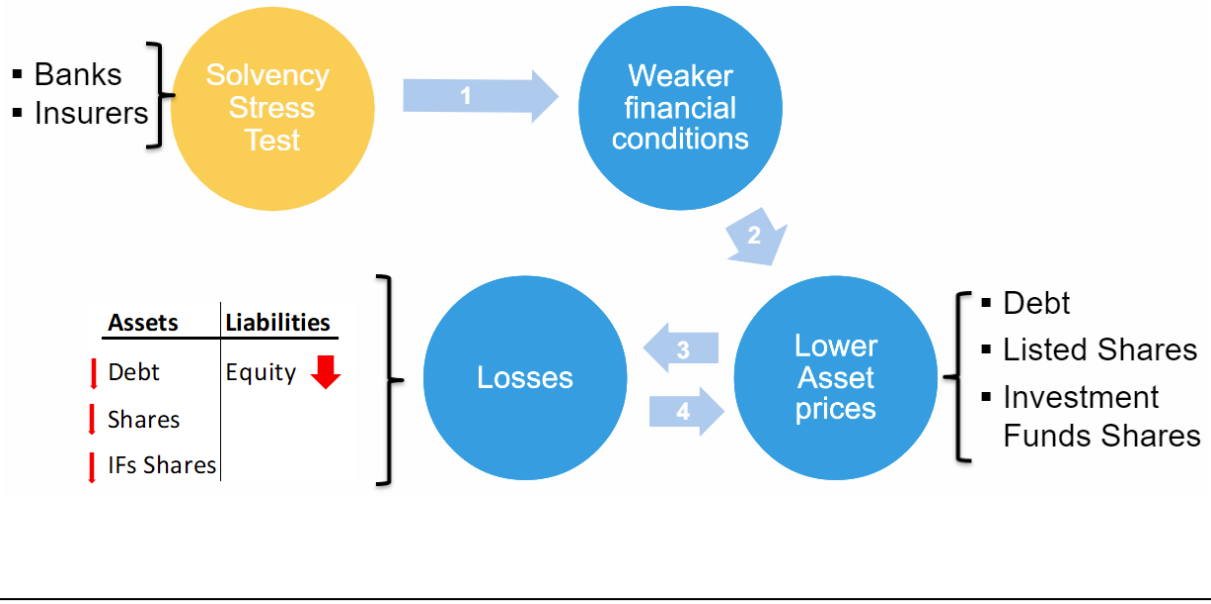
Sources: BIS, ECB, Fed, NBB, and IMF staff calculations.

C. Cross-Sectoral Contagion Analysis

146. This model analyzes the second-round effects of the solvency stress tests of banks and insurers through the crossholdings of financial instruments. In a market set-up, the deterioration of the financial situation of banks and insurance companies because of the stress test would impact the prices of the securities they have issued. As a result, this will generate losses on the books of the institutions who hold those assets. Typically, though, the losses further depress the prices of those same assets, therefore igniting a spiral of losses and lower prices that percolates through the system. Even though in the case of Belgium, cross holdings of financial assets among Banks, insurers, and investment funds are rather limited, insurance companies do have some exposure to banks' debt (about 1 billion Euros) and to investment funds' issued shares (about €17 billion).

147. The analysis is conducted in several steps ((Figure 39). First, satellite models for yields and share prices are estimated (Appendix X). The models show how yields on debt issued by banks and insurance companies as well as their listed share prices are affected by their solvency, liquidity, and profitability. Because of data availability, the coverage of the satellite models—both in terms of institutions and sample period—differ across models. For the yields on bank-issued debt we estimate an unbalanced panel covering six banks, while for banks' share prices we estimate an unbalanced panel covering three banks. Instead, the equations for bond yields and share prices of insurance companies are estimated over a panel covering three insurance groups.

Figure 39. Belgium: Market Interconnectedness Flowchart



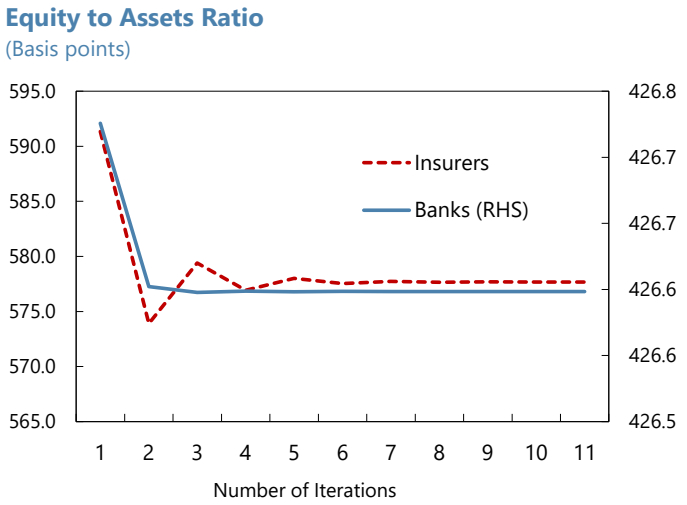
148. In the second step, the models are used to predict yields and share prices under the stress scenario. The results from the solvency stress tests are used as input in the estimated equations to predict yields and share prices that would prevail in the market if banks and insurers saw their financial conditions deteriorate as predicted in the solvency stress test exercises. Because the bank solvency stress test is a result of a scenario unfolding over a four-year horizon, the predicted changes in bond yields and share prices for banks are computed using the change in right-hand-side variables between the first and the last year of the stress test. Instead, for insurers, because the stress test for insurers is the result of an instantaneous shock, they are computed using the chance in right-hand-side variables between the baseline and the peak of the stress. The predicted changes in bond yields and share prices are then used to calculate the change in the market price of investment funds' issued shares. This is assumed to happen mechanically, with the price of investment funds' changing proportionally to the change in the prices of other assets, weighted by investment funds' exposure. Data on exposure come from the "Who-to-whom" matrix as of end 2022.

149. Losses from the revaluation of the asset prices are reflected in a drop in the equity to asset ratio of banks and insurers. The change in equity is computed as the sum of the revaluation losses from the holdings of debt and shares. Specifically, revaluation losses from holding of debt are computed multiplying the change in yield with the exposure and the debt's modified duration. Instead, revaluation losses from holdings of shares are computed multiplying the predicted rate of change of share prices with the exposure. The average duration of debt issued by banks is assumed to be slightly below 4 years, while the average duration of the debt issued by insurers is assumed to be about 10 years.

150. Drops in the equity of banks and insurance companies further increase the yields on their debt and depress the price of their shares. The drop in the equity caused by revaluation losses is then mapped to yields and share prices of banks and insurance companies using the satellite models described earlier. And the same rule-based approach is then used to recompute prices of investment funds' shares. The process can therefore be iterated until prices of financial assets and losses stabilize.

151. The model converges rapidly and shows that losses from crossholdings of market instruments are limited (Figure 40). The losses to equity of banks and insurance companies stabilize relatively quickly (i.e., the algorithm converges after about 12 iterations). The results show losses to be very limited: banks' equity to asset ratio declines from 4.267 percent to 4.266 percent, and insurers' equity to asset ratio declines from 5.913 percent to 5.777 percent. The larger decline for insurers is explained by the fact that they are exposed to revaluation losses from their holdings of bank issued debt. However, even though they hold a relatively large proportion of investment funds' issued shares, this channel of contagion is very weak because investment funds themselves have very little exposure to bank issued debt.

Figure 40. Belgium: Market Interconnectedness Results



Sources: IMF staff calculations.

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Appendix I. Risk Assessment Matrix

Table 1. Belgium: Risk Assessment Matrix[1/]

Source of Risks	Likelihood of Realization of Threat in the Next 1–3 years	Expected Impact on Financial Stability if Threat is Realized (High, Medium, or Low)
Global Conjunctural and Structural Risks		
Intensification of regional conflict(s). Escalation of Russia's war in Ukraine or other regional conflicts and resulting economic sanctions disrupt trade (e.g., energy, food, tourism, and/or critical supply chain components), remittances, FDI and financial flows, and payment systems, and lead to refugee flows.	**High**	**High** Direct energy, trade and financial links with Russia and Ukraine are limited. An escalation of the war would affect the economy mainly via indirect growth spillovers and rekindled inflation from higher commodity prices. Frozen assets of Russian entities held by Euroclear Bank raise litigation and reputational risks with potentially adverse consequences for financial stability.
Abrupt global slowdown or recession. Global and idiosyncratic risk factors combine to cause a synchronized sharp growth downturn, with recessions in some countries, adverse spillovers through trade and financial channels, and market fragmentation causing sudden stops in EMDEs. **Europe:** Intensifying fallout from the war in Ukraine, recurrent energy crisis and supply disruptions, and monetary tightening exacerbate economic downturns, and housing and commercial real estate market corrections.	**Medium** **Medium**	**High** As a highly open economy, spillovers from a sharp downturn in key trading partners (France, Germany, The Netherlands) would dampen economic growth. With elevated financial sector exposures to real estate markets, steep price corrections would weaken macro-financial stability.
Monetary policy miscalibration. Amid high economic uncertainty and volatility, major central banks pause monetary policy tightening or pivot to loosen monetary policy stance prematurely, de-anchoring inflation expectations, triggering a wage-price spiral and spillovers to financial markets	**Medium**	**High** Near-universal automatic wage and benefit indexation may quickly translate de-anchored inflation expectations into wages and prices. International competitiveness would suffer, weakening the external balance and potential output

Table 1. Belgium: Risk Assessment Matrix (Concluded)

Source of Risks	Likelihood of Realization of Threat in the Next 1-3 years	Expected Impact on Financial Stability if Threat is Realized (High, Medium, or Low)
Sovereign debt distress. Domino effects of higher global interest rates, a growth slowdown in AEs, and/or disorderly debt events in some EMDEs spillover to other highly indebted countries, resulting in capital outflows, an increase in risk premia, and loss of market access.	**Medium**	**Medium** Elevated financing costs for a prolonged period would undermine fiscal sustainability, given elevated debt and deficit levels. A favorable sovereign debt maturity profile provides support. The impact on banks is curbed by their relatively modest exposure to sovereign debt.
Deepening geoeconomic fragmentation. Broader and deeper conflict(s) and weakened international cooperation result in a more rapid reconfiguration of trade and FDI, supply disruptions, protectionism, technological and payments systems fragmentation, rising input costs, financial instability, a fracturing of international monetary and financial systems, and lower potential growth.	**High**	**Medium** Belgium is vulnerable to deglobalization due to strong cross-border real and financial linkages and the presence of multi-national corporations and large financial/payment services providers, heightening risks to economic dynamism and financial stability. Financial sector resilience and EU/euro area membership provide support.
Disorderly energy transition. Disorderly shift to net-zero emissions (e.g., owing to shortages in critical materials) and climate policy uncertainty cause supply disruptions, stranded assets, market volatility, and subdued investment and growth.	**Medium**	**Medium** Despite a rather diversified energy supply, slow progress with reaching ambitious climate targets may require accelerated efforts in later years, triggering a disorderly transition with negative consequences for an energy intensive, highly industrialized economy.
Belgium-Specific Risks		
Political uncertainty and fragmentation may intensify ahead of general elections in 2024 and lead to a protracted government formation process, delaying fiscal consolidation and structural reforms in support of higher potential growth, energy security, climate transition and digital transformation	**High**	**High** Fiscal sustainability concerns may result in a substantial increase in borrowing costs and a need for a sharper fiscal adjustment, with negative consequences for growth and financial stability. Prolonged inaction in policy areas demanding urgent attention may dampen economic output, weaken competitiveness, and aggravate social frictions.

[1/] The Risk Assessment Matrix (RAM) shows events that could materially alter the baseline path. The relative likelihood is the staff's subjective assessment of the risks surrounding the baseline ("low" is meant to indicate a probability below 10 percent, "medium" a probability between 10 and 30 percent, and "high" a probability between 30 and 50 percent). The RAM reflects staff views on the source of risks and overall level of concern as of the time of discussions with the authorities. Non-mutually exclusive risks may interact and materialize jointly.

Appendix II. Stress Test Matrix (STeM)

Banking Sector: Solvency Stress Test		
Top-down by IMF		
1. Institutional Perimeter	Exercise	• Top-Down by FSAP team.
	Institutions included	• Seven banks subcategorized as SIs. • Among the SIs, five are domestic and two are subsidiaries of foreign institutions. • All banks are domestically focused, but they have large cross-border exposures.
	Market share	• Total coverage is about 89.4 percent of the banking sector.
	Data and baseline date	• Multiple data vintages: December 2022 (year end, starting point for PnL), and March 2023 (starting point for balance sheet and capital). • Supervisory data: Bank balance sheet and supervisory statistics (including FINREP and COREP), information on interest rate risk in the banking book (IRRBB), liquidity risk and market risk sensitivities (including STE templates) provided by the authorities and the ECB. Expected Default Frequency sourced from Moody's. Further supervisory information was provided, including the probability of defaults by credit portfolios, and a bank-specific stage transition matrix by portfolio from FINREP. • Market and publicly available data, such as information from ECB statistical data warehouse on funding and lending rates by type of asset and funding portfolios. • Scope of consolidation: banking activities of the consolidated banking group for banks having their headquarters in Belgium. Foreign subsidiaries are assessed on the unconsolidated level covering domestic activities only. • Coverage of sovereign and non-sovereign securities exposures: debt securities measured through fair value (FVPL and FVOCI) and amortized cost (AC) account. • Coverage of lending exposure: credit institutions, nonbank financial institutions, household, and corporate.
2. Channels of Risk Propagation	Methodology	• FSAP team satellite models and methodologies. • Balance-sheet regulatory approach. • Market risk is treated as an add-on component, with a separate calibration. The market risk stress scenario has an impact on both capital resources (either via profit and loss or via Other Comprehensive Income (OCI)) and capital requirements (RWA). The impact on capital resources comprises of positions in the trading book as well as other fair valued items in the banking book. The impact on RWA for market risk evolve with balance sheet assumptions. • Traded risk impact from the revaluation of trading assets (FVPL) and securities classified as fair value through other comprehensive income (FVOCI) securities by counterparty: central government (by country issuers), credit institutions, other financial institutions, and nonfinancial corporates. Credit spreads on sovereign, credit institutions and corporate securities interpolated using bank-specific

		residual maturity at the book and issuer level (i.e., sovereign issuers by country and individual corporate issuers by ISIN codes). Credit spreads on other securities estimated on a hypothetical portfolio using a duration proxy. Valuation effects assessed using a modified duration approach. Hedges are considered as ineffective under stress. • The losses for securities portfolios are based on duration approach. Losses on equities (both long and short position) were based on stock market price movement specified by the scenario. • For internally modelled exposures (IRB), projection of PiT and TTC PDs, LGD, EAD and RWA. For STA exposures, projection of new flows of defaulted exposures, coverage ratio for defaulted loans, and risk weight downgrade for performing exposures. Credit risk projections for IRB and STA exposures cover credit institutions, nonbank financial corporates, and households. Corporate PDs for largest exposures are proxied by Moody's EDFs. The resulting impact is translated into credit loss impairment charges and shifts to RWAs due to capital charges for defaulted assets. • Provisioning for IRB and STA are 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) are modeled using COREP data. • Net interest income projection incorporates the maturity profile of assets and liabilities. Effective interest rates are projected through econometric satellite model, where the exogenous variables reflect the interest rate environment. Sensitivity analyses is used to examine the impact of changes in depositor behavior. • Funding costs projected at the portfolio level using funding structure by product (retail and wholesale deposits, secured and unsecured debt securities, repo, etc.) and maturity bucket (overnight vs. term). Funding projections capture systemic risk (linked to the scenario) and idiosyncratic risk (for spreads on debt instruments issued over benchmark). Funding cost projections utilize bank level data on from COREP templates. Lending rates are projected at the system level and attached to bank-specific interest rates and outstanding amount at cut-off date (interest rate on corporate and household loans and debt securities). • Change in risk weighted assets (RWAs) are estimated on banking book exposures (credit risk charges – CRC) and market risk exposures (market risk charges – MRC) according to Basel III rules. Additional regulatory risk charges (operational risk charges – ORC and counterparty credit risk charges – CCRC) will change according to the overall balance-sheet growth assumptions. The balance sheet will follow nominal GDP growth, when positive, or it will remain stable, when the latter is negative.
	Stress test horizon	• 2023 Q1–2026 Q4 (4 years)
3. Tail Shocks	Scenario	Two Scenarios: • A baseline scenario based on the April 2023 WEO macroeconomic projections.

		• An adverse scenario that captures the key risks in the RAM. This scenario relies on GFM, a structural macroeconometric model of the world economy, disaggregated into forty national economies, documented in Vitek (2018). Scenarios for foreign countries where Belgium has significant exposure is extracted from GFM and is internally consistent with country scenarios of other ongoing FSAPs.
4. Risks and Buffers	Risk covered	• Risks covered include credit (on loans and debt securities), market (valuation impact of debt instruments through repricing and credit spread risk as well as the P&L impact of net open positions in market risk factors such as foreign exchange risks) and interest rate risk (IRRBB) on the banking book. • Concentration risk by sensitivity analysis. • Solvency and liquidity risk interactions, mainly through asset 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. • In projecting RWAs, standardized and IRB portfolios are differentiated. For the standardized portfolios, RWAs changed due to the balance sheet growth, new inflows of non-performing loans, new provisions for credit losses, exchange rate movements, and the conversion of a portion of off-balance sheet items (undisbursed credit lines and guarantees) to on-balance sheet items. For the IRB portfolios, through-the-cycle-PDs, downturn LGDs and EAD for each asset class/industry are used to project risk weights. • Interest income from non-performing 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 30 percent of current period net income after taxes (i.e., only if net income is positive) by banks that are in compliance with supervisory capital requirements.
5. Regulatory and Market-Based Standards and Parameters		• National regulatory framework Basel III regulatory minima on CET1 (4.5 percent) and include any requirements due to systemic buffers for three other systemically important institution (O-SII). In addition to the CET1, the team evaluates total banking capital adequacy ratio against the 8 percent level, their Tier 1 capital ratio against the 6 percent benchmark and the leverage ratio during the stress test horizon against the 3 percent Basel III minimum requirement. The same hurdle rate is used for baseline and adverse scenario. The hurdle rate for CET1, T1 and total capital adequacy do not include capital conservation and capital countercyclical buffers as well as pillar 2 requirement. Banks that end the stress test horizon with a capital level or a leverage ratio below the relevant hurdle rates, are considered to have failed the test.

6. Reporting Form for Results	Output presentation	• The results of the stress tests are reported using a variety of charts and tables. These potentially include the evolution of capital ratios for the system as a whole and as groups of retail banks and large international banks. Outputs also include information on impact of different result drivers, including profit components, losses due to realization of different risk factors; capital shortfall as sum of individual shortfalls; in euros and in percent of nominal annual GDP; number of banks and corresponding percentage of assets below the regulatory minimum (or below the minimum leverage ratio).
Banking Sector: Liquidity Stress Test		
Top-down by IMF		
1. Institutional Perimeter	Exercise	• Top-Down by FSAP team.
	Institutions included	• Seven banks subcategorized as SIs (same sample as in solvency stress test).
	Market share	• Total coverage is about 89.4 percent of the banking sector
	Data and baseline date	• Latest data: April 2023. • Source: supervisory data (LCR, NSFR, and ALMM Maturity Ladder template). • Scope of consolidation: banking activities of the consolidated banking group for banks having their headquarters in Belgium. Foreign subsidiaries are assessed on the unconsolidated level covering domestic activities only.
2. Channels of Risk Propagation	Methodology	• Basel III LCR and cash-flow based liquidity stress test using maturity buckets by banks, incorporating both contractual and behavioral (where available) with assumption about combined interaction of funding and market liquidity and different level of central bank support. • Liquidity test in EUR and foreign currencies (USD).
3. Risks and Buffers	Risks	• Funding liquidity. • Market liquidity.
	Buffers	• The counterbalancing capacity, including liquidity obtained from markets and/or the central bank's facilities. Expected cash inflows are also included in the cash-flow based and LCR-based analysis.
4. Tail shocks	Size of the shock	• The run-off rates are calibrated to reflect scenarios of system-wide deposit runs and dry-up of unsecured wholesale and retail funding, with additional run-off for non-resident deposits on top of the retail and wholesale run-off, which is calibrated following historical events, recent international experience in liquidity crisis and IMF expert judgment. • The liquidity shocks will be simulated for 1–month for both LCR, and 5-days, 1-month, 3-months, and 1-year for the cash-flow based approach. • The haircuts of high-quality liquid assets (HQLA) are calibrated against ECB haircuts, past Euro Area FSAPs, and market shock for investment securities and money market instruments in the solvency stress test. • Six cashflow analysis scenarios: The first three capture stress in the retail and wholesale segments, which translate in deposit outflows,

		and lower inflows through losses from loans in the respective segments. The shock is also assumed to affect (modestly) the value of assets—hence affecting inflows and outflows through collateralized operations as well as the value of liquid assets. The fourth scenario features stress on wholesale market funding, translating into a more aggressive haircut on assets. The fifth scenario combines the previous one with a stress on wholesale deposits and loans. Finally, the sixth scenario is a combination of all the previous five. • Since retail deposits is the main source of funding for the financial system the system will implement a sensitivity analysis of the outflow rates on uninsured deposits to identify the liquidity breaking point of the banking sector. • Three cashflow stress scenarios: Scenario A is a deposits funding stress. Household and corporates face strong liquidity strain and banks experience net outflows of deposits as enterprises and households run down their liquid savings, while counterbalancing haircuts increase mildly. Scenario B is a market liquidity stress. Banks experience outflow of funds from wholesale borrowers and the market price of the assets on which banks rely collapse. Subsequently, CBC haircuts increase significantly. Scenario C is a combined stress and is in line with the recent market turmoil / GFC.
5. Regulatory and Market-Based Standards and Parameters	Regulatory standards	• Consistent with Basel III regulatory framework (LCR). • Liquidity shortfall by bank.
6. Reporting Format for Results	Output presentation	• Liquidity ratio or shortfall by groups of banks and aggregated (system wide). • Number of banks that still can meet or fail their obligations.
Banking Sector: Solvency and Liquidity Interaction		
Top-down by IMF		
7. Institutional Perimeter	Exercise	• Top-Down by FSAP team.
	Institutions included	• Seven banks subcategorized as SIs (same sample as in solvency stress test).
	Market share	• Total coverage is about 89.4 percent of the banking sector
	Data and baseline date	• Latest data: April 2023. • Source: Top-down solvency and cashflow analysis output. • Scope of consolidation: banking activities of the consolidated banking group for banks having their headquarters in Belgium. Foreign subsidiaries are assessed on the unconsolidated level covering domestic activities only.
8. Channels of Risk Propagation	Methodology	• Estimate the proportion of the HTM debt portfolio that will be sold to cover net outflows under the three cash-flow analysis scenarios. • Estimate the unrealized losses due to revaluation of the price of these securities over the course of the scenario.

		• Assign an additional forced liquidation haircut and implementation of the total forced liquidation losses to the total profitability and capital depreciation over the course of the scenario.
9. Risks and Buffers	Risks	• Funding liquidity. • Market risk.
10. Tail shocks	Size of the shock	• Total liquidity shocks over a period of 1-year for the cash-flow based approach. • The haircuts of high-quality liquid assets (HQLA) are calibrated against ECB haircuts, past Euro Area FSAPs, and market shock for investment securities and money market instruments in the solvency stress test. • HTM unrealized losses are estimated using the historical increase of the risk rate in 2022 and the risk-free rate path of the macroeconomic scenarios
11. Reporting Format for Results	Output presentation	• Losses from HTM forced liquidation (system wide). • New profitability and capital adequacy ratios.
System-wide: Interconnectedness Analysis		
Top-down by IMF		
12. Institutional Perimeter	13. Exercise	14. Top-Down by FSAP team.
	Institutions included	• Seven banks subcategorized as SIs (same sample as in solvency stress test, institution specific analysis). (Exercise A) • Cross-border contagion: country-pair bilateral exposure across the world. (Exercise B) • Aggregate domestic banking sector, insurance sector, and investment funds sector (sector-wide analysis). (Exercise C)
	Data	• Supervisory data: Bank balance sheet and supervisory statistics (COREP – Large exposures). (Exercise A) • BIS consolidated banking statistics. (Exercise B) • Leper cross-sectoral exposures. (Exercise C)
1. Channels of Risk Propagation	Methodology	• Balance-sheet model: Network model by Espinosa-Vega and Solé (2010). (Exercises A and B) • Satellite models on yields and share prices projections. (Exercise C)
2. Tail shocks	Size of the shock	• Default threshold: banks would default if their capital fall below regulatory minimum. (Exercise A) • Pure contagion: financial distress in foreign countries. (Exercise B) • Market contagion through devaluation of assets. (Exercise C)
Insurance Sector: Solvency Analysis		
Top-down by IMF		
3. Institutional Perimeter	Exercise	• Top-Down by FSAP team, Bottom-Up by insurance undertakings.
	Institutions included	• 8 composite insurers (76% of total balance sheet assets). • 6 composite insurers (63% of total balance sheets assets) for BU exercise.
	Data and baseline date	• Regulatory reporting December 31, 2022.
4. Channels of Risk Propagation	Methodology	• Investment assets: market value changes after price shocks affecting the solvency position.

		• Insurance liabilities: impact on the value of the best estimate by changing the discount rate of future cash flows. • Sensitivity analysis: effect on available capital and solvency position.
5. Tail shocks	Size of the shock	• Instantaneous shock. For example, market shocks on equity and property prices have been front-loaded so that the maximum drawdown during the project horizon of the macrofinancial scenario is realized immediately after the reference date (end 2022). Furthermore, the risk-free rate term structure is adjusted to account for the significant downward reversal of risk-free rates after 2023. The inflation shock extends the path for the CPI and wage inflation to a gradual return to a two-percent inflation after the five-year model period. Furthermore, a 30 percent lapse shock for non-mandatory insurance (term insurance, endowments, unit linked products, and disability) on insurers' in-force life portfolio is assumed. • Risk-free interest rates (without volatility adjustment) 447 bps (1y EUR), 455 bps (10y EUR) • Sovereign bond spreads 90 bps domestic, 55 bps low spread EA countries, 120 bps high spread EA countries, 70 bps other advanced economies, 120 bps emerging and developing countries. • Stock prices -33.6 percent European Union, 33 percent other advanced economies, 32 percent emerging and developing economies. • Property prices 25 percent (commercial), 20 percent (residential) • Corporate bond spreads between 60 bps (AAA financials) and 355 bps (B and lower financials), and between 50 bps (AAA non-financials) and 325 bps (B and lower non-financials) • Mortgage default increase two percent domestic, three percent non-domestic
6. Reporting Format for Results	Output presentation	• Impact on solvency ratios (with and without long-term guaranteed measures and transitionals). • Contribution of individual shocks to changes of eligible own funds. • Impact of reactive management actions (bottom-up only). • Dispersion measures of solvency ratios.
Insurance Sector: Liquidity Analysis		
Top-down by IMF		
7. Institutional Perimeter	Exercise	• Top-down by FSAP team.
	Institutions included	• 8 composite insurers, 2 life insurers with significant IRS exposure (84% of total balance sheet assets)
	Data and reference date	• Regulatory reporting, December 31, 2022.
8. Channels of Risk Propagation	Methodology	• Revaluation of derivative position after interest rate shock • Mass lapse shock and shock to liquid assets
9. Tail shocks	Sensitivity analysis	• Parallel shift of the interest rate term structure, +25 bps, +50 bps, +100 bps
10. Reporting Format for Results	Output presentation	• Variation margin as percent of cash holdings. • Variation margin as percent of cash holdings plus high-quality liquid assets. • Stressed liquidity ratios

Investment Fund Sector: Liquidity Risk		
Top-down by IMF		
1. Institutional Perimeter	Exercise	• Top-Down by FSAP team.
	Institutions included	• Bond and mixed Investment funds.
	Market share	• Varies by type of fund.
	Data and baseline date	• Lipper. • NBB and FSMA supervisory data. • Portfolio reporting date: End of year 2022.
2. Channels of Risk Propagation	Methodology	• Various levels of redemptions shock compared level of highly liquid assets at fund category level. • Redemption shocks calculated based on historical data on redemptions using VaR and Expected Shortfall. • Methodologies with multiple thresholds. • Historical time series with monthly frequency. • Liquidation strategy: vertical vs. horizontal slicing
	Assumptions	• A first set of redemption shocks will be calibrated based on funds' historical flows. Another set of shocks to the value of funds' asset holdings could be calibrated in line with the adverse scenario, assuming funds' returns can be estimated. Based on funds' liquidation strategies, the price impact of asset sales could be assessed.
	Time horizon	• Instantaneous shock.
3. Risks and Buffers	Risks	• Liquidity risk: severe but plausible redemption shock.
	Buffers	• Level of highly liquid assets.
4. Tail shocks	Scenario analysis	• Pure redemption shock: severe outflows based on historical distribution.
	Market-based contagion analysis	• Diebold-Yilmaz methodology applied to fund indices to assess vulnerability to market distress
5. Reporting Format for Results	Output presentation	• Number of funds with a redemption coverage ratio (ratio of highly liquid assets to redemptions) below one. • Liquidity shortfall amount for individual funds after redemptions.

Appendix III. NPL and PDs Regressions Output

1. All PDs (and NPL ratios) used in the solvency stress test have been estimated through time series modelling. PDs and NPL ratios can range between [0, 1], (for 0 percent to 100 percent); thus, all econometric models have been implemented on the logistic transformation of the dependent variables

$$LogitY = ln\left(\frac{Y}{1-Y}\right) \quad \textbf{(10)}$$

where, *Y* is the dependent variable and *LogitY* is its logit transformation. The econometric model has been used to simulate 10,000 alternative paths under both the baseline and the adverse scenarios and the respective average paths have been used as projections.

NPL RATIOS

2. Historical NPL ratio is estimated through a single time series model with exogenous variables. The model has been estimated on quarterly observations from Q1 1995 to Q4 2022 (112 observations). The optimal specification of the model is an ARIMA(1,1,0), according to the minimum Bayesian Information Criterion (BIC). Dependent variable is the logit transformation of the NPL ratio, and exogenous variables are one period lagged of quarterly log-difference in property price index (PPI), one period lagged of quarterly log-difference of CPI, and one period lagged to three periods lagged of quarterly log-difference of real GDP. The specification of the model is presented in the Table XX.

Variable	Estimate	SE	tStat	pValue
AR t-1	0.252	0.098	2.583	0.011
d LN PPI t-1	-0.713	0.374	-1.910	0.059
d LN CPI t-1	1.694	0.803	2.109	0.038
d Unemployment t-1	0.029	0.012	2.354	0.021
d LN GDP t-1	-0.264	0.361	-0.730	0.467
d LN GDP t-2	-0.287	0.381	-0.755	0.452
d LN GDP t-3	-0.604	0.345	-1.753	0.083

Corporate and financial institutions EDF

3. Historical Moody's average corporate EDF of 11 countries is estimated through a panel model with exogenous variables. The model has been estimated on quarterly observations from Q2 2013 to Q4 2022. The panel is unbalanced and consists of observations is 417. The optimal specification of the model is an ARIMA(1,1,0). Dependent variable is the logit transformation of the average corporate EDF, and exogenous variables are country specific quarterly change in sovereign spreads and quarterly log-difference real GDP. The specification of the model is presented in the Table XX.

Variable	Estimate	SE	tStat	pValue
AR t-1	0.2600	0.0471	5.5155	0.0000
d LN GDP t	-0.4135	0.1717	-2.4088	0.0164
d SovSpread t	0.0517	0.0157	3.2975	0.0011

4. Similar to corporate EDF, average financial institutions EDF is estimated through an ARIMA(1,1,0) panel model with exogenous variables. The model has been estimated on quarterly observations from Q2 2013 to Q1 2023. The panel is unbalanced and consists of 429 observations. Exogenous variable is the one period lagged quarterly change of output gap. The specification can be found in table XX.

Variable	Estimate	SE	tStat	pValue
AR t-1	0.1329	0.0480	2.7666	0.0059
d OutputGap t-1	-0.0102	0.0055	-1.8376	0.0668

Appendix IV. Interest Rates Regressions Output

1. Interest rates of different classes of loans (interest-bearing assets) and deposits (liabilities) have been estimated through time series modeling.

Loans

2. Historical interest rates of new/variable residential mortgage loans, unsecured consumer loans and corporate loans have been cointegrated; thus, they are modeled together through a vector error correction model (VECM) with quarterly change of EURIBOR as exogenous variable. The model has been estimated on quarterly observations from Q1 2006 to Q4 2022 (70 observation). The optimal order of the model is zero (according to the BIC).

Variable	Estimate	SE	tStat	pValue
Constant (Retail Mortgage)	0.1221	0.0915	1.3346	0.1820
Constant (Consumer)	0.8333	0.1782	4.6759	0.0000
Constant (NFC Loans)	0.1307	0.1437	0.9098	0.3629
Adjustment (Retail Mortgage, Retail Mortgage)	0.0339	0.0231	1.4664	0.1425
Adjustment (Consumer, Retail Mortgage)	0.2269	0.0450	5.0433	0.0000
Adjustment (NFC Loans, Retail Mortgage)	0.0306	0.0363	0.8438	0.3988
Impact (Retail Mortgage, Retail Mortgage)	0.0788	0.0538	1.4664	0.1425
Impact (Consumer, Retail Mortgage)	0.5280	0.1047	5.0433	0.0000
Impact (NFC Loans, Retail Mortgage)	0.0712	0.0844	0.8438	0.3988
Impact (Retail Mortgage, Consumer)	-0.0691	0.0471	-1.4664	0.1425
Impact (Consumer, Consumer)	-0.4628	0.0918	-5.0433	0.0000
Impact (NFC Loans, Consumer)	-0.0624	0.0740	-0.8438	0.3988
Impact (Retail Mortgage, NFC Loans)	0.0193	0.0131	1.4664	0.1425
Impact (Consumer, NFC Loans)	0.1291	0.0256	5.0433	0.0000
Impact (NFC Loans, NFC Loans)	0.0174	0.0206	0.8438	0.3988
d EURIBOR t (Retail Mortgage)	0.2094	0.0576	3.6345	0.0003
d EURIBOR t (Consumer)	0.0629	0.1122	0.5609	0.5749
d EURIBOR t (NFC Loans)	0.4314	0.0905	4.7691	0.0000

Deposits

3. Four types of deposit rates have been available, term deposits, retail overnight deposits, corporate overnight deposits, and saving deposits. All three are estimated through single equation time series modes, with the quarterly change of EURIBOR and risk-free rate as an exogenous variable and one or two autoregression components. All four models are estimated on quarterly frequency series form Q1 2006 to Q4 2022 (70 observations).

Variable		*Term*	*Retail Overnight*	*Corporate Overnight*	*Savings*
AR t-1	Estimate	-0.3036	-0.0751		0.2133
	SE	0.0981	0.0924		0.0985
	pValue	0.0030	0.4196		0.0342
AR t-2	Estimate		0.3612		
	SE		0.0840		
	pValue		0.0001		
d EURIBOR t	Estimate	0.9609	0.1113	0.2782	0.1904
	SE	0.1092	0.0161	0.0386	0.0350
	pValue	0.0000	0.0000	0.0000	0.0000
d RiskFree t	Estimate			0.0590	
	SE			0.0334	
	pValue			0.0817	

Appendix V. Probabilities of Default Combination

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

$$PD_t^c = w_a PD_t^a + w_b PD_t^b \quad (11)$$

s.t.
$$w_a + w_b = 1 \quad (12)$$

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

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

$$A_{i,i}^{ad} = \frac{A_{i,t}}{\frac{1}{T}\sum_{t=1}^{T} A_{i,t}} \quad (13)$$

$$A_t^{mean} = \frac{1}{I}\sum_{i=1}^{I} A_{i,t}^{ad} \quad (14)$$

$$F_{t,i}^{ad} = \frac{F_{i,t}}{\frac{1}{T}\sum_{t=1}^{T} A_{i,t}} \quad (15)$$

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

3. Then weights are calibrated through the following linear program

$$\min_{w} \sum_{t=1}^{T} (\varepsilon_t^1 + \varepsilon_t^2) \quad (16)$$

$$s.t. \begin{cases} \sum_{i=1}^{I} w_i F_{i,t}^{ad} - A_t^{mean} + \varepsilon_t^1 - \varepsilon_t^2 = 0 \quad \forall\, t \in [1,T] & (17) \\ \sum_{i=1}^{I} w_i = 1 & (18) \\ w, \varepsilon^1, \varepsilon^2 \geq 0 & (19) \end{cases}$$

4. The estimated combination weights are 29.5 percent for the NPL base projection and 70.5 percent for EDF based projection.

Appendix VI. LCR Scenarios

1. The tables below show the LCR Basel weights and the value of the weights under different scenarios (i.e., "Stressed weights"). LCR is computed as the ratio between a weighted average of high-quality liquid assets (HQLA) and a weighted average of inflows and outflows. It gives an indication of whether a bank has an adequate stock of unencumbered HQLA to meet net outflows over a period of 30 calendar days. The baseline LCR scenario uses the coefficients on inflows, outflows and liquid assets as prescribed by the Basel III standards ("Basel" column below). To simulate stress, the coefficients are modified by lowering those on inflows and increasing those on outflows and haircuts on liquid assets. In absence of specific guidelines on how to calibrate these coefficients under stress scenarios we apply proportional changes across all categories. We calibrate six simulated scenarios, incorporating mild and severe stress on asset values, inflows, and outflows. Under "aggressive" scenarios the "stressed Basel coefficients" are roughly doubled/halved with respect to the Basel coefficients. This is broadly consistent with other FSAP exercises. Our stress scenarios are calibrated by "stressing" these weights under the assumption of no changes to the asset composition or flows.

Appendix VI. Table 1: LCR Calibration

Liquid assets

	Basel	Mild	Aggressive
Level 1 Assets			
1. Cash	100%	100%	100%
2. Qualifying marketable securities (sovereigns, central banks, PSEs, and MDBs)	100%	95%	90%
3. Qualifying central bank reserves	100%	95%	90%
4. Domestic sovereign or central bank debt for nonzero risk-weighted entities	100%	95%	90%
5. Level 1 extremely high-quality covered bonds	93%	87%	77%
Level 2a Assets	**85%**	**70%**	**56%**
1. Qualifying marketable securities with 20% risk weighting (sovereigns, central banks, PSEs, and MDBs)			
2. Qualifying corporate debt securities rated AA- or higher			
3. Qualifying covered bonds rated AA- or higher			
Level 2b Assets			
1. Qualifying Mortgage-Backed Securities	75%	62%	48%
2. ABS (commercial or individuals, member state, CQS1)	65%	51%	37%
3. Qualifying corporate debt securities rated between A+ and BBB-	50%	36%	23%
4. Qualifying common equity shares	50%	36%	23%

Inflows

	Basel	Mild	Aggressive
Level 1 assets	0%	0%	0%
Level 1 assets (extremely liquid)	7%	13%	23%
Level 2a assets	15%	25%	38%
Level 2b assets			
-Eligible RMBS	25%	38%	52%
-Other	50%	64%	77%
Margin lending backed by all other collateral			
- Counterparty is a central bank	100%	100%	100%
-Counterparty is not a central bank	100%	90%	82%
Credit or liquidity facilities	0%	0%	0%
Operational deposits held at other financial institutions	5%	5%	5%
Other inflows, by counterparty			
-Retail counterparties	50%	36%	30%
-Nonfinancial wholesale counterparties, transactions not listed above	50%	36%	30%
-Other inflows from non-financial counterparties, non-principal repayment	100%	85%	75%
-Financial institutions and central banks, transactions not listed above	100%	90%	75%
Loans with undefined contractual end date	20%	11%	10%
Other (contractual) cash inflows	100%	85%	75%

Outflows (I)

	Basel	Mild	Aggressive
Retail Deposits			
Demand deposits:			
- *Stable deposits*	5%	10%	10%
- *Less stable retail deposits*	10%	18%	18%
Deposits with payout within 30 days	100%	100%	100%
Term deposits, residual maturity > 30d	0%	10%	10%
Deposits subject to higher outflows:			
- *Category 1*	15%	25%	25%
- *Category 2*	20%	32%	32%
Unsecured Wholesale Funding			
Demand and term deposits, residual maturity < 30d, small business			
- *Stable deposits*	5%	10%	10%
- *Less stable deposits*	10%	18%	18%
Operational deposits generated by clearing, custody, and cash management activities			
- *Portion covered by deposit insurance*	5%	10%	10%
- *Portion not covered by deposit insurance*	25%	38%	38%
Operational deposits mantained in the context of cooperative banks in an institutional network	25%	38%	38%
Non Operational deposits (Nonfin. Corporates, sovereigns, CBs, MDEs, PSEs)			
- *Fully covered by deposit insurance*	20%	32%	32%
- *Not fully covered by deposit insurance*	40%	54%	54%
Other legal entity customers	100%	100%	100%
Secured Funding			
Secured funding with a central bank, or backed by Level 1 assets (excl. EHQ cov bonds collateral)	0%	5%	10%
Secured funding with a central bank, or backed by Level 1 assets (EHQ cov bonds collateral)	7%	13%	23%
Secured funding backed by Level 2A assets	15%	25%	38%
Secured funding backed by non-Level 1 or non-Level 2a asset (domestic sovereign, MDBs, or domestic PSEs as a counterparty)	25%	38%	52%
Funding backed by RMBS eligible for Level 2B?	25%	38%	52%
Funding backed by other Level 2B assets	50%	64%	77%
Other secured funding transactions (No HQLA)	100%	100%	100%

Outflows (II)

	Basel	Mild	Aggressive
Additional Requirements			
Valuation changes on non-Level 1 posted collateral securing derivatives transactions	20%	32%	45%
Excess collateral held by bank related to derivate transactions that could be called anytime	100%	100%	100%
Liquidity needs related to collateral contractually due on derivatives transactions	100%	100%	100%
Increased liquidity needs related to derivative transactions allowing collateral substitution	100%	100%	100%
Loss of funding related on asset backed securities, ABCP, SIVs, conduits, SPVs, or similar	100%	100%	100%
Undrawn but committed credit and liquidity facilities			
- Retail and small business			
> Credit facilities	5%	5%	5%
> Liquidity facilities	5%	5%	5%
- Nonfinancial corporates, sovereigns, central banks, multilat dev. banks, PSEs			
> Credit facilities	10%	10%	10%
> Liquidity facilities	30%	30%	30%
- Supervised banks	40%	40%	40%
- Other financial institutions			
> Credit facilities	40%	40%	40%
> Liquidity facilities	100%	100%	100%
- Other legal entity customers, credit, liquidity facilities	100%	100%	100%
Other contingent funding liabilities			
- Trade finance	5%	10%	18%
- Customer short positions covered by customers' collateral	0%	5%	5%
- Uncommitted funding facilities	10%	10%	10%
Additional contractual outflows	100%	100%	100%
Other products and services	30%	30%	30%
Net derivate cash outflows	100%	100%	100%
Any other contractual cash outflows (not listed above)	100%	100%	100%

Retail Deposits Shock
Wholesale Deposits Shock
Total Deposits Shock
Market Shock
Wholesale Shock

Appendix VII. Cashflow Scenarios

Appendix VII. 1: Cashflow Calibration

	OUTFLOWS	Market Stress	Retail & Wholesale Stress	Combined Stress
1.1	**Liabilities resulting from securities issued (if not treated as retail deposits)**			
1.1.1	unsecured bonds due	100	30	100
1.1.2	regulated covered bonds	25	20	25
1.1.3	securitisations due	50	20	50
1.1.4	other	100	30	100
1.2	**Liabilities resulting from secured lending and capital market driven transactions collateralised by:**			
1.2.1	Level 1 tradable assets			
1.2.1.1	Level 1 excluding covered bonds			
1.2.1.1.1	Level 1 central bank	100	100	100
1.2.1.1.2	Level 1 (CQS 1)	100	100	100
1.2.1.1.3	Level 1 (CQS2, CQS3)	100	100	100
1.2.1.1.4	Level 1 (CQS4+)	100	100	100
1.2.1.2	Level 1 covered bonds (CQS1)	100	100	100
1.2.2	Level 2A tradable assets			
1.2.2.1	Level 2A corporate bonds (CQS1)	100	100	100
1.2.2.2	Level 2A covered bonds (CQS1, CQS2)	100	100	100
1.2.2.3	Level 2A public sector (CQS1, CQS2)	100	100	100
1.2.3	Level 2B tradable assets			
1.2.3.1	Level 2B Asset Backed Securities (ABS) (CQS1)	100	100	100
1.2.3.2	Level 2B covered bonds (CQS1-6)	100	100	100
1.2.3.3	Level 2B: corporate bonds (CQ1-3)	100	100	100
1.2.3.4	Level 2B shares	100	100	100
1.2.3.5	Level 2B public sector (CQS 3-5)	100	100	100
1.2.4	other tradable assets	100	100	100
1.2.5	other assets	100	100	100
1.3	**Liabilities not reported in 1.2, resulting from deposits received (excluding deposits received as collateral)**			
1.3.1	stable retail deposits	5	10	10
1.3.2	other retail deposits	20	25	25
1.3.3	operational deposits	25	40	40
1.3.4	non-operational deposits from credit institutions	30	50	50
1.3.5	non-operational deposits from other financial customers	30	50	50
1.3.6	non-operational deposits from central banks	0	0	0
1.3.7	non-operational deposits from non-financial corporates	30	50	50
1.3.8	non-operational deposits from other counterparties	30	50	50
1.4	**FX-swaps maturing**	100	100	100
1.5	**Derivatives amount payables other than those reported in 1.4**	100	100	100
1.6	**Other outflows**	100	100	100

	INFLOWS	Market Stress	Retail & Wholesale Stress	Combined Stress
2.1	**Monies due from secured lending and capital market driven transactions collateralised by:**			
2.1.1	Level 1 tradable assets			
2.1.1.1	Level 1 excluding covered bonds			
2.1.1.1.1	Level 1 central bank	100	100	100
2.1.1.1.2	Level 1 (CQS 1)	100	100	100
2.1.1.1.3	Level 1 (CQS2, CQS3)	100	100	100
2.1.1.1.4	Level 1 (CQS4+)	100	100	100
2.1.1.2	Level 1 covered bonds (CQS1)	100	100	100
2.1.2	Level 2A tradable assets			
2.1.2.1	Level 2A corporate bonds (CQS1)	100	100	100
2.1.2.2	Level 2A covered bonds (CQS1, CQS2)	100	100	100
2.1.2.3	Level 2A public sector (CQS1, CQS2)	100	100	100
2.1.3	Level 2B tradable assets			
2.1.3.1	Level 2B ABS (CQS1)	100	100	100
2.1.3.2	Level 2B covered bonds (CQS1-6)	100	100	100
2.1.3.3	Level 2B: corporate bonds (CQ1-3)	100	100	100
2.1.3.4	Level 2B shares	100	100	100
2.1.3.5	Level 2B public sector (CQS 3-5)	100	100	100
2.1.4	other tradable assets	100	100	100
2.1.5	other assets	100	100	100
2.2	**Monies due not reported in 2.1 resulting from loans and advances granted to:**			
2.2.1	retail customers	10	30	30
2.2.2	non-financial corporates	10	25	25
2.2.3	credit institutions	100	100	100
2.2.4	other financial customers	100	100	100
2.2.5	central banks	100	100	100
2.2.6	other counterparties	10	30	30
2.3	**FX-swaps maturing**	100	100	100
2.4	**Derivatives amount receivables other than those reported in 2.3**	100	100	100
2.5	**Paper in own portfolio maturing**	100	100	100
2.6	**Other inflows**	100	100	100

COUNTERBALANCING CAPACITY		Market Stress	Retail & Wholesale Stress	Combined Stress
3.1	**coins and bank notes**	0	0	0
3.2	**Withdrawable central bank reserves**	0	0	0
3.3	**Level 1 tradable assets**			
3.3.1	Level 1 excluding covered bonds			
3.3.1.1	Level 1 central bank	0	0	0
3.3.1.2	Level 1 (CQS 1)	15	7	15
3.3.1.3	Level 1 (CQS2, CQS3)	19	11	19
3.3.1.4	Level 1 (CQS4+)	23	15	23
3.3.2	Level 1 covered bonds (CQS1)	17	9	17
3.4	**Level 2A tradable assets**			
3.4.1	Level 2A corporate bonds (CQS1)	17	9	17
3.4.3	Level 2A covered bonds (CQS 1, CQS2)	17	9	17
3.4.4	Level 2A public sector (CQS1, CQS2)	18	10	18
3.5	**Level 2B tradable assets**			
3.5.1	Level 2B ABS (CQS1)	16	8	16
3.5.2	Level 2B covered bonds (CQS1-6)	16	8	16
3.5.3	Level 2B corporate bonds (CQ1-3)	16	8	16
3.5.4	Level 2B shares B3	26	18	26
3.5.5	Level 2B public sector (CQS 3-5)	26	18	26
3.6	**other tradable assets**			
3.6.1	central government (CQS1)	27	19	27
3.6.2	central government (CQS 2 & 3)	39	31	39
3.6.3	shares	39	31	39
3.6.4	covered bonds	39	31	39
3.6.5	ABS	22	14	22
3.6.6	other tradable assets	39	31	39
3.7	**non tradable assets eligible for central banks**	90	40	90
3.8	**undrawn committed facilities received**			
3.8.1	Level 1 facilities	75	30	75
3.8.2	Level 2B restricted use facilities	75	30	75
3.8.3	Level 2B IPS facilities	75	30	75
3.8.4	other facilities			
3.8.4.1	from intragroup counterparties	100	100	100
3.8.4.2	from other counterparties	100	100	100
4.1	**Outflows from committed facilities**			
4.1.1	Committed credit facilities			
4.1.1.1	considered as Level 2B by the receiver	12	60	60
4.1.1.2	other	12	60	60
4.1.2	Liquidity facilities	15	75	75
4.2	**Outflows due to downgrade triggers**	20	75	75

Appendix VIII. Insurance Stress Test Specifications

Appendix VIII. Table 1: Market and Credit Risk

Equity		Haircut
	European Union	-33.6%
	Other advanced economies	-33.0%
	Emerging and developing economies	-32.0%

Property		Haircut
	Residential	-20%
	Commercial	-25%

Corporate bonds and securitisation			spread change
	Non-financials, structured finance	AAA	0.50%
		AA	0.65%
		A	0.75%
		BBB	1.35%
		BB	2.35%
		B and lower	3.25%
		unrated	2.00%
	Financials	AAA	0.60%
		AA	0.75%
		A	0.95%
		BBB	1.55%
		BB	2.65%
		B and lower	3.55%
		unrated	2.20%

Sovereign bonds		spread change
	Belgium	0.90%
	Low spread EA countries	0.55%
	High spread EA countries	1.20%
	Other advanced economies	0.70%
	Emerging and developing countries	1.20%
	Supranationals	0%

Mortgage loan default increase		default increase
	Mortgage loans, domestic	2.00%
	Mortgage loans, non-domestic	3.00%

Source: IMF Staff

Notes: Low spread, high-rated EA countries include Austria, Finland, France, Germany, Ireland and Luxembourg and the Netherlands.

Appendix IX. Cross-Sectoral Analysis Econometric Estimations

1. The market interconnectedness model relies on regression results to estimate the relationship between capitalization, solvency and liquidity and asset prices:

$$yield_{it}^{B,INS} = f^1(Equity_{it}, X_{it}) \quad \textbf{(19)}$$

$$Share\ Prices_{it}^{B,INS} = f^2(Equity_{it}, Z_{it}) \quad \textbf{(21)}$$

2. We estimated four equations, two for banks and two for insurers, to analyze the determinants of yields and share prices. The regressions are linear in the parameters and estimated in first differences. The coverage differed depending on the equation because of data availability.

3. Estimation of equations for Banks. The equation for the yield of bank-issued bonds was estimated on quarterly data over the period 2010Q1 – 2022Q4 and covered six banks (Argenta Investar Holding, Belfius, BNPP Fortis, ING BE, KBC Group, Bank of New York Mellon). The yield for the bank-issued debt was computed as the average of yields for debt maturing between end 2025 and end 2026. The equation for the share prices of banks' shares was instead estimated using share prices of three banks (BNPP Fortis, KBC Group, and Bank of New York Mellon) on quarterly frequency over the same period. Yields and share prices come from Bloomberg. Data for explanatory variables were instead taken from the Fitch database. For some of the banks' balance sheet and income statement information were available on quarterly basis, while for others they were available only semi-annually. In these cases, the data have been interpolated to quarterly frequency. For BNPP Fortis and ING BE, the balance sheet and income statement information is relative to the Belgian subsidiaries only. As for the choice of regressors: capitalization has been proxied by the ratio of equity to assets; credit quality by the ratio of NPLs to total loans, loan loss provisions to total assets and (log of) loan loss reserves to total loans; liquidity has been proxied by the ratio of liquid assets to total assets. As additional controls, the yield equation also includes the risk-free rate (the rate on the yield of the German Bund) and the share price equation includes one lag of the growth rate of the share prices and the bid-ask spread of share prices.

4. Estimation of equations for Insurers. The equations for bond yields and share prices for insurers were estimated for a sample of three insurers (AG Insurance, Baloise, and Ethias) over the period 2010-2022. The frequency of the data was annual. As for the Banks equations, the source for the data on yields and share prices was Bloomberg, while that for the regressors was Fitch database. Again, capitalization has been proxied by the ratio of equity to assets—with equity being defined as excess assets over liabilities. The yield equation also includes the ratio of risky assets to total assets to proxy for the asset quality of insurers, the interbank spread to proxy for the liquidity conditions, and the stock volatility index. Instead, the equation for share prices also includes the change in gross written premia as additional control.

VARIABLES	Banks		Insurers	
	Yields	Share Pr (QoQ)	Yields	Share Pr (QoQ)
Share Prices (QoQ, L1)		-0.440***		
		[0.145]		
D(10y Bund)	0.674**			
	[0.264]			
D(Equity/Assets)	**-0.630****	**15.860****	**-0.270****	**1.072***
	[0.296]	**[7.554]**	**[0.103]**	**[0.531]**
D(NPLs/Loans)	0.871**	-13.010**		
	[0.415]	[6.180]		
D(LLP/Assets)		-0.449*		
		[0.265]		
D(LOG(LLR/Loans))	-2.650*			
	[1.469]			
D(Liquid Assets/Assets)	-0.057	2.639**		
	[0.043]	[1.243]		
D(B/A Spreads)		-4.714		
		[5.182]		
D(Risky Assets / Total Assets)			0.331**	
			[0.159]	
D(gross written premiums - %)				0.223*
				[0.108]
D(Euribor 3m - T-Bill 3m)			3.656*	
			[1.853]	
D(VStoxx50)			0.081***	-0.507***
			[0.028]	[0.156]
Observations	123	80	26	17
R-squared	0.169	0.237	0.502	0.532
Robust standard errors in brackets *** p<0.01, ** p<0.05, * p<0.1				

5. Model selection was performed based on statistical significance, as well as on the solvency stress test results. The choice of the right-hand-side variables was done based on their statistical significance, but the set of variables included in the regressions was limited to those that had a direct mapping to the results of the solvency stress tests. The results from the solvency stress tests were in fact used as input in the estimated equations to predict yields and share prices that would prevail in the market if banks and insurers saw their financial conditions deteriorate as predicted in the solvency stress test exercises:

$$\widehat{yield}_{it}^{B,INS} = f^1(\overline{Equity_{it}}, \overline{X_{it}}) \quad \textbf{(22)}$$

$$\widehat{Share\ Prices}_{it}^{B,INS} = f^2(\overline{Equity_{it}}, \overline{Z_{it}}) \quad \textbf{(23)}$$

Because the bank solvency stress test is a result of a scenario unfolding over a four-year horizon, the predicted changes in bond yields and share prices for banks were computed using the change in right-hand-side variables between the first and the last year of the stress test. Instead, for insurers,

because the stress test for insurers is the result of an instantaneous shock, they were computed using the chance in right-hand-side variables between the baseline and the peak of the stress.

6. The predicted changes in bond yields and share prices were then used to calculate the change in the market price of investment funds' issued shares. This was assumed to happen mechanically, with the price of investment funds' changing proportionally to the change in the prices of other assets, weighted by investment funds' exposure. Data on exposure come from the "Who-to-whom" matrix as of end 2022:

$$Share\ Prices_{it}^{IF} = h\left(\widehat{yield_{it}^{B,INS}}, \widehat{Share\ Prices_{it}^{B,INS}}\right) \quad (24)$$

7. Losses from changes in asset prices were then assumed to affect Banks' and Insurers' equity. Changes in bonds prices because of changes in yields were computed using the average modified duration of the bonds issued. To compute losses, the changes in bonds' and share prices were multiplied by the exposure—taken from the Who-to-whom" matrix. Total losses for banks/insurers were computed as the sum of the losses coming from their exposure to insurers'/banks' bonds and shares and from their exposure to investment funds' shares:

$$\widehat{Equity_{it}^{B}} = g\left(\widehat{yield_{it}^{INS}}, \widehat{Share\ Prices_{it}^{INS}}, \widehat{Share\ Prices_{it}^{IF}}\right) \quad (25)$$

$$\widehat{Equity_{it}^{INS}} = g\left(\widehat{yield_{it}^{B}}, \widehat{Share\ Prices_{it}^{B}}, \widehat{Share\ Prices_{it}^{IF}}\right) \quad (26)$$

8. Losses were assumed to translate directly into lower equity. Because of the estimated losses, both equity and the value of assets decreased, hence impacting the "Equity to Asset" ratio. The new value of the equity to asset ratio was used to compute the second-round effect on yields and share prices:

$$\widehat{yield_{it}^{B,INS}} = f^{1}\left(\widehat{Equity_{it}^{B,INS}}\right) \quad (27)$$

$$\widehat{Share\ Prices_{it}^{B,INS}} = f^{2}\left(\widehat{Equity_{it}^{B,INS}}\right) \quad (28)$$

9. The algorithm was iterated until convergence. After about ten iterations the algorithm converged as losses and asset prices stabilize

Appendix X. Investment Funds Stress Test

Sample of Funds

1. Investment funds in the analysis are collective investment undertakings included in the Economic Function 1. These are collective investment vehicles with features that make them susceptible to runs, including fixed income funds, mixed funds funds-of-funds (FoFs), and money market funds. These investment vehicles may engage in maturity/liquidity transformation or employ leverage and could become susceptible to liquidity pressures because of heightened investor redemption requests.

2. Overall, the analysis considered 435 funds with different investment policies and objectives, including bond funds, mixed-FoFs, non-public alternative investment funds, which are sold to professional investors. A residual category composed by a large number of small heterogeneous vehicles is also considered: structured funds, pension saving funds that are collective investment undertakings under the Belgian law and money market funds. Structured funds are the largest category with 113 funds amounting to 3 EUR bn. All considered, the residual category of other funds amounts to a NAV of 31.6 EUR bn, including 7 EUR bn in money market funds.

Data

3. Investment funds are mapped in Lipper using the ISINs and LEIs. For each fund in the sample, monthly data on flows, net asset value, returns, are retrieved over the 2008–2021 period, together with their investment objectives and geographical focus. Overall, 390 investment funds included in the analysis are retrieved in Lipper.

Computation of net flows: For each fund, net flows in percent of NAV are computed using as:

$$f_t = \frac{FLOWS_t}{NAV_{t-1}} \quad \textbf{(29)}$$

Monthly flows are aggregated at portfolio level across different share classes. Net flows whose absolute value is above 50% were excluded as likely related to either mergers and liquidations of share classes or reporting errors.

Portfolio composition and info on assets: For each fund, supervisory information on fund characteristics and asset-level portfolio composition at the end of 2022 is used for the analysis. This would include asset categories and ISINs, price and market value of the instruments, portfolio weights, the amount of cash held in portfolio. The look-through approach is applied to the other collective investment undertakings held by the funds analyzed. Information on portfolio composition of the underlying funds is obtained from Lipper.

Ancillary information on asset characteristics, sectors, credit quality, maturities, yields, and durations are obtained from Refinitiv EIKON and Bloomberg.
Metrics on liquidity and trading are derived from Eikon and Bloomberg. Total volumes of domestic sovereigns are taken from MTS.

Calibration of the redemption shock

4. The liquidity risk for open-ended investment funds exposed to fixed income instruments is assessed by first calibrating a plausible but severe redemption shock and then comparing it to a measure of highly liquid assets. The shock is intended as instantaneous, i.e., there is no persistence over several periods. The objective is to assess funds' ability to withstand redemptions shocks. The calibration of redemption shocks follows Bouveret and Yu (2021, IMF). Similar approaches have been adopted also in the context of other FSAPs (IMF, 2015b; 2017, 2018, 2021, 2022).

Redemption shocks are calibrated based on the distribution of historical net flows by fund categories following a Value-at-Risk (VaR) approach, where different percentiles of net flows are used to calibrate the shock. Formally, the VaR at the α level is given by:

$$Var(\alpha) = F^{-1}(\alpha) \quad \textbf{(30)}$$

where F^{-1} is the inverse of the distribution function of net flows.
This approach has some drawbacks: 1) extreme shocks below the VaR are not considered; 2) when using a parametric approach, the VaR is subject to model risk (Emmer et al., 2015). To address those two issues, a set of redemption shocks is based on the expected shortfall (ES), which is equal to the average net flows below the VaR. The ES is then given by:

$$ES(\alpha) = E(Z \mid Z < Var(\alpha)) \quad \textbf{(31)}$$

Where Z represents the net flows.

The shock applied to investment funds that are not found in Lipper is the average of the shocks considered for comparable funds, based on the investment policy, the geographical focus and the ownership structure.
The shock is an instantaneous shock, i.e., there is no persistence over several periods.

Homogeneity assumption: each fund within the same investment type and with the same geographical focus face the same redemption shock. In this case the shock is based on the distribution of all individual fund net flows that can be ascribed to the same investment style. The calibration is based on the 3 percent ES. As a robustness check, redemption shocks are also calibrated at the 1 percent and 5 percent levels for the ES, and also at the worst 1 percent, 3 percent, and 5 percent net flows observed (VaR).

Heterogeneity assumption: the redemption shock is calibrated separately for each fund based only on its own historical data. The shock is based on the 3 percent ES. As a robustness check, the shock is also estimated at 1 percent and 5 percent level as well as using percentiles. This assumption does not allow comparing outcomes across funds for a redemption shock of the same magnitude. Moreover, shocks calibrated will not be meaningful if funds have not experienced large outflows, which would not provide insights on their ability to withstand future shocks (see Bouveret, 2017; Bouveret and Yu 2021; ESMA, 2019).

Overall, each fund is subject to 12 different redemption shocks (**Error! Reference source not found.**). The main focus of the stress test is on the shocks calibrated at the 3 percent level.

Appendix X. Table 1: Calibration of Redemption Shocks

Investment type	Homogeneous shock				Heterogeneous shock	
	EU focus		*Global focus*			
	ES	VaR	ES	VaR	ES	VaR
			Level: 1%			
Bond funds	20%	18%	19%	15%	17%	13%
Mixed (FoFs)	9%	2%	15%	9%	6%	5%
Non-public alternative funds	24%	24%	21%	17%	17%	16%
Other	1%-40%	1%-39%	2%-47%	1%-34%	2%-39%	2%-37%
			Level: 3%			
Bond funds	15%	10%	14%	9%	12%	7%
Mixed (FoFs)	4%	2%	9%	5%	5%	3%
Non-public alternative funds	18%	11%	14%	8%	15%	8%
Other	1%-30%	<1%-29%	2%-32%	1%-25%	2%-33%	1%-25%
			Level: 5%			
Bond funds	12%	7%	12%	7%	10%	6%
Mixed (FoFs)	3%	2%	7%	4%	4%	2%
Non-public alternative funds	14%	7%	11%	3%	11%	2%
Other	1%-33%	<1%-25%	1%-30%	<1%-24%	1%-30%	1%-24%

Note: Redemption shocks defined as net outflow in % of NAV. Average flow by fund category under the heterogeneity assumption. Monthly flows from January 2008 to December 2022.
Source: Lipper, IMF staff.

Investment funds' resilience: the liquidity bucket approach

5. The ability of funds to withstand shocks is estimated by comparing the redemptions to the level of high liquid assets. High liquid assets are measured at fund level using the liquidity weights defined in the context of the Liquidity Coverage Ratio for banks. For each asset class, liquidity weights are defined based on the type of assets and for fixed income instruments the credit quality. Liquidity weights are taken from the Basel Committee rather than domestic implementation of the LCR, to allow for comparability (Appendix X Table 2).

The ability of funds to withstand redemption shocks is measured by the Redemption Coverage Ratio (RCR) defined as follows:

$$RCR = \frac{HQLA}{Redemption\ shock} \quad \textbf{(32)}$$

Highly liquid assets for fund i are given by:

$$HQLA^i = \sum_{k=1}^{n} \omega_{i,k} \times s_{i,k} \quad \textbf{(33)}$$

where $\omega_{i,k}$ are liquidity weights assigned to each security $s_{i,k}$ in the fund portfolio as discussed below. When the RCR is below 1, the fund does not have enough highly liquid assets to cover redemptions without selling less liquid assets. In that case, the liquidity shortfall is defined as the difference between the redemption shock and the stock of highly liquid assets:

$$Liquidity\ shortfall = Redemption\ shock - HQLA \quad \textbf{(34)}$$

Appendix X. Table 2: Liquidity Weights

	AAA-AA	A	BBB	Below BBB
Cash			100%	
Equities			50%	
Sovereign bonds	100%	85%	50%	0%
Corporate bonds	85%	50%	50%	0%
Covered bonds and Securitized	85%	0%	0%	0%

Liquidation strategies and price impact of funds sales

6. Once investors redemptions occur, fund managers have to dispose of assets to meet redemptions' requests. Following the redemption shocks, fund managers have to sell securities in portfolio to meet investors' redemptions. Different liquidation strategies can be used: vertical slicing (pro rata)—where the manager sells each asset class in proportion of their weight in the fund's portfolio—waterfall (where most liquid assets are sold first). Depending on the liquidation strategy selected, the impact on remaining investors can be sizable.

The pro-rata strategy allows, in line with the investment policy, the manager not to distort the portfolio. Under the waterfall approach, the manager sells the most liquid assets first, which may have a mitigating effect on the price impact of sales. Remaining investors would be then left with an overall less liquid portfolio, creating additional challenges if redemptions were to continue. The order of the liquidation is based on HQLA liquidity weights. When assets with positive liquidity weights have been entirely sold, managers would then resort to liquidating unrated instruments.

During the COVID-19 market turmoil, funds have increased their cash positions while decreasing their portfolio share in sovereign and other high-quality assets.

Given a redemption shock and a liquidation strategy, the price impact of the sales is estimated by comparing the volume of assets liquidated is to market depth. Following Cont and Schaaning (2017), market depth is estimated as:

$$MD(\tau) = \frac{ADV}{\sigma}\sqrt{\tau} \quad \textbf{(35)}$$

where τ is the time horizon to sell assets, ADV the average daily trading volumes and σ the asset volatility. The impact is lower when the time horizon is longer. Given the instantaneous nature of the shock, τ is considered equal to 1 day.

The price impact is calculated for domestic sovereigns. Volatility is estimated by filtering the ICE BofA All Maturity Belgium Government Index market index through a GARCH (1,1) and taking maximum historical volatility to consider a plausible stress market.

Average monthly traded volumes at the end of 2022 are taken from MTS. Given a liquidation strategy and a redemption shock, we estimate the price impact by comparing the sales by asset classes to market depth:

$$PI(\tau) = \frac{Sales}{MD(\tau)} \quad \textbf{(36)}$$

Investment funds stress test results

Error! Reference source not found.: present the results for the 12 different redemption shocks calibrated on funds outflows under the assumption described before. For each approach, six shocks are defined using either the ES or the VaR at three different levels: 1%, 3%, and 5%.

Appendix X. Table 3: Investment Fund Stress Tests Results: Resilience

Investment type	Homogeneous shock		Heterogeneous shock	
	ES	VaR	ES	VaR
		1%		
Bond funds	4.3%	-	-	-
Mixed (FoFs)	3.3%	0.5%	1.4%	0.5%
Non-public alternative funds	26.3%	21.1%	21.1%	21.1%
Other	-	-	-	-
		3%		
Bond funds	-	-	-	-
Mixed (FoFs)	>1%	-	>1%	-
Non-public alternative funds	13.2%	5.3%	15.8%	15.8%
Other	-	-	-	-
		5%		
Bond funds	-	-	-	-
Mixed (FoFs)	-	-	-	-
Non-public alternative funds	5.3%	5.3%	13.2%	5.3%
Other	-	-	-	-

Note: Share of investment funds with RCR < 1.
Source: IMF staff.

Volatility spillover analysis

7. The transmission of volatility shocks between fund categories and their underlying markets is analyzed using publicly available weekly returns for 3 different fund categories: equity, bond and mixed funds. The spillovers analysis uses the Diebold and Yilmaz's (2009, 2012) approach.

This analysis evaluates the directional co-movement through returns, as prices could—to some extent affect investors and market participants current and expected fundamentals. A financial spillover from an asset class (or an institution) A to asset (or institution) B is defined as the share of

the variation in firm B's equity returns shocks that can be attributed to (contemporaneous or preceding) shocks to A's returns. The concept stresses idiosyncratic shocks and excludes co-movement across markets that is driven by common factors. The VAR is estimated using a lasso-estimator. The specification is as follows:

$$X_t = \Phi(L)x_t + \epsilon_t \quad \textbf{(37)}$$

$$\tilde{d}_{ij}(H) = \mathrm{C}^{\mathrm{H}}_{\mathrm{i}\leftarrow\mathrm{j}} = \frac{d_{ij}(H)}{\sum_{j=1}^{n} d_{ij}(H)} \quad \textbf{(38)}$$

where X_t denotes a $n \times 1$ vector of endogenous variables, $\Phi(L) = \Sigma_h \Phi L^h$ is a $n \times n$ p-th order lag polynomial matrix of coefficients, ϵ_t is a white noise error vector with zero mean and covariance matrix Σ, and $d_{ij}(H)$ is the H-step ahead generalized forecast error variance decomposition matrix.

The VAR model above is used to build a generalized forecast-error variance decomposition (FEVD), using Pesaran and Shin's (1998) methodology, to identify uncorrelated structural shocks. The FEVD identification framework is order invariant by construction, hence avoids the ad hoc ordering of structural shocks characteristic of recursive identification. For each investment fund category and market firm is aggregated in a matrix, with the non-diagonal elements capturing spillovers effects. Specifically, the spillover from *i* to *j* is the percent of *j*'s total inward spillovers that are coming from *i*:

The spillover therefore measures the fraction of the H-month ahead forecast error variance of *j*'s returns that can be accounted for by innovations in *i*'s returns.

Diebold and Yilmaz (2012, 2014) discuss how the connectedness measures $\tilde{d}_{ij}(H)$ (FROM connectedness) are related to modern measures captures exposures of financial entities to systemic shocks from the system (inward spillover) in a fashion analogous to marginal expected shortfalls.

For each index, weekly returns are retrieved over the June 2014–December 2021 period. For each fund or market index, the volatility is estimated through a GARCH (1,1). The market indices considered are the following:

- Fixed income markets:
    - ICE BofA All Maturity Belgium Government Index
    - ICE BofA Euro Corporate Index
    - ICE BofA Global Corporate (Excluding Euro) Index
- Stock markets
    - BEL20
    - EUROSTOXX600
    - SP500