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TECHNICAL NOTE—STRESS TESTING THE BANKING AND INSURANCE SECTORS AND SYSTEMIC RISK ANALYSIS

This Technical Note on Stress Testing the Banking and Insurance Sectors and Systemic Risk Analysis for Belgium prepared by a staff team of the International Monetary Fund. It is based on the information available at the time it was completed on February 26, 2018.

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STRESS TESTING THE BANKING AND INSURANCE SECTORS AND SYSTEMIC RISK ANALYSIS

Prepared By
Monetary and Capital Markets Department

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

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GLOSSARY

AFS	Available for sale
ALM	Asset-Liability Management
bps	Basis Points
BU	Bottom-up (stress test)
CAR	Capital adequacy ratio
CCB	Capital Conservation Buffer
CCR	Counterparty credit risk
CDS	Credit Default Swap
CESEE	Central Eastern and South-Eastern Europe
CET1	Common Equity Tier 1
COREP	Common Reporting
CoVaR	Conditional Value at Risk
CRE	Commercial real estate
DSGE	Dynamic stochastic general equilibrium
EaD	Exposure at default
EBA	European Banking Authority
ECB	European Central Bank
EDF	Expected default frequency
EIOPA	European Insurance and Occupational Pensions Authority
EL	Expected loss
Euribor	European Interbank Offered Rate
FC	Financial Conglomerate
FINREP	Financial Reporting
FSAP	Financial Sector Assessment Program
FSR	Financial Stability Report
FSSA	Financial System Stability Assessment
FX	Foreign Exchange
GDP	Gross domestic product
GFC	Global Financial Crisis
G-SII	Global Systemically Important Institution
HFT	Held for trading
HQLA	High-quality liquid assets
HTM	Held to maturity
IRB	Internal ratings-based (approach)
IRRBB	Interest Rate Risk in the Banking Book
LCR	Liquidity coverage (ratio)
LGD	Loss-given default
LIBOR	London Interbank Offered Rate
LSI	Less Significant Institution
LTG	Long-Term Guarantees
LTV	Loan-to-value (ratio)
LVR	Loan-to-value ratio
NBB	National Bank of Belgium

NII	Net interest income
NIM	Net interest margin
NPL	Nonperforming loan
NSFR	Net-Stable Funding Ratio
OLO	Yield of the Belgium government bond
O-SII	Other Significant Institution
P&L	Profit and loss
PD	Probability of default
PiT	Point-in-time
pps	Percentage points
PTB	Price-to-book (ratio)
RAM	Risk Assessment Matrix
ROA	Return on assets
ROE	Return on equity
RWA	Risk-weighted assets
SI	Significant Institution
STA	Standardized (approach)
STeM	Stress test matrix (for FSAP stress tests)
TD	Top-down (stress test)
TTC	Through-the-cycle
VA	Volatility Adjustment
VAR	Vector autoregression
VaR	Value at risk
VIX	Volatility index
WEO	World Economic Outlook
YOY	Year-on-year
YTM	Yield to maturity

EXECUTIVE SUMMARY[1]

Belgium's financial landscape has changed since the global financial crisis (GFC) and the European sovereign crisis. The banking system has contracted driven by restructuring operations in entities that received government support. Banks have adopted more traditional business models, with greater emphasis on domestic lending and deposit funding. The insurance sector has seen some consolidation and a gradual move away from traditional insurance products to asset management-type products. The scale of cross-border linkages in the financial system, while still significant, has declined markedly.

The Financial Sector Assessment Program (FSAP) stress testing exercise comprises a comprehensive analysis of solvency and liquidity risks in the Belgian banking and insurance sectors. Macroprudential stress tests[2] were conducted to assess the financial system's ability to withstand losses without amplifying shocks to the real economy. One set of tests used macroeconomic scenarios to capture the impact of a drastic deterioration in macrofinancial conditions on the solvency of banks and insurance companies. A second batch of tests used hypothetical deteriorations in liquidity and asset market conditions to gauge the impact of these developments on individual entities as well as on the risk of contagion. This second batch of tests was conducted only on banks.

The financial sector remains resilient in the face of the rising cyclical vulnerabilities, but there is a need for closely monitoring risks. Stress tests on banks and insurance companies confirm that they can absorb credit, sovereign, and market losses in the event of a severe deterioration in macro financial conditions. All banks meet minimum capital requirements and none needs to draw down its capital conservation buffer over the stress horizon. The risk of interbank contagion through direct exposures is low. Insurance companies are also generally resilient and losses incurred in the stress scenarios by those that belong to banking groups do not threaten the soundness of those groups. In the IMF adverse scenario, the median solvency ratio drops from 184 to 124 percent, and to 145 percent in a low-for-long scenario. In each scenario, one out of eight companies drops marginally below a solvency ratio of 100 percent, but these shortfalls could rather easily be restored. Bank resilience reflects relatively healthy loan portfolios and limited exposure to market and liquidity risks, while insurance companies have sound solvency levels and reduced exposures to guaranteed rates. Nonetheless, the tests revealed risks that need to be monitored carefully, including selected risky portfolios and idiosyncratic liquidity and concentration risks in certain banks, and concentrated exposures towards domestic sovereign bonds among insurance companies.

The NBB is encouraged to expand its stress testing capabilities to strengthen the monitoring of financial stability risks. Macroprudential stress tests allow policymakers to assess the financial

1 The authors of this technical note are Laura Valderrama (MCM) and Timo Broszeit (external expert).

2 A top-down macro stress test on bank-level supervisory data combined with a macroeconomic model was conducted to evaluate the direct impact of stress on the banking system, taking account of contagion effects via the interbank channel. This exercise has the potential to assist the design of macroprudential policy to mitigate systemic risk.

system's ability to withstand losses triggered by a deterioration in cyclical macrofinancial conditions or structural changes to banks' business models and support the real economy if a stress does materialize. The NBB is encouraged to develop a top-down stress testing framework for macroprudential purposes to assess financial stability risks from systemically important banks and strengthen vigilance on liquidity pressures from non-maturing liabilities, intersectoral flows, intragroup transactions, and cross-border operations.

Table 1. Belgium: Main Recommendations on Stress Testing and Systemic Risk Analysis

Recommendations and Responsible Authorities	Timing*	Priority**
Banking		
Make Top-Down stress testing for all banks an integral part of the systemic risk monitoring toolkit. (NBB)	MT	H
Develop in-house models in coordination with ECB to assess financial stability risks from solvency and liquidity interactions and contagion from domestic and cross-border counterparties. (NBB)	MT	H
Strengthen vigilance on liquidity pressures from non-maturing liabilities, derivatives, intersectoral flows, intragroup flows, and cross-border operations. (NBB)	I	H
Continue to monitor asset encumbrance and risks from legacy portfolios. (NBB)	I	M
Insurance		
Expand the set of macroprudential stress tests in the insurance sector by introducing multi-period scenarios and projections. (NBB)	ST	M
Use stress testing results to further strengthen microprudential supervision by challenging companies' Own Risk and Solvency Assessment (ORSA) and underlying projections for future business. (NBB)	ST	M
Intensify monitoring of the mortgage loan portfolio of insurers and respective underwriting standards. (NBB)	I	H
Continue the close monitoring of the use and impact of long term guarantee measures, in particular the volatility adjustment. (NBB)	ST	M

* I = Immediate (within one year); ST = Short Term (within 1-2 years); MT = Medium Term (within 3-5 years).
** H= High; M= Medium; L=Low.

MACROFINANCIAL BACKGROUND

A. Weak Recovery but Emerging Financial Vulnerabilities

1. **Growth has picked up since the last FSAP but the medium-term outlook remains subdued.** Real GDP grew by 1.2 percent in 2016, below the euro area average, but is expected to accelerate to 1.7 percent in 2017. The output gap is closing and is expected to turn positive in 2018. The recovery has been driven by business and residential investment, while net exports have become a drag on growth. Monetary and fiscal policies have been supportive, with the government having undertaken relatively little fiscal adjustment since the crisis. However, absent further structural reforms and stronger growth in Europe, growth is expected to remain at around 1.5 percent for the foreseeable future, somewhat below the euro area average.

2. **At the same time, there are signs that the financial cycle is well on its way, fueled by buoyant global financial conditions, and vulnerabilities are rising.** Bank credit growth has accelerated since 2015 and a small positive credit gap opened in 2016. Credit growth is driven by residential mortgages and, to a lesser extent, credit to the construction sector, and is taking place in an environment of low interest rates and volatility, as well as compressed risk premia. While this is driven largely by buoyant global financial conditions, the result has been high domestic equity valuations, rising housing prices, and the buildup of leverage in non-financial sectors. The financial cycle in Belgium appears to be running ahead of the economic cycle, putting a premium on the timely detection of signs of systematic mispricing of risk and excessive risk taking, and the timely deployment of macroprudential policies.

B. An Evolving Financial Sector

3. **The banking sector has shrunk and undergone significant changes in the last 10 years.** Banking system assets shrunk from 470 percent of GDP in 2008 to 250 percent today, mainly because of the scaling back of cross-border activities required by the European Commission and the government to support banks' restructuring operations (e.g., Fortis Bank Belgium's sale of its Dutch activities before being acquired by BNP Paribas), and National Bank of Belgium (NBB) regulations limiting Belgian subsidiaries' exposure to their parent companies. Other important changes include the takeover by the Belgian government of the Belgian subsidiary of Dexia Group, which has become Belfius Bank and the acquisition by the French bank BNP Paribas of a majority stake in the Belgian subsidiary of Fortis. Belgium's largest (BNP Paribas Fortis) and fourth largest (ING Belgium) banks are subsidiaries of EA significant institutions.

4. **The 2008 financial crisis hit particularly hard the top three Belgian banks, which underwent vast restructuring with state support.** Fortis Group came under pressure in 2008 following its acquisition of a part of ABN AMRO. Difficulty in renewing the funding in September 2008 prompted state intervention, which resulted in the forced sale of Fortis Group's Dutch activities to the Dutch government and the acquisition by the French bank BNP Paribas. Dexia is a Franco-

Belgian financial group, that was bailed out twice.[3]The Group was dismantled in 2011, and several international operations were disposed. The Belgian government purchased for € 4 billion the Group's Belgian subsidiary, which later was rebranded as Belfius.[4] KBC Group received in 2008-09, a total of € 7 billion of capital injections by the federal and regional governments to bolster its buffers in a context of deteriorating market conditions.[5] KBC has entirely repaid the public support it received during the crisis, and has started distributing dividends. BNP Paribas Fortis is now the largest Belgian bank with a 30 percent share of total system assets followed by KBC banks with 24 percent share, and Belfius with 15 percent.

5. Banks have reoriented their business models towards traditional financial activities but have also embraced the digital push. Banks' exposures to the non-financial private sector increased from 40 percent of their assets in 2008 to about 50 percent in 2016, while the size of their bond portfolio declined by half. During the same period, deposit funding rose from under 40 percent of total liabilities to 55 percent in 2016. Banks also redirected their lending activities towards the local economy. Internationally active banks are now concentrated on their core markets (Czech Republic, France, Ireland, Luxembourg, Netherlands, and Turkey), with very limited exposure outside of them. Some banks are shifting to digital banking platforms, which is helping rationalize networks by integrating branches and reduce costs.

6. The Belgian insurance sector has seen moderate growth and changing business models in the post-crisis environment. Total assets of the insurance sector have increased by about 12 percentage points of GDP over 2012-16 and represented 80 percent of GDP in 2016. Most of this increase, however, reflects the introduction of market-based valuation of assets under Solvency II. In fact, the sector has undergone some restructuring in response to the protracted period of sluggish growth and low interest rates, with 12 percent of licensed firms exiting the sector since 2013 and several life insurance firms announcing that they will stop selling life insurance contracts with guaranteed rates. At the same time, several insurers have moved from traditional insurance products to asset management type products. Despite this shift, annual premiums in the life business have declined by 31 percent between 2012 and 2016.[6]

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[3] First, in 2008, the acute liquidity crisis following the failure of Lehman Brothers forced the authorities from Belgium, France and Luxembourg to issue a joint guarantee order of € 150 billion to cover many of Dexia's funding sources, in addition to capital injections of € 6.4 billion. In exchange to this State aid, the group reduced its risk profile and refocused on core activities. Second, in 2011, as a result of the severe impact of the EU sovereign debt crisis and to avoid the systemic risk from a disorderly liquidation, Dexia group was put under orderly resolution with State aid.

[4] The residual assets are managed on a run-off mode by Dexia S.A. and its subsidiary Dexia Credit Local, which benefit from a funding guarantee mechanism up to € 90 billion provided by the Belgian, French and Luxembourg governments. At end of 2016, Dexia's asset portfolio, constituted mainly of sovereign and public-sector assets, amounted to € 117 billion, down from € 150 billion in 2012. In 2016, about 60 percent of the asset portfolio had a remaining maturity of over 10 years.

[5] In addition, following significant losses on a portfolio of collateralized debt obligations (CDOs), the Belgian government granted a guarantee on KBC's structured credit instruments.

[6] This was partially driven also by higher (from 1.1 to 2 percent) taxes on premiums introduced in 2013.

KEY RISK FACTORS

A. Risks of the Banking Sector

7. Banks' balance sheets have strengthened since the last FSAP on the back of a vast deleveraging and de-risking process. Capital ratios increased significantly with the average CET1 ratio rising by 200 basis points since 2012 to 15.7 percent in 2016. Similarly, the quality of banks' loan portfolio improved further with non-performing loans reducing to 3.4 percent of gross loans in 2016, and very low estimated loan loss provisioning rates reflecting mainly improved macroeconomic conditions in foreign markets.

8. Following major deleveraging in non-core markets, Belgian banks have boosted their domestic mortgage lending activities. As a result, mortgage loans have grown at a rapid pace and represent around 20 percent of banks' balance sheet at end-2016. While banks had tightened their lending policies over 2012–14, during the last two years a further build-up of high-risk segments has been observed. This increases banks' vulnerability to credit risk if conditions in the Belgian real estate market deteriorate.

9. Maintaining profitability is a challenge going forward. Net interest margins have increased since 2014 despite falling interest rates, because banks' funding costs were adjusted faster than asset yields. However, sustaining profitability will be challenging going forward, given the large waves of mortgage repayments and refinancing at lower fixed rates in 2014-2016[7] and the lower bounds hit by funding costs.[8] In addition, the introduction of IFRS9 in 2018 will likely lead to higher provisions.[9] The gradual implementation of additional capital requirements through 2019 will further squeeze profits.[10]

10. Banks' profitability could be further challenged by an abrupt reversal of compressed risk premia. An abrupt and sustained increase in short-term and long-term interest rates would lead to higher funding costs which could outpace the repricing of assets, compressing (overall/net) margins, if banks are not adequately hedged against interest rate hikes.

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[7] In 2015–2016, house loan pre-payment rates in Belgium reached around 22 percent, compared to a euro area average of 12 percent. This rate decreased to around 14 percent in 2017.

[8] While the penalty payments linked to remortgaging have temporarily boosted banks' net interest income through increased fees and commissions, the lower rate negotiated by these customers will adversely impact banks' future interest income. Other factors that have contributed to bolster the recent profitability of the Belgian banking sector are valuation effects on financial instruments from declines in interest rates which might reverse in the future.

[9] Based on the EBA impact assessment launched in the first quarter of 2016, IFRS9 is expected to increase accounting provisions by around 20 percent on average. This estimate came down to around 13 percent in the second impact assessment launched in the last quarter of 2016. While the quantitative impact is estimated at the reference date for implementation in 2018, some long-lasting effects can be expected due to the estimation of lifetime expected credit losses for the new flow of stage 2 exposures depending on market conditions.

[10] These include mainly the capital conservation buffer introduced in January 2016, starting off at 0.625 percent and rising to 2.5 percent by 2019; the countercyclical capital buffer introduced in January 2016 set currently at 0 percent for Belgian exposures; and the O-SII capital surcharge being gradually incremented from 0.5 percent (bucket 1) and 0.25 percent (bucket 2) to 1.5 percent and 0.75 percent, respectively as of January 2018.

11. The FSAP's Risk Assessment Matric (RAM) (Appendix I) identified the following key macrofinancial risks for the banking sector:

- *A sudden increase in general risk aversion in global markets*. This would lead to higher money market rates, a steepening of the yield curve, reductions in market liquidity, and possibly broad-based financial market dislocation, pushing down securities valuation and bank equity values. Economic activity would then slow down in advanced and emerging market countries.

- *A large correction in the Belgian real estate market*. The direct impact on banks could be followed by losses associated with weak consumption if households were to deleverage aggressively. Depressed mortgage loan valuations would also impact banks' asset encumbrance and increase funding costs.

- *A reassessment of regional sovereign risk*. Fiscal stress in the euro area could re-emerge triggered by political uncertainty or concern about debt sustainability. This would weaken banks' balance sheets and hamper their access to wholesale funding.

- *A prolonged period of low growth and low interest rates in the euro area ("low-for-long" scenario).* The impact on interest margins and profits could be significant and would likely be exacerbated by credit losses. This muddle-through scenario would depress corporate earnings, weaken stock returns, increase market leverage, and lead to higher corporate defaults.

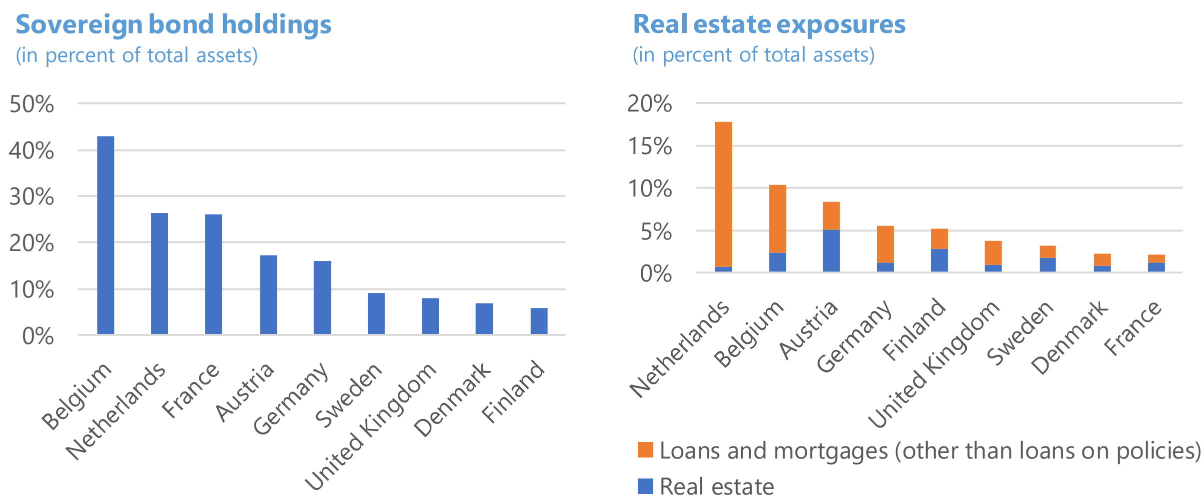
B. Risks of the Insurance Sector

12. The move towards asset management-type products has led to a change in the risk profile of insurers. Interest rate risks stemming from duration mismatches have declined in recent years as a result of better asset-liability matching. But, while the shift away from guaranteed products has reduced insurers' exposure to interest rate and other market risks, it has rendered them vulnerable to liquidity risk as policyholders might redeem their contracts especially in times of rising interest rates. Purchases of mortgage loan portfolios by some companies further expose them to liquidity risk. Low interest rates continue to weigh heavily on the profitability. The sector's return on equity, which averaged 20 percent before the financial crisis, declined to around 8-10 percent in 2015/16, but tends to be higher for composite insurers pursuing both life and non-life businesses.

13. Compared to their peers, Belgian insurers have large holdings in domestic sovereign bonds and real estate (Figure 1). Risks on the asset side are dominated by the concentrated exposure towards sovereign bonds, which account for 43 percent of total assets. More than half of these bonds are Belgian sovereign bonds. Real estate exposures are also high and come mainly in the form of mortgage loans issued in the Belgian and Dutch market. Additionally, being part of a financial conglomerate (FC), some insurers have concentrated exposures towards banks, specifically deposits within the same group.

Figure 1. Investments of Belgian Insurers in Comparison with EU Peers

Belgian insurers hold large amounts in sovereign bonds and are also more exposed to real estate and mortgage loans than other EU peers.



Source: IMF staff calculations based on EIOPA data

C. Common Macroeconomic Scenarios for Banks and Insurers

14. The common macroeconomic scenarios were designed by the FSAP team to explore the impact of global and domestic risks on Belgian banks and insurers. The scenario-based stress tests included a baseline scenario and a stress scenario projected over a five-year horizon. The scenario starts in the first quarter of 2017 and extends through the fourth quarter of 2021. This is a longer horizon than the 2016 EU-wide bank stress test ("EBA") scenario. This addresses the possible persistence of some vulnerabilities and amplification channels that might accumulate over time.

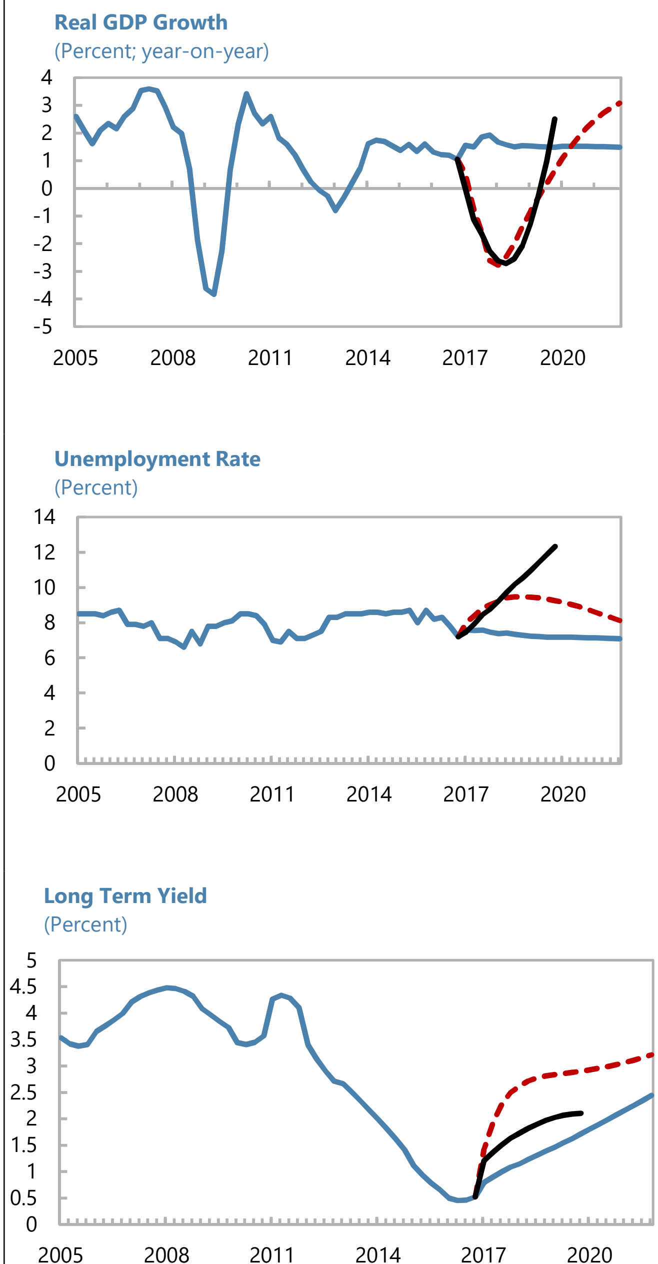
15. The baseline scenario was based on the October 2017 World Economic Outlook (WEO). Baseline projections included paths for ten key macrofinancial variables in Belgium and ten material geographies for Belgian banks, including Bulgaria, Czech Republic, France, Hungary, Ireland, Luxembourg, Netherlands, Slovakia, Switzerland, Turkey, other EA countries, and other emerging markets. WEO baseline projections incorporate risks from Brexit which might adversely impact Belgium's exports.

16. The set of projections include variables related to economic activity, borrowers' capacity to service debt, bank profitability, and asset valuations. Core variables include paths for real and nominal GDP, inflation, unemployment, short-term rates, long-term rates, public debt, and foreign exchange fluctuations. Missing data on some geographies was estimated using benchmark data from comparator economies. The 2017 WEO scenario is consistent with NBB's baseline projections for Belgium.[11]

[11] An exemption includes the relative path for real exports and imports. But these are not significant to project bank capital ratios.

Figure 2. Belgium Macroeconomic Scenario

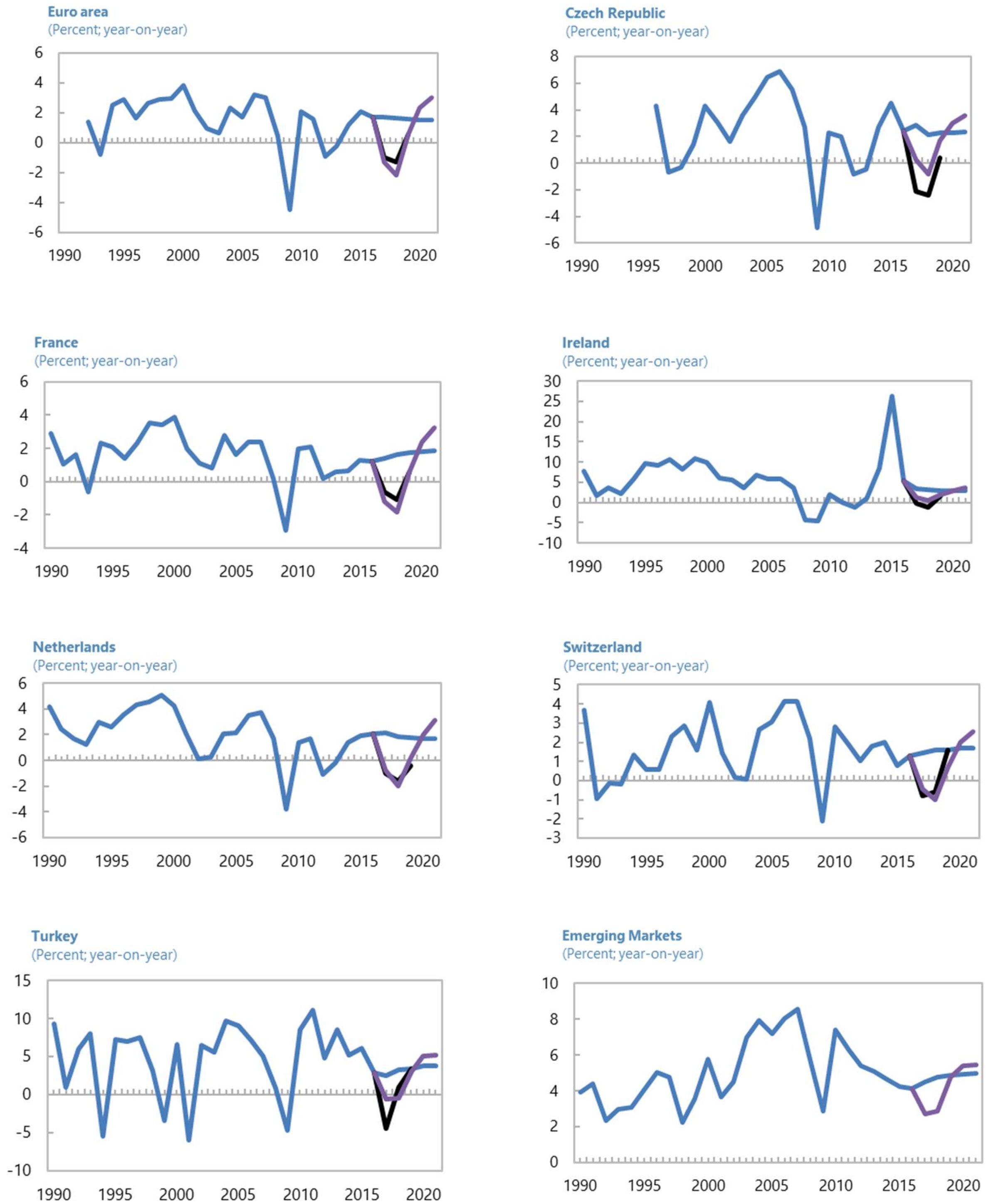
The severity of the adverse scenario is comparable to the 2016 EU-wide stress test scenario for key paths but outweighs market corrections. Projections are in blue (baseline), red (FSAP), and black (2016 EBA).



Source: IMF staff calculations and European Banking Authority.

Figure 3. International Macroeconomic Scenario

Real GDP growth paths in material geographies for Belgian large internationally active banks. Projections are in blue (baseline), purple (FSAP), and black (2016 EBA).



Sources: IMF staff calculations and European Banking Authority.

Table 2. Key Scenario Assumptions for Adverse Scenario

Scenario designed followed a layers-of-shocks approach. The resulting paths for core variables reflect both exogeneous shocks as well as the endogenous behavior reflected in the structural macro model.

Layer 1: Tightening of financial conditions in systemic economies, 2017Q1 – 2018Q2	
Long term government bond yield; Duration risk premium shocks	
High Spread Euro Area Economies	+200 basis points
Low Spread Euro Area Economies	+50 basis points
Japan, United Kingdom, United States	+100 basis points
Real equity price; Equity risk premium shocks	
China, Euro Area, Japan, United Kingdom, United States	−20 percent
Money market interest rate spread; Credit risk premium shocks	
China	+100 basis points
Euro Area, Japan, United Kingdom, United States	+75 basis points
Real bilateral exchange rate; Currency risk premium shocks	
Euro Area	+5.0 percent
Layer 2: Fiscal consolidation in the Euro Area, 2017Q1 – 2019Q2	
Primary fiscal balance ratio; Fiscal expenditure shocks	
High Spread Euro Area Economies	+2.0 percentage points
Low Spread Euro Area Economies	+1.0 percentage point
Layer 3: Credit cycle downturns in emerging market economies, 2017Q1 – 2019Q2	
Loan default rate; Loan default shocks	+0.0 to +6.4 percentage points
Layer 4: Suppressed economic risk taking worldwide, 2017Q1 – 2021Q4	
Private investment; Investment demand shocks	−4.0 percent
Private consumption; Consumption demand shocks	−1.0 percent
Layer 5: Domestic Layer: Sovereign risk, funding stress, and housing correction in Belgium, 2017Q1 – 2019Q4	
Long term government bond yield; Duration risk premium shocks	+100 basis points
Primary fiscal balance ratio; Fiscal expenditure shocks	+1.0 percentage point
Wholesale funding spread, Credit risk premium shocks	+50 basis points
Real housing price correction, peak-to-trough	-20 percent
CRE price correction, peak-to-trough	-30 percent
Private investment; Investment demand shocks	−8.0 percent
Private consumption; Consumption demand shocks	−2.0 percent
Layer 6: Regional Layer in Germany and selected Emerging European Economies, 2017Q1 – 2019Q4	
Growth Slowdown in Germany and Selected Emerging European Economies (CZE, POL, TUR)	
Private investment; Investment demand shocks	−4.0 percent
Private consumption; Consumption demand shocks	−1.0 percent
Market pressures in Selected Emerging European Economies (CZE, POL, TUR)	
Long term government bond yield; Duration risk premium shocks	+100 basis points
Real equity price; Equity risk premium shocks	−10 percent
Real bilateral exchange rate; Currency risk premium shocks (only TUR)	+20.0 percent

Source: IMF staff calculations.
Note: All scenario assumptions are expressed as deviations from the Aprilm2017 World Economic Outlook baseline. Endogenous variable adjustments peak in 2018Q2 or 2019Q2 were indicated and half dissipate by 20121Q4. The long-term government bond yield is for a 10-year security, while the money market interest rate is for a 3-month security. The high spread Euro Area economies are Greece, Ireland, Italy, Portugal and Spain, while the low spread around Euro Area economies are Austria, Belgium, Finland, Germany and the Netherlands.

17. The adverse macro scenario covered the first three risks identified in the RAM while the low-for-long scenario was assessed using single-factor shocks.[12] The stress scenario was designed to incorporate banks' profits headwinds from search-for-yield behavior, valuation changes from a reversal of the low volatility environment, the contraction of interest margins on the back of rising funding costs, higher credit risk from stressed borrowers, and higher regulatory capital from

[12] Details of the approach to scenario design are shown in the Stress Testing Matrix (SteM) in Appendix III.

shifts to fundamentals. The scenario was calibrated using IMF's in-house Global Macrofinancial Model (GFM).

18. The realization of financial stability risks leads to business cycle downturns in major economies, heightened volatility in financial market and sharp corrections in real estate prices (Figure 2). Under this stress test scenario, Belgium experiences a balance sheet recession with nine quarters of negative growth rates peaking at -2.8 percent in 2018Q1. Output falls 8.1 percent below baseline by 2019, consumption price inflation falls 3.5 percentage points below baseline by 2020, money market rates widen by 120 basis points, long-term yields rise by 150 basis points by 2018, real equity prices fall by 20 percent, and real estate prices collapse by 20 percent.

19. The international component of the scenario reflects additional stress in core markets for Belgian internationally active firms (Figure 3). This is captured through a regional layer of shocks in the euro area and material geographies for Belgian banks. Within the euro area, the output loss is concentrated in high spread economies, which experience a fall of 9.1 percent below baseline. Among emerging markets, the CESEE region is particularly hit by the retrenchment in trade and capital flows with an output loss around 7.0 percent at the low point in 2019.

20. The severity of the adverse macro-financial scenario is comparable to the 2016 EU-wide stress testing exercise but exceeds that of recent FSAPs. There is no single variable that determines the overall level of severity. For any given variable, there is no single metric of severity as this is related to the evolution relative to baseline as well as to the starting point. To provide an overall sense of severity, Figures 2-3 compare the FSAP adverse scenario to the 2016 EBA scenario. They show similar severity in terms of real economic activity, but the market volatility generated by adjustments in asset prices is greater under the FSAP scenario on the back of heightened cyclical imbalances in financial markets. The stressed GDP path constitutes a 3.1 standard deviation move in the two-year cumulative real GDP growth rate by 2018.[13] The key scenario assumptions are reflected in Table 2.

21. Macroeconomic projections were extended to a set of financial variables that are likely to influence bank resilience to shocks. These include shifts to benchmark rates, yield curve by sovereign issuers, equity values, credit growth, residential real estate prices, and commercial real estate prices in a way that is consistent with the core macroeconomic projections. The calibration of the traded risk component of the scenario is sector-specific and is described in more detail below.

[13] This is larger than the severity benchmark used in other FSAPs of shocks to real GDP that represent around 2.0 standard deviations in terms of historical volatility.

STRESS TESTING THE BANKING SECTOR

A. Stress Testing under the FSAP Program

22. **Macroprudential stress tests were conducted to assess the Belgian financial system's ability to withstand losses without amplifying shocks to the real economy.**[14] The stress test contributes to the objective of ensuring that banks have the capacity to absorb shocks without engaging in deleveraging or amplification of market and liquidity stress in the face of severe stress triggered by: (i) rising cyclical vulnerabilities from rising leverage, abrupt asset prices corrections, or deterioration of underwriting standards in mortgages; and (ii) structural shocks from their shift towards more traditional business models, reduced activities in the Belgian interbank market with interbank activities conducted with foreign counterparties, and greater reliance on non-maturing domestic deposits.

23. **The FSAP stress tests of the Belgian banking system should be seen in conjunction with the recent tests undertaken by EBA, ECB, and NBB.** The resilience of the Belgian banking sector has been recently examined by the 2016 EBA/ECB stress tests, the 2017 Interest Rate Risk in the Banking Book ECB exercise, and the 2017 NBB stress test. While these exercises are of similar nature, their coverage of risks and institutional perimeter differ markedly. Whereas the 2016 EBA/ECB stress tests and the 2017 NBB test both have a comprehensive coverage of risks, the former includes five Belgian SIs and the latter targets only Belgian LSIs. On the other hand, the 2017 Interest Rate Risk in the Banking Book ECB exercise is a sensitivity analysis with multiple interest rate shocks designed to test only interest rate risk in the banking book. Similar to the 2016 EBA/ECB stress tests, it includes only SIs.[15]

24. **The FSAP stress test results should be interpreted with caution**. The FSAP stress test results on the Belgian banking system are based on end-2016 supervisory data. These data were complemented by NBB's pre-June 2014 supervisory data for a core set of variables (e.g., default rates, funding cost by instrument, net trading income) notwithstanding some revisions to FINREP and COREP definitions. For other variables, the FSAP team had to merge post-2014 SSM reporting templates with data sourced from publicly available sources as it did not have access to long series of supervisory data (e.g., banks' sovereign exposures were drawn from annual reports). Despite the FSAP team's best efforts to build a consistent database, the matching and reconciliation of risk data extracted from multiple data sources is a complex exercise.

25. **Additional challenges are posed by the use of proxy variables and the nature of tail risk events**. Some risk parameters were projected using proxy variables on the back of data availability constraints, adding challenges to the quantitative impact of the stress testing exercise. For instance, the duration of the fixed income portfolio was proxied by remaining maturity using the transparency template of the 2016 EBA exercise even though periodic coupon payments would

[14] A top-down macro stress test on bank-level supervisory data combined with a macroeconomic model was conducted to evaluate the direct impact of stress on the banking system.

[15] In the 2016 EBA/ECB and 2017 Interest Rate Risk in the Banking Book ECB exercise two significant subsidiaries of large EU SIs (i.e., BNP Paribas Fortis and ING Belgium) are only tested via their parent company.

reduce duration. PD estimates for selected portfolios were projected drawing on expected default frequency (EDFs) series which tend to display greater volatility than regulatory PDs and are based on a country-based representative portfolio. A broader caveat is that stress test scenarios are calibrated using historical data which identify extreme "tail events" based on a historical distribution, even though it is well known that the nature of crises is to have unanticipated shocks and unexpected interrelationships where the past offers limited guidance. While some nonlinear effects can be captured in stress tests, it is always possible that unknown patterns emerge, especially if extreme shocks materialize.

B. FSAP Stress Testing Strategy

26. The resilience of the Belgian banking system was assessed under a battery of stress tests (Figure 4). The assessment followed a four-pronged approach:

- *A solvency stress test including a fully-fledged scenario-based test and a range of sensitivity tests to assess the system's capital adequacy.* The macrofinancial scenario explored domestic as well as global risks. It also included a traded risk scenario to capture business risk from tighter financial conditions, changes in market valuations, and vulnerabilities from asset liability management (ALM) operations. A range of sensitivity tests was conducted to further explore the resilience of the Belgian banking system to wider shifts to risk factors.

- *A wide range of liquidity stress tests to assess bank resilience to sudden, sizable withdrawals of funding. The* analysis was based on two complementary liquidity frameworks: (i) a Liquidity Coverage ratio (LCR)-based approach implemented under four different scenarios, and (ii) an implied cash-flow test applied under six alternative scenarios, simulating a range of stress factors over eighteen maturity buckets ranging from one-day through twelve months.

- *A contagion module to shed light on the potential for the interbank market to spread stress across banking institutions.* The transmission of shocks in the interbank market ("bilateral exposure channel") was examined drawing on Belgian banks' bilateral matrix of large exposures, including intragroup transactions.[16]

- *A systemic risk module to assess contagion through equity markets.* Systemic risk and cross-border spillovers were assessed using a market-based CoVaR approach. This methodology ("market contagion channel") allows evaluating correlated losses through equity markets which might be unrelated to credit or funding exposures (i.e., due to common exposures, similarities in banks' business models or investors' correlated strategies).

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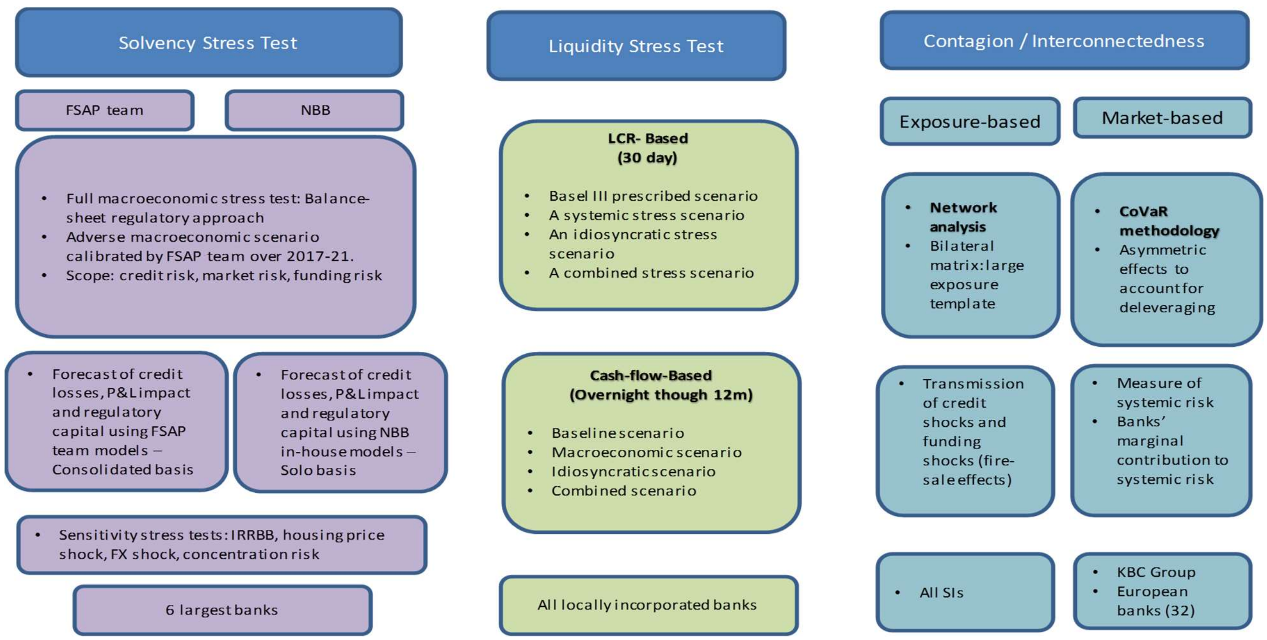
[16] The stress test assessed the potential impact from credit risk from exposures to other credit institutions as well as from funding concentration to large counterparties. Amplification mechanisms through fire sales and cascading defaults were assessed using a network analysis on the Belgium interbank market.

Figure 4. Overview of Stress Testing of the Banking Sector

The resilience of the Belgian banking system is assessed under 3 Pillars…



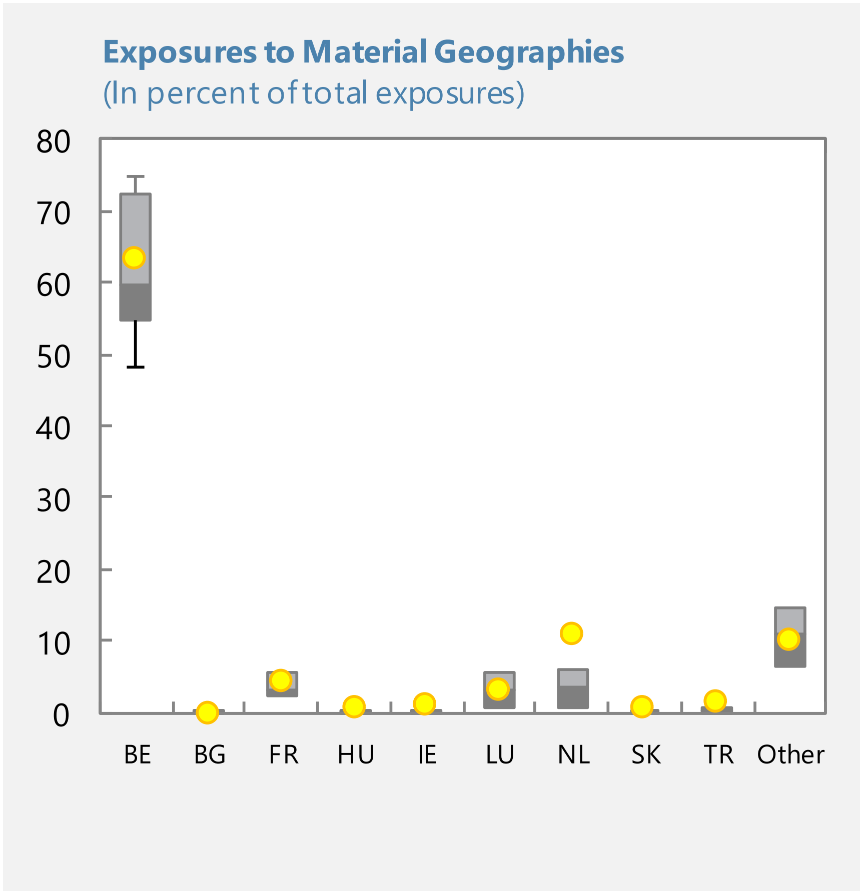
Source: IMF staff.

27. The stress test examined a comprehensive range of credit risk exposures, funding risk channels, and P&L items:

- A separate credit risk analysis was calibrated for five Basel asset classes, two regulatory books, and eleven material geographies for Belgian banks. Material geographies for credit exposures vary widely among Belgian banks reflecting their different business models (Figure 5).
- A granular analysis was conducted to project net trading income in the trading book including from equity positions, debt instruments, and trading derivatives, as well as to forecast non-interest income including dividend income and insurance income.
- Funding costs were projected at the bank level broken down by reference rate, bank spread over the three-month Euribor benchmark, funding instrument, and repricing date drawing on supervisory data.
- A sensitivity analysis assessed the impact of bank-level pass-through of funding costs to customers using the projected path for funding costs generated by the scenario (idiosyncratic driver) and the system-wide macrofinancial scenario (systemic driver).

Figure 5. Material Geographies for Credit Risk

Notwithstanding significant balance sheet deleveraging of cross-border exposures post-GFC, Belgian banks are active in their core markets. Material geographies differ across banks.



Source: SSM and IMF Staff calculations.

Note: Both IRB and STA exposures are included after CRM adjustments for all credit portfolios excluding exposures to sovereigns. The sample of banks included the six major Belgian banks. Boxplots include the mean (yellow dot), the 25th and 75th percentiles (grey box, with the change of shade indicating the median), and the 10th and 90th percentiles (whiskers).

BANK SOLVENCY TESTS

A. Scope of the Stress Test

28. **The IMF stress test covered the six major Belgian SIs, representing around 90 percent of total banking system assets.**[17] The IMF stress test was conducted at the highest level of

[17] The six major Belgian SIs are Argenta, AXA Bank Belgium, Belfius Banque, BNP Paribas Fortis, ING Belgium, and KBC Group. The two remaining Belgian SIs are not significant in terms of activities in Belgium. Banque Degroof Petercam is a small bank with mainly cross-border assets; and Dexia is a vehicle on run-off mode and subject to SSM's regulatory waivers.

consolidation in Belgium including the insurance arm for KBC Group and Belfius and the consolidation of banking associates and foreign subsidiaries.[18] The NBB analysis covered the same sample at a solo level, excluding foreign subsidiaries.

29. Stress tests were based on ECB/SSM confidential supervisory data post-June 2014 and NBB supervisory data before. The ECB shared supervisory returns including ITS files (i.e., FINREP and COREP), and STE files (i.e., maturity ladder) for the solvency test, The NBB shared pre-September 2014 data for credit risk measures (i.e., NPL series, loan loss rates) and P&L items (i.e., net trading income, and interest expense for deposit funding and debt instruments). The composition of the debt securities portfolio was extracted from banks' annual reports, Pillar 3 disclosures, and the 2016 EBA transparency exercise.

30. The assessment criteria ("hurdle rate") include the capital standards implemented via the Capital Requirements Regulation (CRR) and the fully implemented O-SII buffer. The hurdle rate applied in the FSAP stress test was set at the fully loaded Pillar I minimum common equity, the fully loaded O-SII buffer, and the fully implemented capital conservation buffer, This lead to a CET1 hurdle rate of 8.5 percent for the Big 4 and 7.75 percent for the remaining two O-SIIs. The hurdle rate also includes a 3 percent Tier 1 ratio based on the CRR leverage framework.

B. Scenario Specification

31. The scenario includes material shocks to sovereign yields for all material sovereign exposures. Sovereign shocks were calibrated for all the sovereigns to which Belgian banks were exposed to end-2016 (Table 3). Specific shocks to 10-year sovereign yields relative to end-2016 are shown in Table 3 for twenty-three sovereigns. Under the baseline scenario, shocks to the risk-free rate proxied by the 10-year Bund increase by an average 36 basis points per year close to the average 37 basis points for the Belgian OLO rate. Under the adverse scenario, OLO rate exhibits credit spread shocks over the Bund with rates rising by 140 basis point in 2017, and a further 69 basis point in 2018, relative to the increase in Bund rates by 70 basis points in 2017 and 44 basis points in 2018. The duration of banks' holdings of sovereign securities was proxied by the residual maturity reported in the transparency templates of the 2016 EBA exercise.

32. Corporate yields rise to levels observed during the GFC. Corporate yields were proxied by Moody's Baa Index. Under the baseline, spreads rise in line with shifts to the OLO curve. Under the adverse, spreads rise by 358 basis points in 2017, and 179 basis points in 2018, which reflect price corrections under a spike in volatility in fixed income markets. The duration of corporate securities in banks' portfolio was proxied by the average maturity of all active corporate bonds as of October 2017, yielding an average duration of 4 years weighted by face value.

[18] The solvency stress test is based on Argenta's banking group rather than Investar which includes Argenta insurance arm. However, the liquidity stress test is conducted on Investar.

Table 3. Sovereign and Corporate Yields Projections

Sovereign yields were projected for all the sovereigns in the fixed income portfolio of Belgian banks.

Baseline Projections (basis points; year-on-year)						Adverse Projections (basis points; year-on-year)					
	2017	2018	2019	2020	2021		2017	2018	2019	2020	2021
AT	32	37	40	38	36	AT	66	47	34	31	32
BE	41	31	36	39	39	BE	149	69	18	15	19
BG	22	15	20	20	60	BG	112	33	-4	0	48
CA	36	30	40	63	51	CA	70	41	37	59	47
CZ	22	15	20	20	60	CZ	112	33	-4	0	48
DE	37	34	37	38	34	DE	70	44	31	32	30
ES	57	54	37	38	34	ES	198	104	14	6	7
FI	22	24	18	18	10	FI	55	34	12	12	6
FR	52	11	41	20	17	FR	85	21	35	13	13
HU	37	50	30	20	20	HU	154	82	6	-5	2
IC	5	-1	-6	0	0	IC	146	49	-29	-32	-27
IE	92	54	67	63	34	IE	234	104	44	31	7
IT	79	37	40	38	36	IT	220	87	17	6	9
JP	12	10	10	10	9	JP	84	37	0	-6	-3
LV	24	18	18	10	10	LV	58	28	12	4	6
LT	22	24	18	18	10	LT	55	34	12	12	6
LU	-3	6	10	12	14	LU	31	16	4	5	10
NL	-6	12	20	24	28	NL	28	22	14	17	24
PT	-43	37	40	38	36	PT	99	87	17	6	9
PL	0	0	0	0	0	PL	117	32	-24	-25	-18
SK	-4	38	42	46	46	SK	113	70	19	21	28
SI	-104	52	50	50	0	SI	13	85	26	25	-18
US	52	45	53	15	-2	US	124	71	42	0	-15
BAA yield	15	27	38	43	47	BAA yield	358	179	29	31	37

Source: IMF staff estimates based on WEO and Bloomberg data.

33. **The adverse scenario features a correction in money markets and real estate markets** (Figure 6). The adverse scenario assumes an abrupt decompression of asset risk premia relative to baseline, amplified by low secondary market liquidity as financial risk taking unwinds, interacted with the re-emergence of financial stress in the euro area. Euribor spreads over Bund T-bill rise around 100 bps over the stress test horizon.[19] Tightening financial conditions and confidence losses in Belgium trigger large property market corrections in Belgium, with the real residential property price and the real commercial real estate price falling by 20 percent peak-to-trough.[20] This leads to a credit crunch with credit to the private sector reaching negative rates starting in Q12018 at a peak of -4.45 percent.

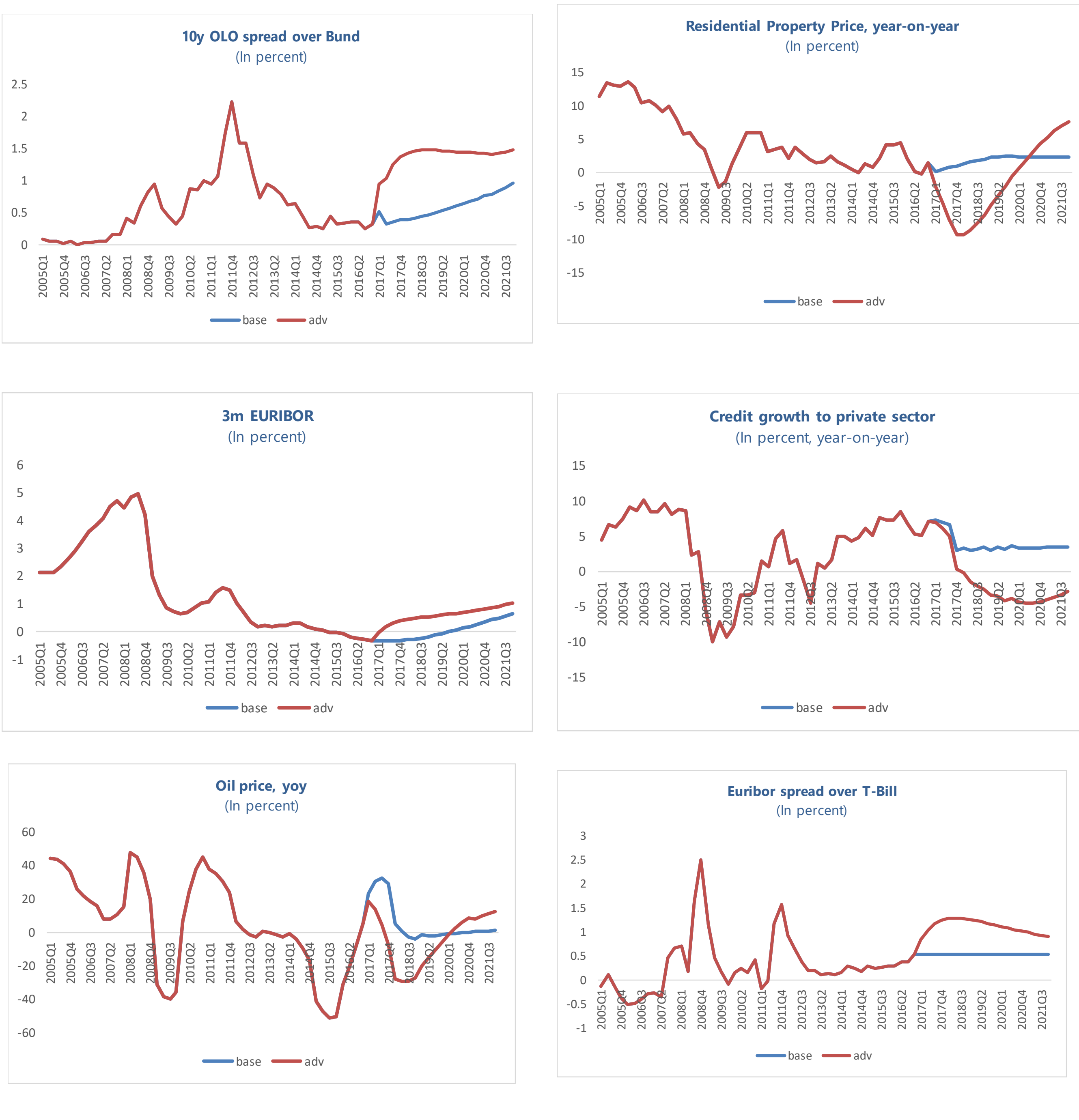
34. **Concerns on "Too Much Money Chasing Too Few Yielding Assets" are reflected in heightened volatility in equity markets.[21]** One may expect that changes in investors' risk preferences, partly due to fluctuations in aggregate liquidity, will influence portfolio allocation decisions and investors' willingness to bear sovereign risk. The FSAP team generated a volatility path under the baseline and adverse scenario in relevant equity markets for Belgian banks. Forecasts were based on a measure of realized volatility linked to the equity market projections generated for three equity indexes, i.e., Eurostoxx 50, BEL-20, and S&P 100 (Appendix II

[19] The projected path for money market rates in Belgium reaches a peak in 2018 with a 120bps increase relative to baseline.

[20] The path of real estate prices was part of the macroeconomic scenario jointly agreed with the NBB and ECB.

[21] This concern was highlighted in the IMF October 2017 Global Financial Stability Report (Chapter 1).

Figure 6. Global Assumptions



Source: IMF staff calculations.

C. Credit Risk Modelling Approach

35. Credit risk accounts for the largest regulatory capital requirement of Belgian banks. At end-2016, the size of the largest six Belgian banks reached €917 billion, with RWAs of €349 billion, representing around 40 percent risk density. Over 85 percent of capital is required to cover unexpected losses from credit risk. By contrast, market risk represents just under 2 percent of capital requirements which probably reflect post-GFC structural reforms which included a capital surcharge on banks' trading activities above a threshold and a ban on proprietary trading by banks introduced in the New Banking Law of 2014.

36. The impact of credit risk on banks' capital ratios depends on the regulatory approach used by banks to book credit exposures. As credit risk materializes, scenario-based stress testing requires assessing the impact of shocks to macroeconomic and financial variables on banks' loan loss provisions and capital requirements. For exposures booked under the IRB approach, credit risk evolves with the exposure at default (EaD), the probability of default (PD), and the loss-given default (LGD). For exposures under the STA approach, credit risk is reflected in higher provisioning rates and credit risk migration to substandard categories

37. The large Belgian banks rely mainly on the advanced IRB approach to book credit exposures (Figure 7). The aggregate non-defaulted EaD reported by large Belgian banks reached €876 billion in 2016, of which 90 percent was booked under the IRB approach. The split is the same for exposures to central governments or central banks which represent around fifth of total exposures. This suggests that large Belgian banks do not make use of STA approach to book sovereign exposures at a risk weight of 0 percent.[22]

Credit Risk Model for IRB Exposures

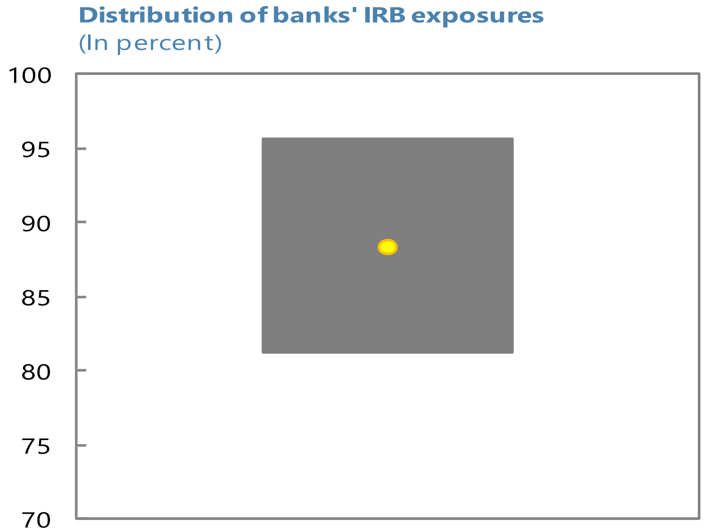
38. The impact of stress on regulatory capital through increased provisions was computed as the level of expected losses: $EL_{i,t}^{j} = PD_{i,t}^{j} * LGD_{i,t}^{j} * EAD_{i,t}^{j}$ where *i* denotes the bank, *j* denotes the asset class, and *t* is the time dimension. The FSAP team estimated separate credit risk models by portfolio and geography. All material geographies for Belgian banks are covered in the risk analysis, namely Belgium, Bulgaria, Czech Republic, France, Hungary, Ireland, Luxembourg, Netherlands, Slovak Republic, Switzerland, Turkey.[23]

[22] Under the CRR, exposures to Member States' central governments, and central banks denominated and funded in the domestic currency of that central government and central bank shall be assigned a risk weight of 0 percent. Until 31 December 2017, the same risk weight shall be assigned in relation to exposures to the central governments or central banks of Member States denominated and funded in the domestic currency of any Member State as would be applied to such exposures denominated and funded in their domestic currency.

[23] Note that different Belgian banks have exposures to different core markets.

Figure 7. Belgian Banks' IRB and STA Exposures

Belgian banks rely mainly on IRB models to compute credit risk.



Source: : IMF staff calculations based on SSM data.
Note:The definition of exposures includes all portfolios including exposures to governments and central banks. The box plot chart includes the mean (yellow dot) and the 25th and 75th percentiles.

39. The regulatory credit risk parameters (PD, LGD, EaD) for Belgian banks' approved IRB models are "hybrid" estimates. They lie between 'pure PiT' and 'pure TTC' estimates. The precise modelling approach depends on the entirety of banks' methodological choices (model structure, method to calibrate on historical data, incorporation of time-varying 'central tendency'), which contribute to rendering the parameters more or less 'PiT' or 'TTC'. This motivates the two-pronged FSAP approach to project credit risk parameters.

40. The FSAP team used a two-step process to project stressed PDs. The approach of the FSAP team was twofold:

- Based on the stress test scenario, a time series of aggregate PD proxies was projected by portfolio and geography using market-based PDs. These series are available at the monthly frequency and cover all material geographies, and therefore are suited to feed the FSAP team satellite models for credit risk.
- A statistical approach was used to forecast bank-specific PDs using post-June 2014 supervisory data to adjust aggregate projections to bank's IRB regulatory PDs.[24]

[24] A regression analysis of bank-level regulatory PDs on country-level EDFs was conducted in order to adjust the path of projected EDFs at the bank level.

41. The PD proxy for corporate and retail unsecured exposures was obtained from Moody's Analytics using the average one-year expected default frequency (EDF) by geography and portfolio. For each geography, the following portfolios were used: the corporate group, the construction and real estate development group, the financials group, and the consumer nondurables and services group. These categories were mapped to COREP portfolios, i.e., corporate and SME exposures, specialized lending exposures, exposures to institutions,[25] and retail unsecured, respectively. The analysis was conducted using monthly data over January 2005 through December 2016.

42. The PD proxy for exposures to central governments was extracted from sovereign yields using the Merton approach. The FSAP team used data from FINREP on banks' securities portfolio to back out the implied COREP exposure to sovereigns from central bank exposure. The composition of the sovereign portfolio from banks' annual reports for AFS and HTM portfolios (subject to impairment charges) was used to proxy the breakdown of sovereign exposures by issuer.

43. A reduced-form structural model to extract PD estimates from the sovereign spreads projected under the scenario. This approach assumes that the difference between a risk-free security and a risky security is the put option on the value of the assets which includes the loss induced by the stressed PD and LGD of the bond. Using the credit spreads for sovereign i linked to the scenario $S^i_{t,T}$, time to maturity (T-t), and assuming LGD=45 percent, the implied risk-neutral PD is backed-out as

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

44. To project PDs for retail exposures secured by real estate property (i.e., mortgages), the FSAP team used the shifts to PDs generated by the ECB staff modeling tool.[26]. The FSAP team did not have access to time series of default rates for mortgages from credit registers to inform default projections. Instead it relied on estimates produced by the ECB using data provided by national competent authorities (NCAs) in the context of the 2016 EBA stress testing exercise and calibrated under the FSAP scenario.

45. To address the truncated distribution nature of default rates, a logit transformation was applied before conducting the analysis. The logit transformation addressed biases generated by the truncated distribution of default rates and ensured that the projected rate is contained within the 0-1 bound once the logit forward path is applied on the forecast.

46. A battery of over 300 credit risk specifications was run to obtain PD projections. The FSAP team estimated a range of credit risk models covering eleven geographies using three approaches: (i) a panel-based regression by geography using fixed effects and robust standard errors to capture time-invariant portfolio effects; (ii) a dynamic panel-based regression using Arellano and Bond lagged structure of determinants as instrumental variables; (iii) an individual portfolio-based estimation by geography; (iv) a dynamic individual estimation by portfolio and

[25] In the IRB advanced approach, most exposures to institutions are exposures to financial institutions; some exposures are to sub-regional governments and municipalities but these are only material for one Belgian bank.

[26] ECB (2017), "STAMP€: Stress-Test Analytics for Macroprudential Purposes in the euro area", Chapter 4 (February).

geography with robust errors. Each approach was tested against different lagged structures ranging between one and three lags, and under alternative specifications capturing different sets of country factors, regional factors, and global factors.

47. Model selection was based on a combination of criteria. This included goodness of fit of the regression, forecasting performance, and expert judgment applied over the forecasted paths based on the behavior observed during the 2008-09 global financial crisis and the 2012 European sovereign debt crisis. Estimated projections were applied over the forecast window 2017Q1-2021Q4 under each scenario.

48. Credit risk in Belgian corporate exposures is heightened by stressed conditions in Belgium, the EA, and global markets. Table 4 shows that higher unemployment and a credit crunch contribute to rising corporate EDFs. Default rates increase with deteriorating financial conditions in euro area debt sovereign markets captured by soaring spreads of 10y OLO rates to Bund rates. Strains in money markets captured by widening spreads of USD Libor rates over T-bill rates also contribute to a worsening of the risk outlook amid Belgian corporates.

49. The determinants of credit risk in overseas exposures differ across geographies. Table 4 illustrates key drivers for corporate exposures in Turkey. A worsening of domestic macroeconomic conditions proxied by rising inflation and currency depreciation are major relevant determinants of credit risk in Turkey. In addition, regional conditions in emerging markets from a weakening of the growth outlook, and tightened global conditions in money markets are significant drivers of corporate credit risk.

50. Shifts to PDs were applied to the FSAP team's estimated non-defaulted bank regulatory PDs. COREP supervisory data shows exposures assigned to obligor grades for IRB-F and IRB-A with obligor grade PD=1 (defaulted) by asset class but not by geography. The FSAP team combined these data with the geographical breakdown of exposures by residence of the obligor which shows average PDs and LGDs by portfolio. It then extracted the defaulted exposures from the original exposure and estimated non-defaulted PDs and LGDs by portfolio and geography which was then applied to the exposure after credit risk mitigation techniques. This process required making adjustments to address the fact that not all exposures are assigned to obligor grades or pools by obligor.[27]

[27] The key assumption is that the distribution of credit quality steps of exposures not subject to obligor grades has the same structure than that of exposures included in the obligor pool.

Table 4. EDF Projections for Two Portfolios

PD projections were estimated by portfolio and geography on a set of country, regional, and global drivers.

EDF Corp BE				EDF Corp TR			
BE regressors	FE 1	FE 2	FE 3	**TR regressors**	FE 1	FE 2	FE 3
L.u	0.024***	0.006***	0.123***	L.fx	0.001***	0.002***	-0.001***
	(0.001)	(0.001)	(0.000)		(0.000)	(0.000)	(0.000)
L2.u		-0.146***	-0.386***	L2.fx		0.004***	0.007***
		(0.001)	(0.002)			(0.000)	(0.000)
L3.u			0.148***	L3.fx			0.001***
			(0.002)				(0.000)
L.credit	-0.069***	-0.031***	-0.030***	L.g	-0.027***	-0.010***	0.011***
	(0.001)	(0.000)	(0.000)		(0.000)	(0.000)	(0.000)
L2.credit		-0.039***	0.044***	L2.g		-0.031***	-0.000
		(0.000)	(0.000)			(0.000)	(0.000)
L3.credit			-0.088***	L3.g			-0.019***
			(0.000)				(0.000)
L.lt	-0.095***	-0.363***	-0.805***	L.inf	0.047***	0.067***	0.044***
	(0.003)	(0.004)	(0.004)		(0.001)	(0.002)	(0.001)
L2.lt		0.244***	1.136***	L2.inf		-0.032***	0.009***
		(0.005)	(0.002)			(0.001)	(0.001)
L3.lt			-0.521***	L3.inf			-0.024***
			(0.003)				(0.001)
L.bel_ger	0.464***	0.402***	0.019***	L.credit	0.020***	0.016***	0.006***
	(0.006)	(0.009)	(0.003)		(0.000)	(0.000)	(0.000)
L2.bel_ger		0.018*	0.465***	L2.credit		0.000	0.001***
		(0.008)	(0.002)			(0.000)	(0.000)
L3.bel_ger			0.035***	L3.credit			0.003***
			(0.004)				(0.000)
L.g_em	-0.061***	0.007***	-0.023***	L.lt	-0.109***	-0.034***	-0.090***
	(0.001)	(0.001)	(0.001)		(0.001)	(0.002)	(0.000)
L2.g_em		-0.065***	0.112***	L2.lt		-0.120***	0.036***
		(0.000)	(0.000)			(0.001)	(0.002)
L3.g_em			-0.121***	L3.lt			-0.116***
			(0.001)				(0.001)
L.libor_tbill	0.287***	0.375***	0.523***	L.g_em	-0.083***	-0.064***	-0.035***
	(0.001)	(0.002)	(0.002)		(0.000)	(0.002)	(0.000)
L2.libor_tbill		-0.053***	-0.168***	L2.g_em		0.020***	-0.049***
		(0.001)	(0.001)			(0.003)	(0.002)
L3.libor_tbill			0.356***	L3.g_em			0.055***
			(0.002)				(0.001)
Constant	-3.892***	-2.527***	-2.870***	L.libor_tbill	0.308***	0.194***	0.214***
	(0.015)	(0.015)	(0.034)		(0.000)	(0.002)	(0.002)
				L2.libor_tbill		0.149***	0.148***
						(0.004)	(0.002)
				L3.libor_tbill			0.170***
							(0.000)
				Constant	-2.766***	-1.955***	-2.166***
					(0.002)	(0.021)	(0.011)
Observations	294	288	282		270	264	258
R-squared	0.813	0.858	0.910		0.869	0.949	0.991

Note: The estimation period is 2005Q1 through 2016Q4. EDF Corp BE (TR) denotes Moody's 1-year average expected default frequency (EDF) for the corporate portfolio (i.e., "1-Yr EDF 9 Average") in Belgium (Turkey). Key drivers include country-specific, regional, and global conditions. Their significance differs by country. They include: u (unemployment rate), credit (yoy growth of credit to the private sector), lt (10-year sovereign yield), bel_ger (10-year Belgian sovereign bond yield over 10-year Bund), gem (yoy GDP growth of emerging markets), libor_tbill (spread of 3-month US libor over US 3m T-bill), fx (yoy depreciation relative to USD), g (yoy GDP growth), inf (yoy inflation rate). Three specifications are shown for each corporate portfolio with L denoting 1 lag, L2 denoting 2 lags and L3 denoting 3 lags. The model is used for forecasting purposes rather than for the structural identification of shocks. Therefore, the forecasting ability of the specification is the relevant metric for model performance rather than the economic interpretation and magnitude of the drivers.

Table 5. NPL Projections by Bank

NPL projections were estimated by bank, using the macroeconomic paths of their core markets.

Bank	(1)	(1)	(1)	(2)	(2)	(2)	(3)	(3)	(3)	(4)	(4)	(4)	(5)	(5)	(5)	(6)	(6)	(6)
Specification	Spec 1	Spec 2	Spec 3	Spec 1	Spec 2	Spec 3	Spec 1	Spec 2	Spec 3	Spec 1	Spec 2	Spec 3	Spec 1	Spec 2	Spec 3	Spec 1	Spec 2	Spec 3
L.u	0.150**	0.058	0.069	0.056	0.035	0.163*	0.159**	0.250**	0.256**	0.134*	0.062	0.113	0.151***	0.167**	0.168**	0.193***	0.122*	0.134**
	(0.056)	(0.071)	(0.077)	(0.121)	(0.141)	(0.094)	(0.074)	(0.098)	(0.108)	(0.079)	(0.087)	(0.076)	(0.050)	(0.064)	(0.062)	(0.058)	(0.064)	(0.054)
L2.u		0.192***	0.111		0.148	-0.112		-0.126	-0.021		0.125*	0.061		0.050	0.133*		0.170***	0.108
		(0.065)	(0.085)		(0.127)	(0.118)		(0.095)	(0.112)		(0.070)	(0.087)		(0.061)	(0.077)		(0.054)	(0.070)
L3.u			0.104			0.170			-0.239**			0.145*			-0.021			0.010
			(0.078)			(0.121)			(0.112)			(0.074)			(0.080)			(0.061)
L.credit	-0.001	0.014	0.006	-0.004	0.034	0.002	0.025*	0.001	0.018	-0.037***	-0.002	-0.013	0.014**	0.012	0.017	0.014**	0.022**	0.018
	(0.005)	(0.012)	(0.015)	(0.014)	(0.024)	(0.020)	(0.014)	(0.019)	(0.017)	(0.007)	(0.014)	(0.013)	(0.007)	(0.011)	(0.011)	(0.006)	(0.009)	(0.011)
L2.credit		-0.017*	-0.013		-0.042*	0.012		0.028*	0.016		-0.039***	-0.010		0.005	0.001		-0.006	0.004
		(0.009)	(0.013)		(0.023)	(0.024)		(0.015)	(0.020)		(0.013)	(0.018)		(0.011)	(0.011)		(0.008)	(0.014)
L3.credit			-0.009			-0.074***			0.001			-0.024			0.008			-0.020*
			(0.013)			(0.020)			(0.017)			(0.016)			(0.010)			(0.011)
L.lt	0.026	0.052	-0.002	-0.189***	0.152	-0.458	-0.254***	-0.356	-0.182	-0.141***	0.001	-0.165	-0.039	0.047	0.216	-0.020	-0.107	-0.228
	(0.028)	(0.226)	(0.275)	(0.056)	(0.423)	(0.329)	(0.061)	(0.254)	(0.263)	(0.036)	(0.276)	(0.285)	(0.030)	(0.146)	(0.137)	(0.031)	(0.150)	(0.154)
L2.lt		-0.013	-0.073		-0.342	0.361		0.111	-0.043		-0.128	0.362		-0.063	-0.057		0.111	0.050
		(0.219)	(0.312)		(0.386)	(0.445)		(0.232)	(0.408)		(0.262)	(0.328)		(0.138)	(0.151)		(0.145)	(0.249)
L3.lt			0.106			-0.229			0.017			-0.341			-0.136			0.149
			(0.192)			(0.218)			(0.275)			(0.202)			(0.087)			(0.165)
L.bel_ger	0.202***	0.209***	0.242**	0.434***	0.295	0.175	0.801***	0.221	0.197	0.625***	0.519***	0.484***	0.171***	-0.054	-0.031	0.289***	0.103	0.078
	(0.044)	(0.074)	(0.099)	(0.157)	(0.267)	(0.203)	(0.079)	(0.181)	(0.151)	(0.079)	(0.115)	(0.124)	(0.058)	(0.091)	(0.103)	(0.052)	(0.087)	(0.116)
L2.bel_ger		0.044	-0.030		0.291	0.198		0.573**	0.280		0.182	0.087		0.256**	0.080		0.252**	0.170
		(0.138)	(0.165)		(0.313)	(0.240)		(0.231)	(0.263)		(0.175)	(0.190)		(0.104)	(0.117)		(0.119)	(0.169)
L3.bel_ger			-0.006			0.052			0.274			0.244			0.273***			0.011
			(0.128)			(0.187)			(0.192)			(0.157)			(0.070)			(0.121)
L.g_em	-0.052**	-0.119**	-0.107**	0.040	-0.031	0.001	-0.110**	-0.057	-0.111*	-0.052**	-0.092	-0.067	-0.023	-0.063*	-0.057**	-0.040*	-0.087**	-0.086**
	(0.021)	(0.054)	(0.050)	(0.046)	(0.125)	(0.091)	(0.054)	(0.046)	(0.058)	(0.025)	(0.063)	(0.056)	(0.019)	(0.033)	(0.027)	(0.020)	(0.037)	(0.032)
L2.g_em		0.063	-0.030		0.063	-0.141		-0.047	-0.029		0.020	-0.032		0.039	0.024		0.046	-0.018
		(0.069)	(0.076)		(0.151)	(0.106)		(0.060)	(0.071)		(0.077)	(0.060)		(0.041)	(0.034)		(0.042)	(0.054)
L3.g_em			0.102			0.310***			-0.000			0.038			-0.031			0.106**
			(0.073)			(0.060)			(0.065)			(0.064)			(0.025)			(0.051)
L.libor_tbill	-0.112	-0.100	-0.045	-0.269**	-0.112	0.060	0.010	0.168**	0.072	-0.123	0.047	0.164	-0.129**	-0.050	-0.041	-0.107*	-0.082	-0.068*
	(0.077)	(0.091)	(0.105)	(0.124)	(0.133)	(0.098)	(0.066)	(0.076)	(0.130)	(0.082)	(0.090)	(0.102)	(0.050)	(0.076)	(0.063)	(0.056)	(0.052)	(0.038)
L2.libor_tbill		0.035	0.025		-0.014	-0.043		-0.196**	0.065		-0.099	-0.056		-0.085	0.065		0.019	0.029
		(0.106)	(0.150)		(0.154)	(0.117)		(0.086)	(0.144)		(0.094)	(0.116)		(0.083)	(0.056)		(0.070)	(0.058)
L3.libor_tbill			-0.093			-0.145			-0.322**			-0.023			-0.123**			-0.077
			(0.100)			(0.124)			(0.134)			(0.099)			(0.058)			(0.054)
dummy_bel							0.020	0.337**	0.178									
							(0.131)	(0.134)	(0.132)									
Constant	-5.928***	-6.785***	-7.081***	-4.442***	-5.526***	-6.006***	-4.952***	-4.722***	-3.511***	-4.146***	-4.561***	-5.726***	-4.851***	-5.441***	-5.921***	-4.120***	-5.049***	-4.781***
	(0.493)	(0.755)	(0.921)	(1.068)	(1.437)	(1.214)	(0.658)	(0.852)	(1.074)	(0.681)	(0.911)	(0.932)	(0.430)	(0.532)	(0.649)	(0.523)	(0.568)	(0.738)
Observations	47	47	47	47	47	47	47	47	47	47	47	47	38	38	38	47	47	47
R-squared	0.605	0.711	0.764	0.676	0.757	0.902	0.889	0.932	0.958	0.891	0.936	0.960	0.793	0.878	0.940	0.739	0.860	0.908

Note: The estimation period is 2005Q1 through 2016Q4. Key variables include country-specific, regional, and global factors: u (unemployment rate), credit (yoy growth of credit to the private sector), lt (10-year sovereign yield), bel_ger (10-year Belgian sovereign bond yield over 10-year Bund), g_em (yoy GDP growth of emerging markets), libor_tbill (spread of 3-month US libor over US 3m T-bill), and dummy_bel (values: 1 for Belfius in 2011Q4; 0 otherwise). The table shows 3 specifications by bank with L denoting 1 lag. The model is estimated using robust standard errors. Robustness checks are conducted on a panel-based regression with fixed effects.

51. Adverse LGDs were calibrated for the first three years of the scenario by portfolio, under the adverse scenario provided by the FSAP team. LGD projections were derived by bank, using estimated non-defaulted LGD ratios and shifts to LGD by portfolio as:

$$LGD_{i,t}^{j} = LGD_{i,t-1}^{j} + \Delta LGD_{t}^{j}$$

where $LGD_{i,t}^{j}$ is bank *i* post-credit risk mitigation LGD for portfolio *j* at time *t*, and ΔLGD_{t}^{j} is the aggregate LGD shift for portfolio *j* at time *t*.

52. The projection of EAD was driven by balance sheet assumptions, structural FX risk in foreign geographies, and triggered credit lines and guarantees. Specifically, changes to EAD in the IRB portfolio were governed by:

$$EAD^{j}_{i,t} = EAD^{j}_{i,t-1} \cdot \left(1 + g_{i,t} + f^{j}_{i,FX} \cdot \Delta FX_{t}\right) \cdot \left(1 - PD^{j}_{i,t-1}\right) + \Delta L^{j}_{i,t} \cdot UCL^{j}_{i,t-1}$$

where *i* denotes the bank, *j* denotes the asset class, and *t* is time, $g_{i,t}$ is the growth rate of the IRB portfolio, $f^{j}_{i,FX}$ is the fraction of foreign currency loans. ΔFX_{t} is the shock to foreign currency under the macro scenario, $\left(1 - PD^{j}_{i,t-1}\right)$ represents the non-defaulted portfolio, $\Delta L^{j}_{i,t}$ is the shock to triggered credit lines and guarantees, and $UCL^{j}_{i,t-1}$ is the amount of undrawn guarantees.

53. **The FSAP scenario assumed constrained dynamic balance sheets by geography, excluding banks' management actions.**[28] Under the FSAP scenario, credit growth is determined by credit demand shocks triggered by negative consumption and investment shocks that lead to a slowdown of credit under the adverse scenario. On the other hand, credit supply effects or banks' management actions to restore capital ratios were disallowed. Given the geographic footprint of Belgian banks, the growth rate of credit varies across banks. It was computed as the EAD-weighted nominal GDP growth across relevant jurisdictions. Data on FX structural effects was projected under the assumptions that loans are denominated in the domestic currency of the overseas exposure. To calibrate the shock to triggered credit lines and guarantees, the FSAP team used the maximum increase in the off-balance sheet exposures to EAD ratio for corporates reported by banks in their Pillar 3 disclosures.

54. **To compute capital requirements, 'hybrid' regulatory risk parameters were projected and applied to Basel III formula for IRB exposures.** The derivation of RWAs is dependent on estimates of PD, LGD, EAD, correlation assumptions, and effective maturity for each exposure. According to the Basel III framework, RWAs were computed after applying the scaling factor of 1.06 to credit RWAs. Also, a multiplier of 1.25 was applied to the correlation parameter of all exposures to large regulated financial institutions and to all unregulated financial institutions.

Credit Risk Model for STA Exposures

55. **Expected losses for STA exposures are expected to rise due to the migrations from performing loans to the nonperforming category (NPLs), as well as to migration effects within the performing and non-performing buckets.** The amount of NPLs included loans and receivables as well as HTM investments. The definition covered past due loans over 90 days as well as defaulted loans. Provisions were projected for specific and collective allowances for incurred but not reported losses. Credit impairments are reported under FINREP and thus are not disaggregated between IRB and STA exposures. This might introduce some biases in the analysis for internationally active banks, for which NPLs might be larger among STA exposures if this regulatory approach is applied by subsidiaries which are subject to higher credit risk.

56. **Credit impairments for NPLs were estimated using supervisory data and were calibrated to banks' core markets (Table 5).** Merging post-June 2014 SSM data, 2008Q1–2014Q2

[28] This assumption differs from the EU-wide stress test balance sheet assumption contributing to the macroprudential nature of the IMF stress test exercise.

NBB data, and Fitch data over 2005Q1–2007Q4, the FSAP team ran a range of bank-specific regressions using a wide range of specifications and lag structures. Given the differential geographic footprint among Belgian banks, individual regressions were estimated on stressed macrofinancial paths for core markets. Panel estimations with fixed effects were also run for robustness. As for the IRB PD-based analysis, a logit transformation on NPL values was applied before conducting the analysis to ensure that the projected rate lies within the [0-1] range.

57. To compute the impact of migration on capital requirements, the FSAP team used a three-pronged approach:

- The risk weight of NPL was set at an average 100 percent, following Basel III's regulatory framework which specified that a 100 percent risk weight should be applied on past-due loans when specific provisions are no less than 20 percent of the outstanding amount of the loan.

- The difference between 100 percent and the average risk weight of each STA exposures (excluding sovereign and central bank exposures) was multiplied by the nominal amount of NPLs projected under the scenario to forecast the increase in risk weights attributed to the STA exposures in default.

- The non-defaulting portfolio was assumed to downgrade one notch under the adverse scenario. The asset-weighted risk weight of Belgian banks' STA exposures (net of sovereign and central bank claims) corresponds to a Basel III credit assessment for corporate claims between A+ to A- (50 percent) and BBB+ to BB- (100 percent). A one-notch downgrade in the BBB+ to BB- category represents an increase of 8.3 percent in the average risk weight of the non-defaulted portfolio.

58. Capital requirements for STA exposures were also driven by changes in provisioning rates, growth of EAD, structural FX risk, triggered credit lines and guarantees, and migration effects. There are four main components driving shifts to RWAs in the STA portfolio. The first component reflects the motion of RWAs generated by the flow of provisions, the growth rate of the portfolio, and FX effects. The second component shows the increase in risk weights resulting from triggered off-balance sheet credit lines and guarantees. The third component reflects the increase in risk density from the transition of loans from the performing to nonperforming category. Finally, the fourth component denotes the change in risk density from the transition matrix estimated for performing exposures:

59. The coverage ratio was projected using a joint econometric approach and historical evidence. A similar econometric strategy was devised to project coverage ratios using a merged time series drawing on supervisory data and banks' annual reports. Under the baseline scenario, end-2016 reported ratios by bank were used. Under the adverse scenario, coverage ratio estimates were forecast based on econometric projections and using the floor of Basel findings on the behavior of coverage ratios during the global financial crisis which stood at an average 65 percent.

D. Market Risk Approach

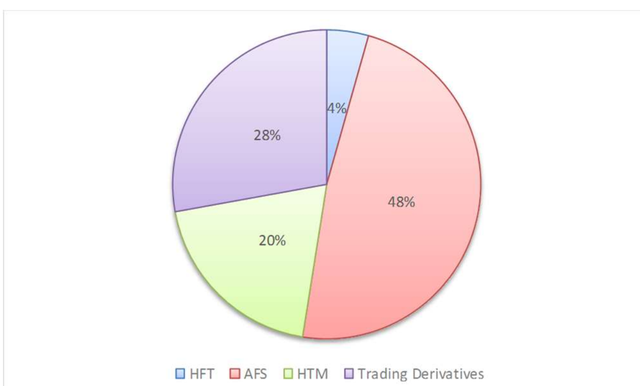
Fair Valuation Impact

60. The losses on financial assets and liabilities held for trading, financial assets designated at fair value, and available-for-sale (AFS) securities were estimated using granular approach. The FSAP team applied a full revaluation approach on all debt securities held in Belgian banks' portfolios.[29] A granular analysis was performed on the sovereign portfolio. The assessment included all sovereign exposures by issuer and regulatory book. The composition of Belgian banks' sovereign portfolios drew on banks' Pillar 3 reports at end-2016. On aggregate Belgian banks are exposed to sovereigns domiciled in 23 jurisdictions.

61. Most of the repricing impact comes from the AFS portfolio (Figure 8). The valuation losses under stress were transferred to regulatory capital through the statement of other comprehensive income (OCI). The AFS portfolio is the largest portfolio among Belgian banks, as it is used to park liquidity balances. The aggregate composition of the AFS portfolio is split between sovereign exposure to the Belgian government (40 percent) and foreign governments (37 percent) with under one fifth of total exposures to financial and non-financial corporates. Corporate exposures were proxied using the Moody's Baa corporate index.

Figure 8. Composition of Securities Portfolio, 2016
(Percent of assets)

Holding of securities in the AFS portfolio account for under 50 percent of total securities.



Sources: IMF staff calculations based on SSM data.

62. Belgian banks also hold large derivative books notwithstanding the large post-GFC decline (Figure 9). In line with the decrease of Belgian banks' wholesale activities, the size of their derivative portfolio, which in notional amount was as high as 8 times the balance sheet of the sector at the end of 2008, declined to € 3.2 trillion (or 3.2 times the total on-balance sheet assets of the

[29] Hedges for interest rate risk are assumed to be ineffective under stress and the fair value of hedges is not stressed under the adverse scenario.

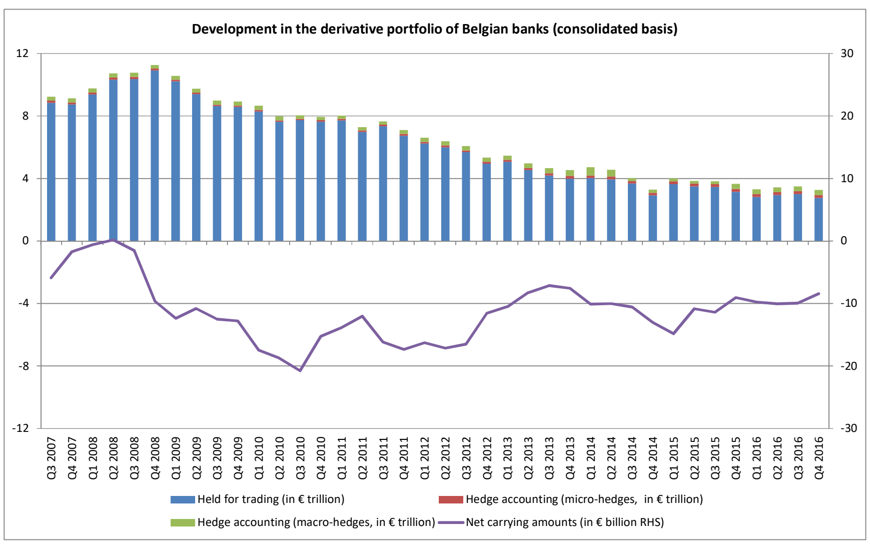
sector) by 2016. In terms of market value, the relative size of the derivative portfolio shrank from 16 percent of the balance sheet to 6 percent at the end of 2016.

63. The fair value of derivatives was not stressed on the back of the nature of Belgian banks' derivatives' trades. Belgian banks frequently agree new contracts with reverse features to neutralise their existing derivative positions, i.e., "back-to-back" derivative contracts. Thus, their value develops in the same way on the asset and liability side of the balance sheet. At the same time, about 85 percent of derivatives are classified as IFRS accounting category "held for trading".[30] The fact that most derivatives are classified as held for trading does not necessarily mean they belong to the prudential trading book. The accounting criteria imposed by IFRS to establish a hedging relationship (and thus qualify as "hedge accounting" derivative) are sometimes difficult to fulfil, and if these criteria are not met, then derivatives are—by default—classified in the IFRS accounting category "Held for trading".

Figure 9. Derivative Portfolio of Belgian Banks

(Nominal amounts, consolidated basis)

The size of the derivative portfolio of Belgian banks has decreased from 8 times the aggregate balance sheet to around 3.2 times in 2016.



Sources: NBB.

64. However, there are some concerns over counterparty credit risk related to derivatives transactions. In case of failure of the counterparty, which in some cases belongs to the same financial group, it may be difficult for the bank to hedge against the open position. While counterparty credit risk was not further stressed in the exercise, these concerns are reflected in the relatively large capital charges for credit valuation adjustments (CVA) at around 1.5 percent of RWAs. CVA capital charges may also be driven by other factors such as the type of specific deals and

[30] Of which 10 percent are identified in the prudential reporting as economic hedges. Another 10 percent of the derivative portfolio of the sector are macro-hedges used to hedge a specific portfolio (e.g., mortgage loans).

in some cases, some legacy deals for which the counterparty has already been close to default rating.

65. The impact of traded risk stress test on profit and loss (P&L) differentiates between the general interest rate impact and the credit spread impact. The FSAP team calculated a haircut for each fixed income instrument under stressed conditions as the result of multiplying the modified duration for each security by the shifts to credit spreads:

$$-\frac{D}{\left(1+r_t^f+cs_t\right)}\cdot Sec_t\cdot\Delta cs_t$$

where D denotes average duration, Sec_t denotes the carrying value of the debt security portfolio in June 2016, r_t^f reflects the risk-free rate and Δcs_t the shock to credit spreads. Shocks to credit spreads are shown in Table 4.

66. The large duration of some banks' securities portfolio was a key driver on valuation impact. Asset duration was proxied by residual maturity by sovereign issuer and regulatory book disclosed in the transparency templates of the 2016 EBA stress test exercise. For corporate exposures, the average duration of all active corporate bonds (financial and non-financial) in the Belgian market was used as a proxy weighted by the face value of the bonds. This yielded an average duration in the corporate portfolio of 4 years.

67. A similar approach was followed to compute the impact on asset valuations from repricing risk. The 10-year Bund rate was used as the benchmark rate for repricing risk calculations. Given the lower-zero bound in policy rates in the euro area which constrains the monetary policy response under the adverse scenario, the re-emergence of sovereign debt concerns in the euro area, and the absence of flight-to-quality effects, Bund rates also increase in the scenario adding further valuation pressures to the securities portfolio.[31] Under the adverse scenario, the 10-year Bund rate increases by 70bps in 2017 (relative to the initial point) and a further 44bps in 2018.

68. Banks' securities portfolio evolves in line with the constrained balance sheet assumption for credit risk. The notional values of the securities portfolio grow according to:

$$B_{i,t}^j=\left(B_{i,t-1}^j-\Pr_{i,t}^j\right)*\left(1+g_{i,t}+f_{i,EUR}\cdot\Delta FX_{EUR}+f_{i,USD}\cdot\Delta FX_{USD}\right)$$

where $\Pr_{i,t}^j$ is the level of provisions for asset class *j*, by bank *i*, at time *t*; $g_{i,t}$ is the growth of interest-bearing assets for bank *I*; $f_{i,EUR}$ ($f_{i,USD}$) is the fraction of bank's *i* portfolio denominated in EUR (USD); and ΔFX_{EUR} (ΔFX_{USD}) is the FX shock to EUR (USD). On the other hand, no portfolio rebalancing or liquidation of positions was allowed throughout the stress test horizon.

[31] Disallowing flight-to-quality effects in bond markets was a core element of the traded risk component of the scenario to increase the severity of the test.

Other Risk Factors

69. Market risk from shocks to FX rates and commodity prices is negligible. The market risk test covered shocks to FX rates in material jurisdictions of Belgian banks as well as relevant currency pairs including GBP, JPY, CHF, CAD, and USD. The traded risk component of the scenario also included sharp corrections in commodity prices for fuel and non-fuel commodities over the five-year test horizon. Belgian banks, however, do not carry material short or long net positions in foreign exchange or commodities risk measured under the standardized approach for foreign exchange risk and position risk in commodities.

70. Other risk factors, including basis risks and optionality risks, were excluded due to data limitations. Belgian retail banks that use swap contracts to hedge themselves against the impact of a shift to benchmark curve are exposed to a form of basis risk stemming from a diverging path between the interbank rate and sight and saving deposit rates. Another source of basis risk is linked to the fact that the reference indices for repricing variable rate mortgage loans are based on OLO-rates, while the hedging of mortgage loan-related interest rate risks is based on swaps. This risk can be exacerbated when credit spreads on Belgian sovereign bonds are high. In addition, the Belgian mortgage loan portfolio can also be a source of optionality risk as the penalty for early reimbursements of residential mortgage loans is legally limited to three months of interest on the outstanding capital, thereby providing a relatively cheap refinancing option to clients with a mortgage loan. However, this risk has diminished following the 2014-16 refinancing wave.

Net Trading Income

71. Net trading income (NTI) was projected for Belgian banks on account of the size of their derivative books. The fair value of trading derivatives reached 85 percent of trading assets at end-2016. Although the P&L impact of net trading income was low at -5 percent in 2016, it is a volatile component of total operating income and trading losses can be exacerbated under market duress.

72. NTI includes income on trading assets including debt instruments, equities, and derivatives as well as interest expense on trading liabilities. The econometric analysis was applied on supervisory data provided by the NBB pre-2014 and merged with SSM post-2014 supervisory returns. The share of net trading income on trading assets was projected using the following drivers: (i) changes to fair value of trading assets; (ii) shocks to benchmark money market rates; and (iii) shocks to equity realized volatility using projected paths for equity prices in three equity indexes: EURSTOXX 50, BEL-20, and S&P 100 (Appendix II).

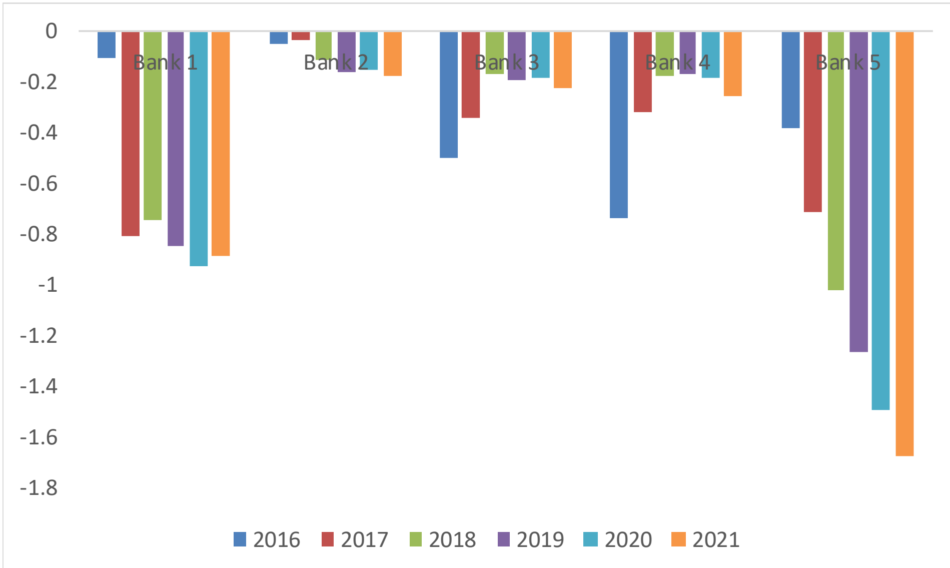
73. The econometric framework followed a Bayesian Model Averaging (BMA) technique (Box 1). For scenario analysis, forecasts are produced including the predicted values for the exogenous variables projected under the adverse scenario (i.e., market rates and equity volatility) over the five-year forecast window. We treat net trading income and the fair value of assets as endogenous in the BMA estimation.

74. Results suggest that shocks to NTI are negative though contained (Figure 10). Given the different composition of trading books across banks, some banks benefit from the heightened volatility envisaged in the scenario, while other banks' trading losses are somewhat exacerbated.

Figure 10. Point Estimates of NTI

(Percent of Trading Assets)

The impact of the adverse scenario is relatively small but varies across banks.



Sources: IMF staff estimates.

Box 1. Overview of the Bayesian VAR Methodology

VAR modeling is a useful approach to estimate and evaluate economic-wide models. It provides a flexible forecasting tool, it forms the basis of Granger causality testing, and it can be used to compute impulse responses. The key characteristics of this system of equations is that each equation is expressed as a function of its own lags, and other lags including lagged values of all the other variables of the system. For a multivariate VAR consisting of K variables $\{Y_{1,t}, Y_{2,t}, \ldots, Y_{K,t}\}$, the VAR is given by:

$$
\begin{aligned}
Y_{1,t} &= f_1\left(Y_{1,t-1}, Y_{1,t-2}, Y_{2,t-1}, Y_{2,t-2}, \ldots, Y_{K,t-1}, Y_{K,t-2},\right) + e_{1,t} \\
Y_{2,t} &= f_2\left(Y_{1,t-1}, Y_{1,t-2}, Y_{2,t-1}, Y_{2,t-2}, \ldots, Y_{K,t-1}, Y_{K,t-2},\right) + e_{2,t} \\
&\ldots \\
&\ldots \\
&\ldots \\
Y_{K,t} &= f_K\left(Y_{1,t-1}, Y_{1,t-2}, Y_{2,t-1}, Y_{2,t-2}, \ldots, Y_{K,t-1}, Y_{K,t-2},\right) + e_{K,t}
\end{aligned}
$$

Where $\{e_{1,t}, e_{2,t}, \ldots, e_{K,t}\}$ is a vector of non-correlated error terms with zero mean and covariance matrix Ω.

Box 1. Overview of the Bayesian VAR Methodology (concluded)

The principle of Bayesian analysis is to combine the prior information on the distribution for the estimated parameters (the prior distribution) with the information contained in the data (the likelihood function). This technique allows obtaining an updated distribution accounting for both these sources of information, known as the posterior distribution. This is done by using what is known as Bayes rule, which represents the cornerstone of Bayesian analysis. For a general vector of parameters λ and a data set Y, Bayes rule can be obtained from basic definitions of conditional probabilities as:

$$\pi(\lambda|y) = \frac{\pi(\lambda|y)\cdot\pi(\lambda)}{\pi(\lambda)}$$

To set the properties of the prior distribution, we use the original Minnesota prior proposed by Litterman (1986). We check robustness against the natural conjugate prior, and the independent normal-Wishart prior with Gibbs sampling.

To overcome estimation challenges over the joint distribution of the parameters included in the set λ, we assume independence between parameters so that the joint density simply becomes the product of the individual densities. In the BVAR application the vector of parameters λ represents two blocks of parameters, the VAR coefficients on the one hand, and the residual variance-covariance matrix on the other hand. The assumption of independence allows reducing the problem to the determination of one distribution for each individual element, an easier and more meaningful strategy than looking for a joint density.

This technique is very useful for stress testing as it allows simulating a scenario for some exogenous drivers and observes the outcome for the variables of interest. Also, it compares the differences in outcomes obtained under the baseline and adverse scenario. For net trading income projections, we assume that trading income and the fair value of trading assets are endogenous and respond to shocks in money markets and equity markets.

See Dieppe, Legrand, and Van Roye (2016), ECB.

E. Pre-Provision Net Revenue (PPNR)

75. **PPNR is a key driver of financial risk and getting the forecasting of PPNR right is critical to understanding the extent of risks facing the bank**. Embedded PPNR vulnerabilities having significant medium-term effects was assessed under the muddle-through sensitivity test. Also, in a crisis situation compressed lending spreads and rising funding costs might exacerbate P&L impact.

76. **In contrast to credit and market risk assessment, PPNR impact is decomposed into underlying drivers that breaks them into underlying components.** [32] PPNR modelling separates the shock to margins into the behavior of reference rates, volume of credit, newly defaulted balances, and banks' commercial strategies. Focusing on economically meaningful drivers increases the robustness of results, and the quality of the challenge and debate around them. Relationships between drivers and market/economic conditions are derived from historic data using statistical

[32] See Oliver Wyman (2016), "Risk of the PPNR Machines".

techniques. The impact of 'specific' drivers (related to banks' commercial margins and debt issuance practices) is a crucial part of forecasting P&L and differs from credit and trading losses on portfolios which are primarily sensitive to 'systemic' drivers).

Funding Costs

77. Funding costs are split into a reference date and a spread by bank and by instrument using supervisory data. As a basis to generate funding cost projections, the FSAP team used a merged series using NBB's pre-2014 data and SSM post-2014 series on the implicit interest expense by bank for deposits, debt, and other liabilities.

78. The bank-specific deposit rate spread over benchmark was forecasted using a BVAR approach. To account for differences in the deposit structure of banks and the credit sensitivity of retail funding, a BVAR technique was applied on a set of macrofinancial variables and bank specific determinants, including capital ratios and asset quality. The funding benchmark is the 3m Euribor path generated by the scenario which was treated as an exogenous variable in the scenario analysis. Figure 11 shows the impulse responses for each bank under the adverse scenario.

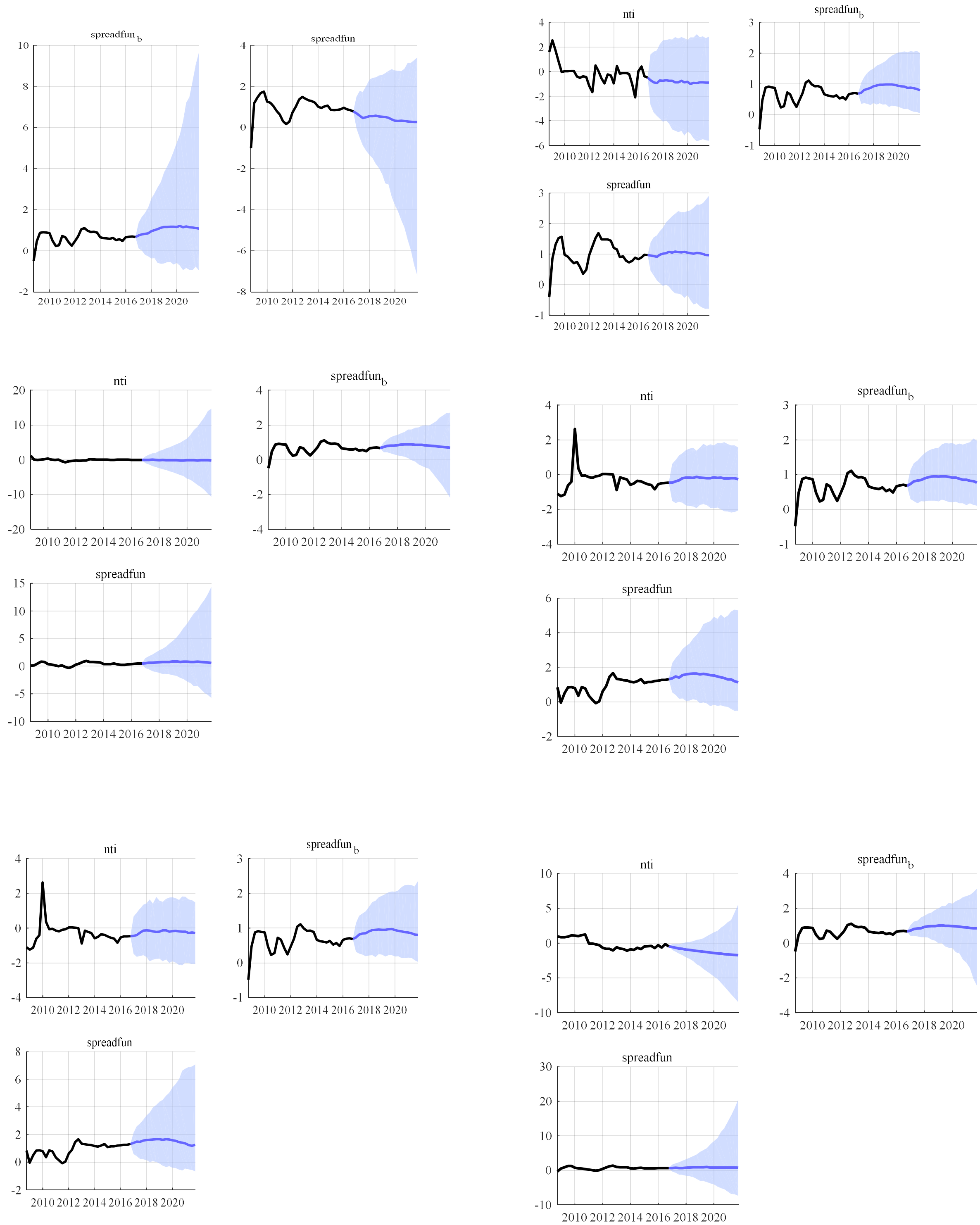
79. Bank spreads over Euribor reach around 75bps in 2017 and 100bps in 2018 (Figure 12). Relative to the starting point, spread shocks are small at around 18bps in 2017 and 12bps in 2018. This is manageable given the current low rate environment, although the uncertainty around point estimates is not negligible (Figure 11).

80. A broader strategy was applied to forecast bank spreads for debt instruments. Data on the liability structure of banks by re-pricing maturity bucket was sourced from the STE maturity ladder template. Three approaches were used to project bank spreads over reference rate for outstanding debt liabilities:

- Behavior of yield-to-maturity spreads over benchmark for all single-name issued bonds active during the GFC and the sovereign debt crisis. Spreads were projected as the spike observed in crisis episodes on active bonds as of end-2016. The data was sourced from Bloomberg over 2005-May 2017.
- Evolution of spreads at issuance of bank debt excluding short-term paper. The dataset covered all the issuing subsidiaries that belong to the same financial group at the Belgian highest level of consolidation. The data was sourced from Dealogic over 2005-May 2017.
- A BVAR approach drawing on the effective rate over debt reported by banks in their supervisory returns. Stress test median outcome results are shown under this approach.

Figure 11. Net Trading Income and Funding Spreads Projections by Bank

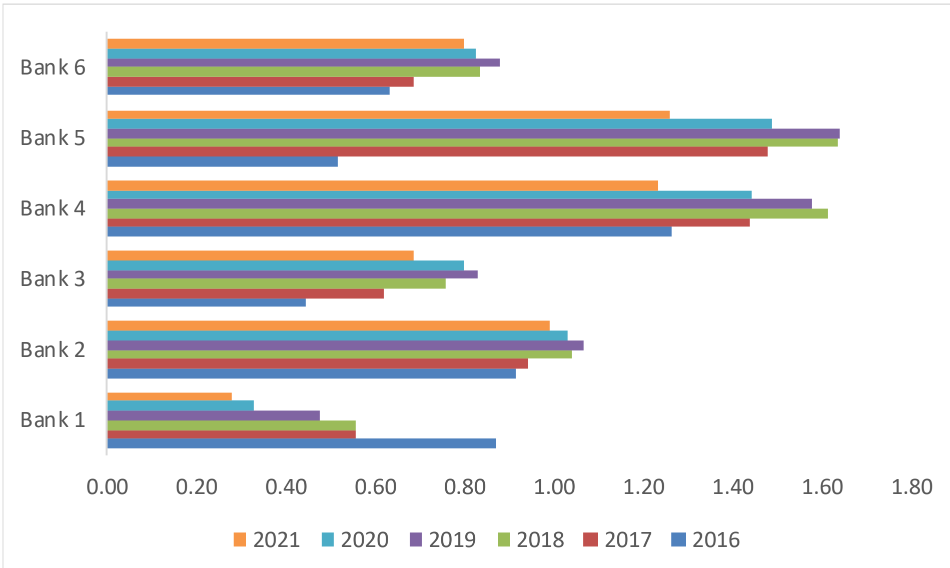
Projected NTI and funding spreads show small point estimates but wide confidence intervals which vary across Belgian banks.



Source: IMF estimates.

Figure 12. Point Estimates of Bank Deposit Spread over Benchmark
(In Percent)

The impact of the adverse scenario is relatively small but varies across banks.



Sources: IMF staff estimates.

81. **The behavior of funding costs was determined largely by the behavior of benchmark rates and bank spreads over deposit rates.** Banks rely mainly on retail deposits to fund their balance sheet. This is reflected on their liability structure with 85 percent deposit funded, and only 15 percent debt funded, although this estimate varies across banks in a range between 75 percent and 95 percent. Given the historical behavior of deposits, the strong retail base limits the rise in funding costs for Belgian banks under stressed conditions.

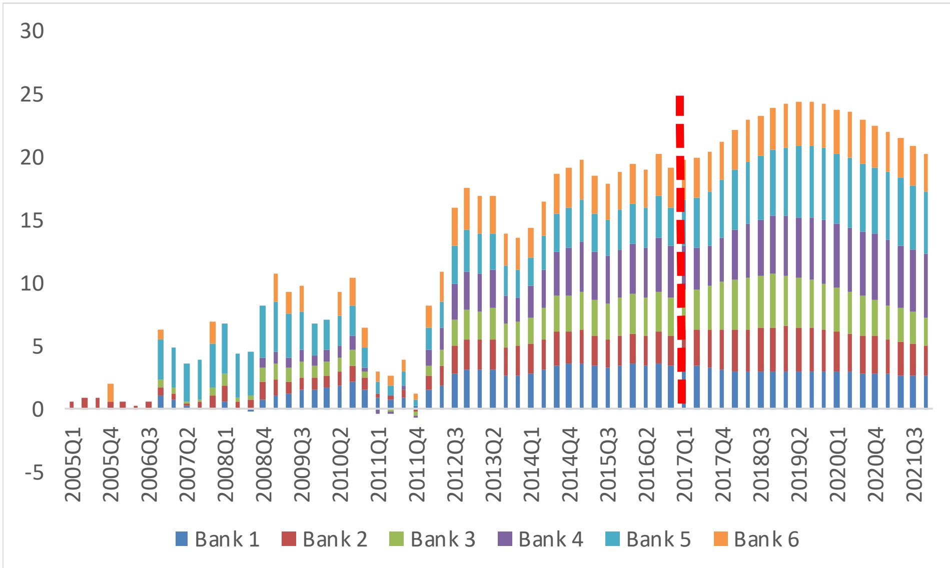
Interest Income

82. **Lending rates on loans and advances were broken down into the 5y OLO reference rate and a bank specific spread over benchmark.** The FSAP team used publicly available data on implicit lending rates from banks' quarterly reports.

83. **The determinants of lending spreads included the core macrofinancial conditions generated under the scenario as well as the projected path of funding cost discussed above.** The FSAP team used a BVAR econometric strategy to estimate empirically the pass-through idiosyncratic funding costs to customers at the bank level. Although the main stress testing results are presented under the assumption of non-pass through, the positive impact of pass-through is presented as a sensitivity test.

Figure 13. Point Estimates of Bank Lending Spread over Benchmark
(In Percent)

The estimated pass-through is significant for some banks.



Sources: IMF staff estimates

84. Results suggest that the impact is moderate ranging between 9bps and 11bps over the first two years of the stress (Figure 13). This result is driven by the moderate increase in idiosyncratic funding shocks projected under the adverse scenario as well as by banks' commercial lending practices which points out at a competitive environment to retain/increase market share.

85. To compute interest income from the securities portfolio, the implicit interest rate was calculated over the last two reporting periods. Using banks' reported information, yields were computed for the AFS, and HTM regulatory books by asset class, that is, own sovereign bonds, foreign sovereign bonds, corporate bonds, and other securities. The implicit interest rate was projected forward, assuming no changes in portfolio composition during the stress test period.[33] This is a conservative assumption, given the extent to which the low interest rate environment prevailing at end-2016 was pushing down market yields.

86. Interest rate in the banking book is driven by policy rate shocks and banks' repricing gaps in assets and liabilities. Interest rate gaps by time to repricing across six maturity buckets were computed for each bank, that is, <1m, 1m-2m, 2m-3m, 3m-6m, 6m-12m, and >12m, and net income is calculated as:

$$income_{i,t} = \sum_{b} gap_{i,t}^{b} \cdot \left(\frac{365 - mid^{b}}{365} \right) \cdot \Delta i_{t}^{f}$$

[33] This is a reasonable assumption supported by findings by Covas, F., M. Rezende, and C.M. Vojtech, 2015, "Why Are Net Interest Margins of Large Banks So Compressed?" FEDS Notes, October 5. They show that recent contributions to NIM are mainly driven by changes to yields rather than changes to portfolio composition.

where $gap_{i,t}^{b}$ is the gap of bank *i* in bucket b and time *t*, mid^{b} is the mid-point in bucket *b* (in days), and Δi_{t}^{f} is the shock to risk free rates at *t*.

Other P&L Items

87. The bank tax rate is driven by the macroeconomic scenario. Econometric analysis suggests that the effective bank tax rate over net profit is not very sensitive to changes in the macroeconomic environment on average. A panel-based regression is conducted and adjusted to banks' reported tax rates at the reference date.

88. Other P&L items were projected drawing on a panel-based estimation using fixed effects. The time series data was sourced from Fitch and applied to FINREP bank supervisory returns. The main variables included:

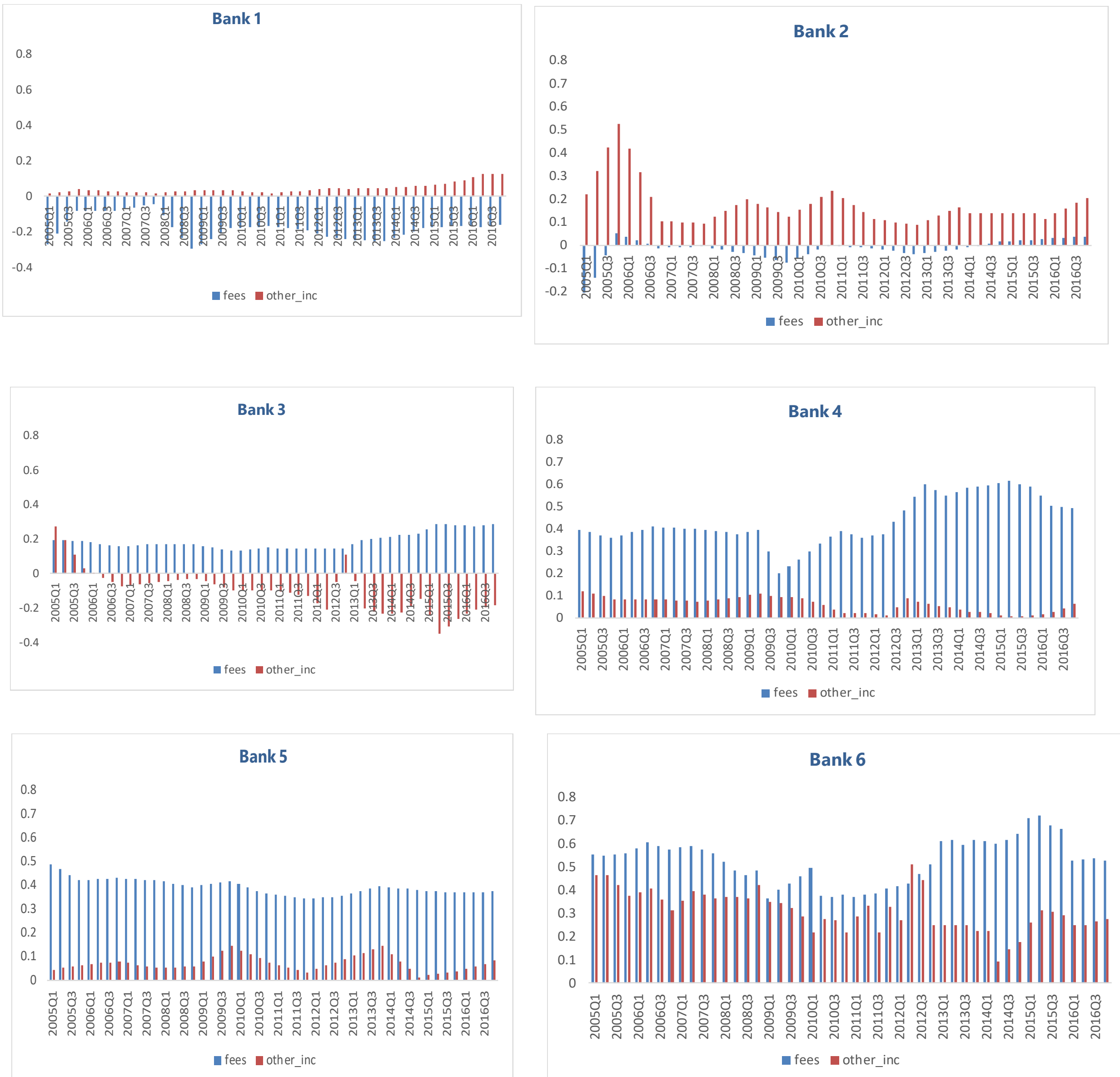
- Fees and commissions relative to total assets;
- Non-interest income relative to total assets;
- Non-interest expenses relative to total assets including administrative expenses and operating expenses;
- Tax rate over net profits.

89. The behavior of non-interest income shows banks' different business models with wide variation in reliance (Figure 14). In the case of financial conglomerates, fees and commissions are linked to linked insurers and insurance income sold by bank branches and recognized at the asset manager. Fees and commissions represent up to 70bps of total assets for some banks. Other non-interest income includes dividend income, in some cases generated by the upstream of dividend income from the insurance or asset management arm, and other operating income. It is relatively smaller at around 30 bps for some banks.

90. The dividend payout ratio was fixed throughout the stress testing horizon. The FSAP team considered three options to set payout ratio projections. The dividend payout ratio is linked to banks' net profits. Under positive profits, the dividend payout floor is set at 30 percent subject to dividend restrictions if banks breach their capital conservation buffer. If profits exceed 50 percent of profits at the reference date, the dividend payout ratio is set at 50 percent. If banks are making losses no dividend payout is assumed.

Figure 14. Other P&L Items
(Percent of total assets)

Projected NTI and funding spreads show small point estimates but wide confidence intervals which vary across Belgian banks.



Source: IMF staff calculations based on Fitch data.

F. Solvency Results

Scenario-Based Results

91. Under the baseline scenario, capital ratios decline slightly because of the full implementation of Basel III deductions and balance sheet expansion. Aggregate CET1 ratios stabilize at around 15 percent in the later years. The deductions required by Basel III leave CET1 ratios comfortably above the fully-loaded minimum of 8.5 percent for the four largest O-SIIs and at 7.75 percent for the remaining two O-SIIs. Total regulatory capital is projected to decline by an additional 30 basis points to 17.3 percent by 2021 due to the elimination of capital instruments no longer eligible as Tier 2 capital. This is a conservative assumption as the replacement of Tier 2 grandfathered instruments is disallowed in the test. On the other hand, there is minimal impact from AT1 grandfathered instruments.

92. Banks are resilient in the face of a severe global economic downturn. Under the adverse scenario, all banks meet minimum capital requirements and none needs to draw down its capital conservation buffer at the low point of the stress (Figure 15).[34] Aggregate CET1 ratios fall by 370 basis points from 15.1 percent at end-2016 to a low point of 11.4 percent in 2018 before trending back to 13.2 percent by 2021. Although every bank maintains sufficiently high capital ratios, the losses experienced by them vary widely across banks, revealing differences in business models and risk exposures.

93. The results are explained by the limited impact of market risk and resilient pre-provision income projections (Figure 16). Banks' aggregate CET1 ratio is projected to deteriorate significantly, with the trough in 2018. The decrease in the aggregate CET1 ratio from RWAs materializes in the near term whereas the impact from credit losses takes longer to develop. RWAs rise by 290 bps over the first two years[35], while the contribution to lower CET1 from credit and valuation losses is estimated at 140 basis points and 210 bps, respectively.[36] At the end of the 5-year horizon, however, most of the reduction in CET1 is explained by the contribution of credit and valuation losses which depress CET1 ratios equally by 310 basis points, absorbed somewhat by robust pre-tax profits driven by resilient interest margins. While the market risk impact on P&L is contained on the back of smaller size of banks' trading assets relative to pre-crisis period and small equity exposures, valuation losses on the AFS portfolio are significant given the severity of the assumed correction in fixed income markets and the relatively long duration of banks' securities portfolio. Overall, these results are broadly in line with NBB's projections.

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[34] The hurdle rate is defined by Pillar 1 capital requirements including the full implementation of O-SII capital surcharge for SIs. Pillar 2 capital requirements are excluded.

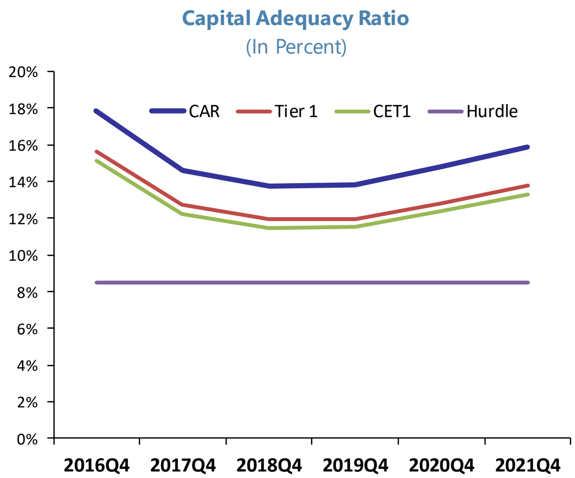
[35] RWA expansion is explained mainly by the deterioration of credit risk parameters, particularly default rates. Higher LGD rates from peer benchmarking and a deteriorating economic environment also contribute to shifts to RWAs.

[36] The limited impact of credit losses is explained by the composition of the loan portfolio, the low initial default rates, and the de-risking of banks' balance sheets.

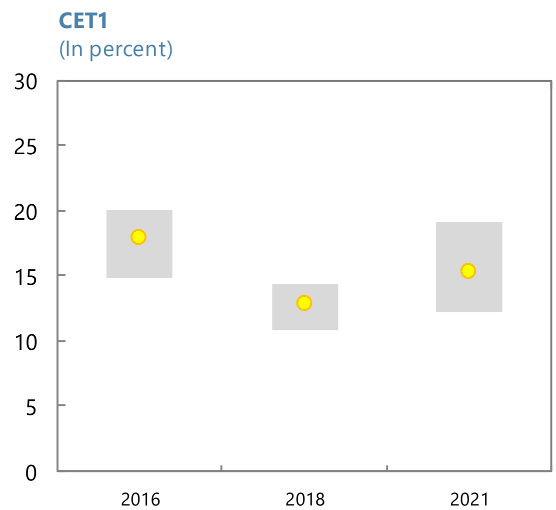
Figure 15. Results of the FSAP Solvency Stress Test—Adverse Scenario

Under the severe scenario, all banks would still meet minimum requirements but there is a large dispersion of impact across banks.

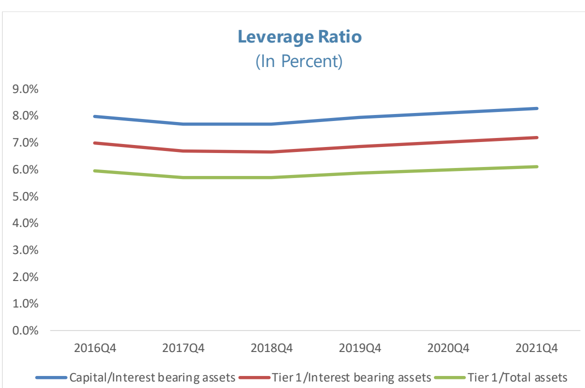
Risk-based bank CET1 ratios decline by 370bps at the low point of stress to 11.4 percent…



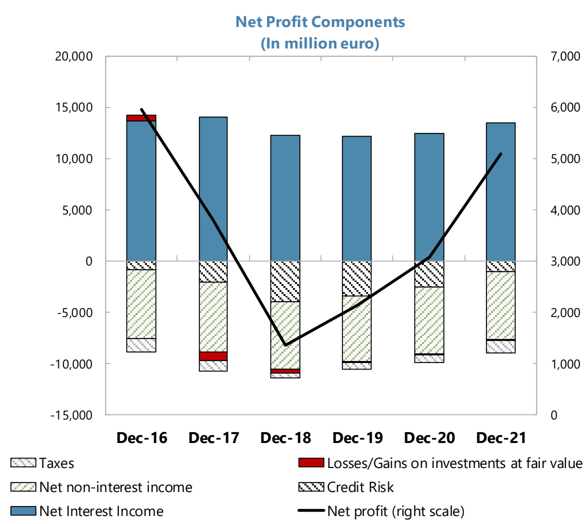
……with a wide dispersion in impact across banks.



Risk-neutral leverage ratios soften by around 40 basis points before recovering in the outer years.



Profit and loss impact is driven by the compression in net interest income and an increase in loan loss rates.

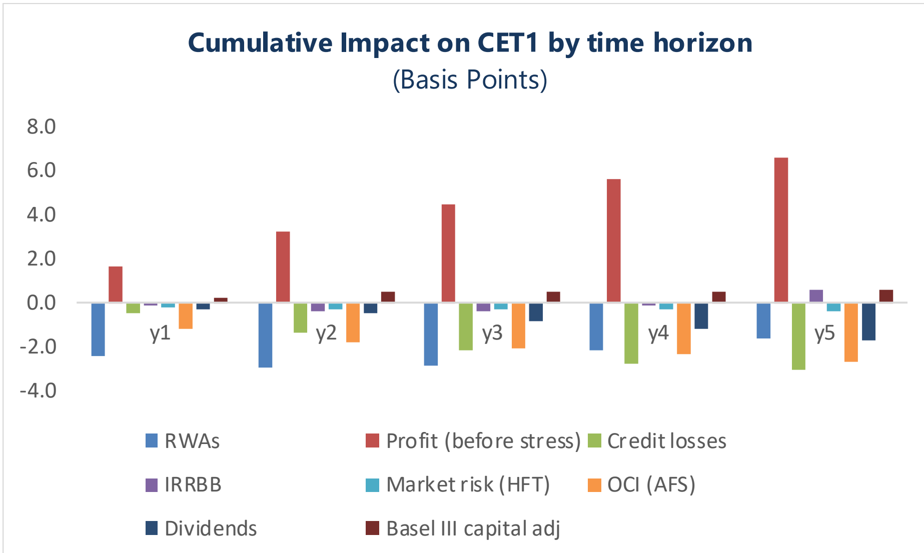


Source: IMF Staff Estimates. The sample of banks included the six major Belgian banks. The dashed line indicates the minimum capital regulatory ratio. Boxplots include the mean (yellow dot), and the 25th and 75th percentiles.

Figure 16. Cumulative Impact on CAR

(In percent)

The shortfall of 370 basis points in aggregate capital ratios at the low point of stress in 2018 is driven by stressed RWAs, credit losses, and portfolio valuation losses.



Source: IMF staff estimates.

Sensitivity Tests

94. Banks are also resilient to a low-for-long scenario, but their profits would suffer under a prolonged period of low rates (Figure 17). In this scenario, policy rates and lending rates remain constant at end-2016 levels, which amounts to a cumulative decline in interest rates of some 150-bps relative to the baseline. With declines in lending rates exceeding those on liabilities—given the latter's proximity to the statutory lower bound—interest margins and profitability fall relative to the baseline, pushing down CET1 capital ratios by 130 bps by 2021. The impact of lower rates is mitigated by the banks' long duration of assets (mainly on account of long-dated fix rate mortgages). Banks are also resilient to idiosyncratic concentration risk.[37]

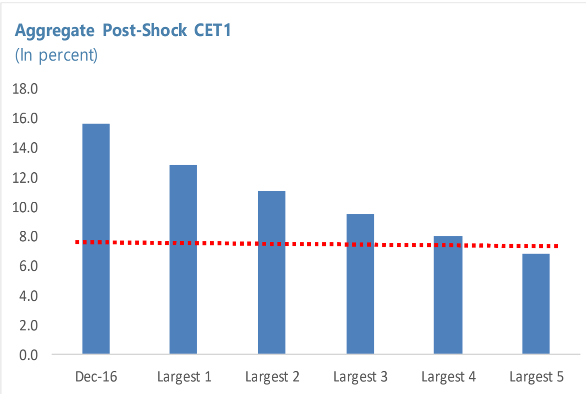
95. Interest rate risk in the banking book is generally well managed by most Belgian banks. The interest sensitivity of the banking book was assessed by assuming 200 bps increases or decreases in interest rates and measuring the impact on on- and off-balance sheet exposures. The resulting changes in CET1 are relatively small on average but can be severe for some banks. Nonetheless, no bank's solvency is threatened. The robustness of banks' books to changes in interest rates reflects the widespread use of portfolio hedging strategies against interest rate volatility and the stability of non-maturing deposits.

[37] The default of each bank's largest three exposures leaves CET1 ratios above regulatory minima in all cases, but the results vary across banks.

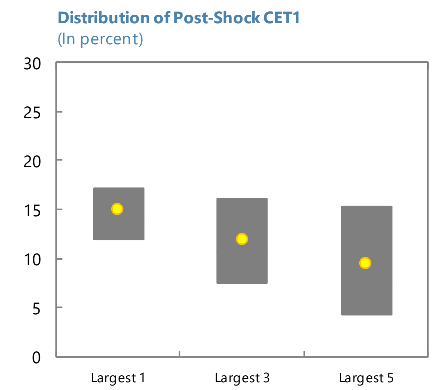
Figure 17. Sensitivity Tests

The average impact of concentration risk, interest rate risk in the banking book, and 'low-for-long' environment is contained but masks significant variability across banks.

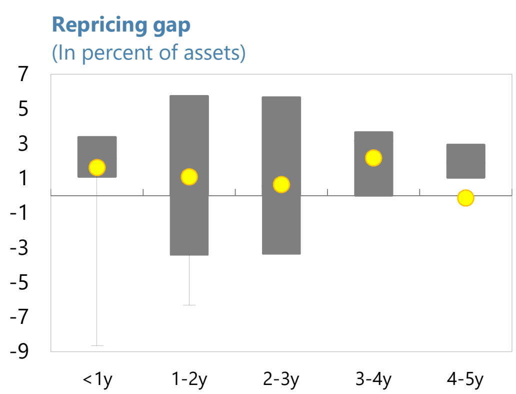
The simultaneous failure of the five largest counterparties would push capital ratios toward their regulatory minimum…



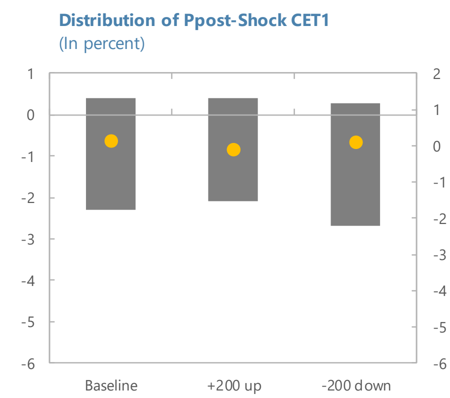
…while the dispersion in capital impact increases with the size of the shock.



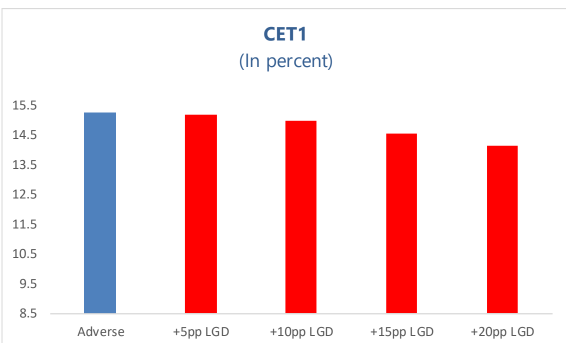
Belgian banks have different asset and liability management strategies…



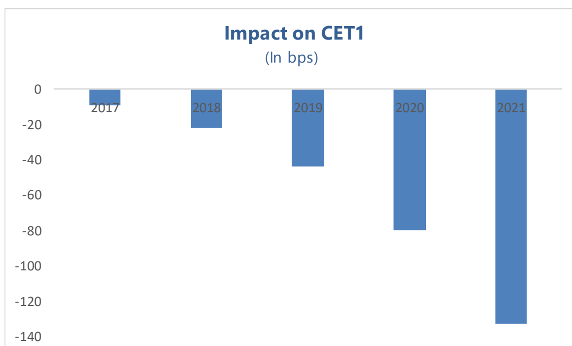
…which masks the differential impact of shifts to the risk curve on capital ratios



Banks are resilient to further reductions in recovery values in housing collateral



A low-for-long environment would erode capital ratios by 130 bps at the end of the stress test horizon.



Source: IMF staff estimates.

Note: The box plot charts include the mean (yellow dot) and the 25th and 75th percentiles.

96. The Belgian banking system is resilient to idiosyncratic risk from the default of their three largest exposures. The default of each bank's three largest exposures leaves CET1 ratios above regulatory minima in all cases, but the results vary across banks. This is the outcome of a credit concentration test conducted to explore bank risk concentration to single obligor risk**.** Concentration risk was assessed by simulating the default of the largest counterparties, including banks, other financial institutions, and corporates. The average CET1 ratio would tilt towards the regulatory minimum following the default of the five largest counterparties. This result masks, however, a wide dispersion of impact among banks.

97. Banks are resilient to additional shocks to the quality of their mortgage portfolios, but this may change if underwriting standards continue to deteriorate. The impact of an abrupt housing price correction in Belgium is contained under the current structure of the mortgage book. The effect of a collapse in real estate prices was ascertained through increases in default rates in mortgages and depressed recovery values. The impact on default rates was limited because strategic defaults under full-recourse mortgages tend to be negligible. The impact on recovery values, proxied by an increase of 25 percentage points in LGDs on Belgian mortgages, is more severe and would lead to a decline of 110 bps of CET1. Banks would still post a 14 percent CET1 ratio at the low point of the stress.

98. The aggregate impact of including derivatives in the repricing gap structure is positive on the account of hedging strategies used to hedge against IRRBB (Figure 18). This sensitivity test is conducted using the projected paths for benchmark rates generated under the adverse scenario. The effect of derivatives is positive with some banks building their capital buffers by between 50bps and 70bps relative to a benchmark scenario excluding derivative assets and liabilities. Results, however, are diverse among banks partly reflecting their different hedging strategies with some banks using a 'earnings-at-risk' hedging strategy while other banks manage 'value-at-risk' strategies.

99. Allowing for empirically estimated pass-through effects would raise CET1 ratios up to 60bps in some cases. Figure 18 shows the positive impact on capital ratios from including the pass-through ratios estimated using a BVAR approach by bank. The effect would be more beneficial for banks experiencing higher funding cost shocks or managing lending spreads. A caveat of the analysis is that the estimation does not take account volume effects on consumer credit from rising lending rates. The credit path used to estimate CET1 impact is exogenous to banks' lending practices and is determined entirely by the stress test scenario.

BANK LIQUIDITY TESTS

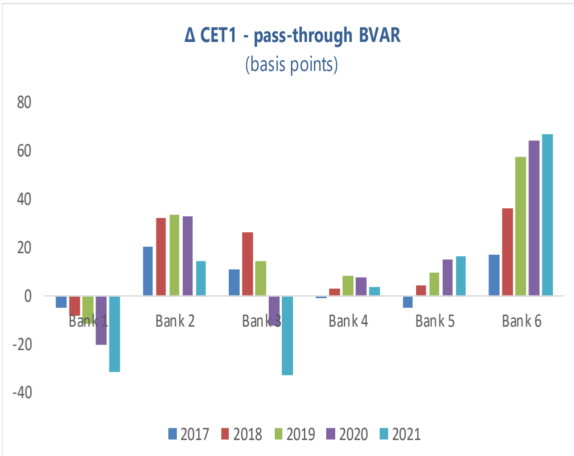
A. Scope of the Stress Test

100. The liquidity stress test covered the entire banking sector. For the LCR-based test, the sample is the one used by the SSM for liquidity stress testing, which comprises the six banks in the solvency stress test sample, plus two other SIs (Degroof Petercam and Bank of New York Mellon), and all LSIs. For the cash-flow based test, the sample covered the six major Belgian banks and Bank of New York Mellon.

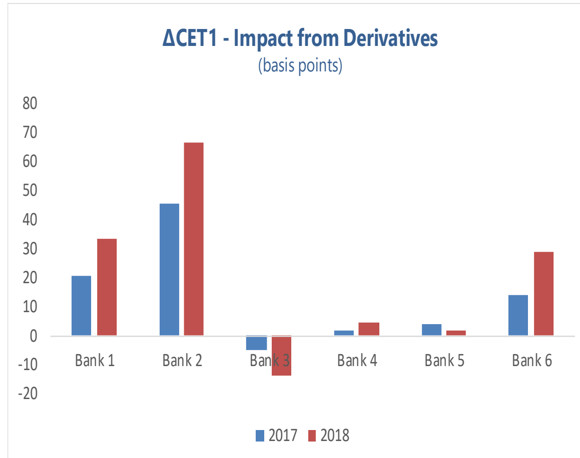
Figure 18. Impact of Pass-through and Derivatives Maturity Ladder

The impact is contained but there is wide dispersion across banks on the back of diverse commercial lending practices and hedging strategies.

The aggregate impact of allowing pass-through effects on lending rates is positive…



…as well as of including hedging strategies to shed interest rate risk in the banking book.



Source: IMF staff estimates.

101. LCR-tests were conducted on scenarios calibrated by ECB staff. Stress tests were conducted jointly with NBB using supervisory data as of June 2017. Three LCR scenarios were used with assumptions on haircuts, inflow rates, and cash-flow run-off rates more severe than those prescribed by Basel:

- A systemic stress scenario which applies lower market values and higher haircuts to HQLA assets. It also assumes higher outflow rates from the drawdown of liquidity lines under system-wide distress of counterparties, and the reduction of some inflow rates from financial counterparties.
- An idiosyncratic scenario which applies higher run-off rates to unsecured funding, including stable retail deposits. This scenario is motivated by credit risk sensitive investors.
- A combined scenario which applies the most stressed assumptions on HQLA, inflow rates and run-off rates from the previous two scenarios.

102. The cash-flow based tests were conducted using ECB's liquidity tool[38]. The tool covers six stress scenarios and simulates a range of stress factors over eighteen maturity buckets ranging from one-day to twelve months. The calibration of these scenarios is motivated by the need to

[38] This is an ECB internal monitoring tool used for supervisory purposes.

identify potential pressure points (as a 'diagnostic tool') rather than to project liquidity shortfalls under plausible conditions (as a 'forecasting tool'). The assessment is subject to the following caveats. First, the analysis is performed using the mapping of bank reported data using EBA's old liquidity templates on the liquidity tool based on the new COREP liquidity templates and is therefore subject to potential misreporting of some items. Second, the severity of some scenarios is too extreme. For instance, the 'contractual scenario' assumes that run-off rates for non-maturing liabilities reach 100 percent which has not been observed in any past crisis episode. Third, the calibration of the 'combined scenario' has some shortcomings on a few items which exhibit amplification effects in run-off rates which get compounded across maturity buckets.

B. Liquidity Results

103. The LCRs reported by banks show ample liquidity buffers above the required 100 percent (Figure 19). This is partly due to the strong deposit base of Belgian banks, the high quality of counterbalancing capacity (i.e., high quality assets), and the early implementation of a prudential liquidity requirement ratio in 2012. The average LCR ratio stood at around 140 percent in March 2017 for the whole sector, the Big six, and the Big four.

104. The LCR-based liquidity stress tests show that the banking system is resilient to a sudden withdrawal of funding. The tests used three scenarios more severe than those prescribed by Basel: an *idiosyncratic* stress scenario with higher run-off rates to unsecured funding and lower inflow rates; a *systemic* stress scenario with higher haircuts to HQLA assets and increased net cash-outflows; and a combined stress scenario that uses the most stressed parameters from the idiosyncratic and systemic stress scenarios. The average LCR ratio would shed 40 basis points under the systemic scenario and 46 basis points under the idiosyncratic scenario. Even under the combined scenario, the average LCR ratio would edge slightly above the 80 percent mark.

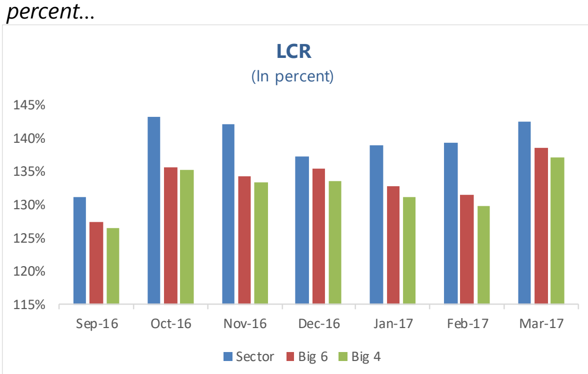
105. Banks' resilience in the face of a systemic tightening of liquidity conditions reflects their shift to traditional funding patterns and holdings of high quality assets. Belgian banks' relatively low vulnerability to systemic stress is due to the high quality of their liquidity buffers and reliance on deposits. However, the stability of retail deposits varies across banks and their volatility may change. As a result, Belgian banks are relatively vulnerable to idiosyncratic liquidity stress, and this is captured by the idiosyncratic scenario of the LCR-based and the cash flow-based stress tests.[39]

[39] Results from the cash-flow-based analysis should be interpreted with caution due to potential inconsistencies in the data used in those tests.

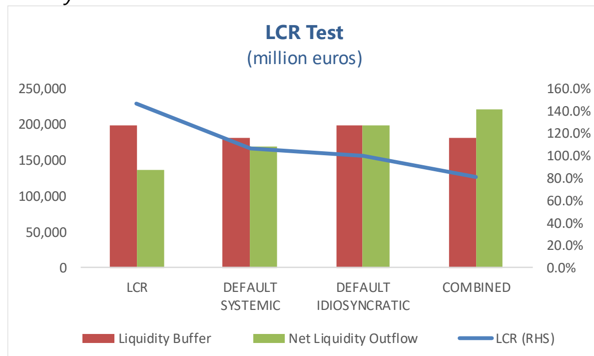
Figure 19. Liquidity Stress Tests

The main financial source of sector vulnerability is the dry-up of unsecured funding and shocks to the duration of non-maturing liabilities.

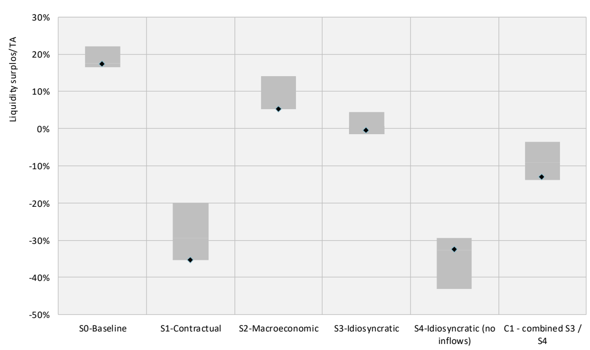
LCR ratios have been building up to an average of 140 percent…



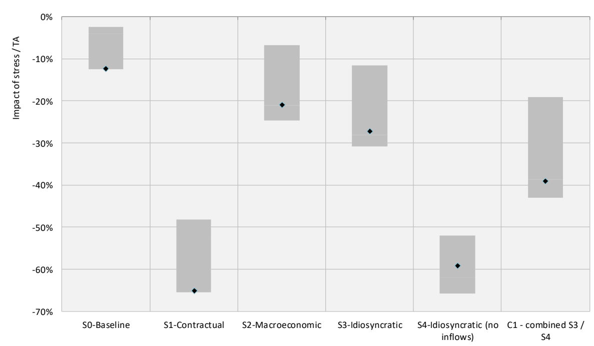
…and are resilient to additional stress from idiosyncratic and systemic shocks.



Banks are particularly exposed to a contractual stress scenario which would depress liquidity surplus relative to gap positions…



… and would lead to the largest impact shedding 65 percent of the counterbalancing capacity relative to assets.



Source: National Bank of Belgium and IMF staff calculations.
Note: The bottom charts cover eight SIs in Belgium. Boxplots include the mean (blue dot), and the 25th and 75th percentiles.

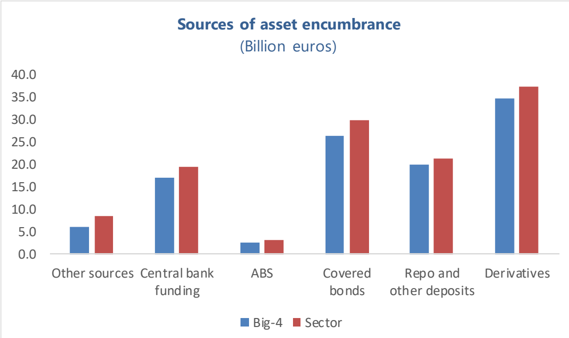
106. **Although asset encumbrance for the sector is manageable, it represents a potential source of liquidity risk for some large banks, which warrants continued monitoring** (Figure 20)**.** Although the average asset encumbrance ratio of Belgian banking system stood at 13.7 percent of total assets in 2016, it reached over one fourth of total central bank eligible assets. Asset encumbrance is driven by banks' large derivative books against cash collateral (in some cases related to legacy portfolios), covered bonds against mortgage loans, and reliance on repo transactions supported by general collateral. While the LCR addresses 30-day liquidity pressures from repo transactions, its look-back approach is not well suited to capture forward-looking stressed flows from collateralized derivatives associated with large shifts to market risk factors.[40]

[40] This is because the increased liquidity needs related to market valuation changes on derivatives are backward-looking under the LCR ratio. Any stressed outflow is included in the calculation to the extent that the collateral flow has realized during the preceding 24 months.

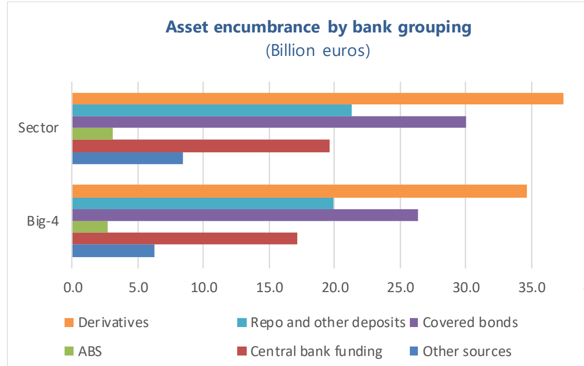
Figure 20. Asset Encumbrance

Some large banks have long derivative positions that give rise to collateral requirements and encumber assets.

Derivative positions, covered bonds, and repos are the main sources of asset encumbrance…



…with some dispersion among groupings of banks



Source: National Bank of Belgium and IMF staff calculations.

BANK STRUCTURAL RESILIENCE

A. Scope of the Stress Test

107. Additional tests were conducted to determine whether the financial system is likely to absorb or amplify severe macrofinancial shocks. The analysis was confined to the banking system and focused on the risk of contagion through the Belgian interbank market including intragroup domestic exposures. Contagion through equity markets was assessed using the market-based CoVaR methodology.

108. The transmission of shocks from an individual bank to the rest of the system is assessed through the following channels:[41]

- **Bilateral exposures:** Counterparties with large exposures to a distressed firm may suffer material losses resulting in their inability to satisfy their obligations hence transmitting distress to other parts of the interbank market in the form of cascading defaults.

- **Market contagion:** Banks may suffer equity losses from market participants' revised expectations on the solvency of banks following similar business models to a bank in distress, conditional on the broader economic environment.

[41] These channels have been highlighted by Daniel K. Tarullo, "Regulating Systemic Risk," Speech, 2011 Credit Markets Symposium, North Carolina, Charlotte, March 31, 2011, Board of Governors of the Federal Reserve System, available at http://www.federalreserve.gov/newsevents/speech/tarullo20110331a.htm.

109. The potential for cascading defaults through the interbank market was assessed in a sample comprising all Belgian SIs using large exposures supervisory data.[42] The analysis includes a credit shock simulation whereby one credit counterparty defaults at a time. It also includes a funding shock simulation whereby the default of a funding counterparty might induce a liquidity shortfall.[43]

110. To assess the transmission of systemic risk through the financial system, four relevant peer groups to Belgian banks were constructed drawing on public data (Table 6): (i) a European banking system including 32 large banks from 14 EU countries. The initial list of banking institutions draws from the 2018 EU-wide stress test sample of 49 banks. In addition, we add two large financial institutions that were covered in the 2016 EU-wide stress test sample but were excluded in the 2018 test.[44] Since the methodological approach requires stock market data we exclude non-listed banks. The resulting sample is formed by a total of 35 large banks. The selection criterion to configure the sample is the availability of comparable data over a long period of time;[45] (ii) European banks with local presence in material geographies for Belgian banks including six banks from four countries. Peer banks are formed by listed banks with local presence in Belgium as well as banks incorporated in core markets of Belgian banks; (iii) European banks with local presence in Belgium including three banks from three countries; and (iv) European banks with the same core markets than the Belgian banks, including five banks from four countries. The analysis uses weekly data from June 2005 through May 2017.[46]

B. The Network Analysis

111. Network analysis allows understanding risk propagation through the interbank market given the current network of exposures. The failure of one or more banks in a stress test might have implications for other banks through credit or funding channels if they are exposed to banks that, in turn, are creditors of the failing institutions. Thus, network analysis moves the analysis towards a more systemic view—a deeper understanding of which institutions are central or peripheral in a crisis—and is a material improvement on bilateral exposure data in evaluating potential second-round effects on other institutions from credit or funding shocks.

112. The possibility of contagion depends strongly on the precise structure of interbank claims. Contagion is less likely to occur in a 'complete structure of claims,' in which every bank has symmetric linkages with all other banks in the economy. However, 'incomplete structures,' where banks have links only to a few neighboring institutions are expected to be much more fragile. In

[42] The sample coverage includes eleven banks, i.e., Argenta, Axa Bank Europe, Degroof, Belfius, BNPPF, INGB, Investar, KBC Bank, KBC Group, and Bank of New York Mellon.

[43] Based on Espinosa, M., and Sole. J. (2010).

[44] The list adds Banca Monte dei Paschi Siena and Banco Popular.

[45] This criterion excludes ABN Amro Group N.V., incorporated in Dec 2009; CaixaBank S.A., incorporated in June 2011; and, BFA Tenedora de Acciones S.A.U., incorporated in December 2010.

[46] The starting date of the sample is determined by the incorporation of Raiffeisen Bank International to the sample.

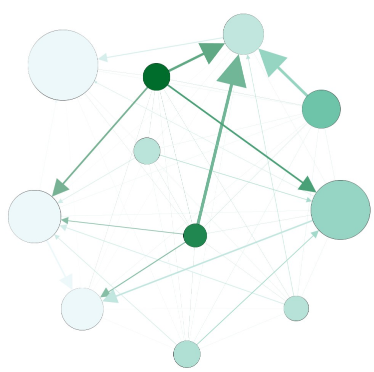
two-tiered structures, the failure of the money center bank is more likely to trigger the breakdown of other institutions that the failure of a bank on the periphery.

113. The density of the Belgian interbank network is low (Figure 21). The network displays negative assortativity suggesting that nodes of a similar degree are associated with each other. Looking at the structure of the network, the Belgian interbank market is associated to the benchmark core periphery model. Contrary to other banking networks, the largest banks are at the periphery rather than at the core. This is consistent with the large reduction in interbank market activities, particularly between 2007 and 2014. This was mainly due to the restructuring process of the sector and the deleveraging of some trading activities.

Figure 21. Network Analysis

The potential for contagion through cascading networks is insignificant.

The Belgian banking system is characterized by a low-density network with the largest banks at the periphery of the network.



Even under extreme assumptions of LGD=90 percent of original exposures, there is no potential for contagion rounds.

	Induced Failures	% Failed Capital	Contagion Rounds	Hazard	Hazard Rate	Index of Contagion	Index of Vulnerabilit
Bank 1	0	2.5	0	0	0.0	0	0.5
Bank 2	0	1.5	0	0	0.0	0	0.8
Bank 3	0	0.6	0	0	0.0	0	8.6
Bank 4	0	10.0	0	0	0.0	1.07	0.1
Bank 5	0	24.0	0	0	0.0	0.22	0.0
Bank 6	0	8.4	0	0	0.0	0	0.4
Bank 7	0	10.1	0	0	0.0	0.49	0.0
Bank 8	0	2.7	0	0	0.0	0	0.5
Bank 9	0	16.4	0	0	0.0	0.57	1.4
Bank 10	0	20.4	0	0	0.0	3.1	0.1
Bank 11	0	3.4	0	0	0.0	0	1.9

Source: IMF staff estimates.

Note: The nodes in the chart represent different banks. The lines between the nodes represent gross exposures between the banks. A thicker line between the nodes implies a larger bilateral exposure.

114. The potential for the transmission of stress depends crucially on the characteristics of the claim as well as on banks' capacity to absorb losses. Collateralized exposures are less likely to propagate stress by reducing the unsecured portion of the loan. Strong capital ratios increase banks' ability to absorb losses following the default of a borrowing counterparty. A stronger counterbalancing capacity relaxes banks' cash-flow constraint on maturing liabilities, mitigating funding liquidity risk from the default of funding counterparty.

115. The risk of contagion from a bank default through interbank exposures in Belgium is minimal (Figure 21). Under the standard assumptions of 40 percent LGD, 35 percent of lost funding that is non-replaceable, and 30 percent fire sales discount, there are no banks whose default would lead to consecutive defaults of other institutions. Results are robust to the definition of exposures (i.e., original exposure or exposure after exemptions and credit risk mitigation), LGD parameters, rollover assumptions on lost funding, and fire-sale haircuts. These results reflect the fact that interbank exposures are small compared to banks' capital levels and that the resulting connectivity of this network is low.

116. The results of the contagion analysis should be interpreted with caution. First, the data is drawn from the large exposures supervisory reporting template (including both secured and unsecured exposures) and therefore exclude small exposures. Second, the contagion analysis is limited to the domestic interbank market (i.e., exposures to foreign counterparts are excluded) and assumes a passive role from the central bank. Third, active fire-sale assets are calibrated exogenously.[47] Also, valuation effects from common exposures to stressed assets by banks holding similar assets are excluded. Fourth, contagion effects from a bear-market sentiment to banks following similar business models to the bank in distress are excluded. Fifth, the mechanism does not explore precautionary liquidity hoarding, whereby banks that have suffered solvency shocks or deposit run-offs may decide to cut lending to their counterparties ultimately leading to a freeze in aggregate interbank markets. Finally, Knightian uncertainty about whether other banks will roll over funding or carry out a run on a counterparty to which they all have exposures is not covered in the analysis.

C. Systemic Risk Assessment

117. To capture risks to the stability of Belgian banks from market contagion, the CoVaR methodology is applied (Box 2). The CoVaR methodology evaluates the potential for individual bank stress to propagate through equity markets. Contagion can occur if the failure of one bank is a signal to investors that banks operating in the same region or with similar business models are likely to be in trouble. A correction in market value or the restriction of liquidity might follow as counterparties shy away.[48] The quantification of contagion effects depends on: (i) the definition of the financial system; (ii) the characterization of financial stress; and (iii) the macrofinancial environment in which firm stress arises.

118. The financial system is defined as the set of large internationally active European banks, i.e., "EBA" sample (Table 6). The sample of Belgian peer banks includes 32 large banks from 14 EU countries. The initial list of banking institutions draws from the 2018 EU-wide stress test sample of 49 banks. In addition, we add two large financial institutions that were covered in the 2016 EU-wide stress test sample but were excluded in the 2018 test.[49] Since the methodological approach requires stock market data we exclude non-listed banks. The resulting sample is formed by a total of 35 large banks. The selection criterion to configure the sample is the availability of comparable data over a long period of time.[50]

119. Results are robust to the definition of Belgian banks' peer group. Three additional peer groups to Belgian banks were constructed: "Peer_local," comprising European banks with local

[47] The spiral effects from further declines in prices as a function of the aggregate increase in supply of assets are not modeled explicitly.

[48] This notion of contagion follows the definition of market contagion suggested by the Financial Stability Oversight Council.

[49] The list adds Banca Monte dei Paschi Siena and Banco Popular.

[50] This criterion excludes ABN Amro Group N.V., incorporated in Dec 2009; CaixaBank S.A., incorporated in June 2011; and, BFA Tenedora de Acciones S.A.U., incorporated in December 2010.

presence in material geographies for listed Belgian banks; "Belgium," comprising European banks with local presence in Belgium; and "Peer_CESEE," comprising European banks with the same core markets than listed Belgian banks. The results are consistent with those obtained using the broader "EBA" sample. The analysis uses weekly data from June 2005 through May 2017.[51]

120. We define that a bank is distressed when it reaches its VaR returns. VaR is the most common indicator to measure portfolio downside risk. This statistical measure has been popularized by the current regulatory framework, as it allows approved banks to use internal VaR models to set capital requirements. Paralleling the VaR definition, the CoVaR is defined as the maximum loss to be expected in a certain portfolio (e.g., an individual bank or, more generally, a portfolio representative of the whole financial system) for a given confidence level and time horizon, given the maximum loss expected in another portfolio at a specific confidence level and time horizon (Box 1).

121. The estimation of systemic risk measures is conditional on a set of macro-financial state variables which are expected to impact bank returns. We use a set of state variables sampled from United States, European, and Belgian financial markets as common conditioning variables. This approach seems reasonable on the back of the composition of the bank sample. The U.S. state variables used in this analysis include: the Volatility Index (VIX) of the Chicago Board Options Exchange (CBOE); and the change in the credit spread between the 10-year Moody's seasoned Baa corporate bond and the 10-year U.S. Treasury bond. The European state variables include: the liquidity spread (difference between the 3-month Euro repo rate and the 3-month German T-bill yield); the change in the German Treasury bill secondary market 3-month rate; the change in the slope of the German Bund (yield spread between the German benchmark 10-year bond and the German 3-month T-bill); and the Eurostoxx 500 Composite Index return. The Belgian financial variable is defined as the spread of the 5y OLO rate over the swap curve. All these variables are sampled weekly. The data have been obtained from Bloomberg.

122. Market perceptions of systemic risk through equity markets have eased following crisis episodes (Figure 22). The VaR of financial system returns, controlling for macrofinancial drivers, edged down to around -12 percent of quarterly equity returns in May 2017 from a peak of -65 percent during the GFC and -40 percent during the European sovereign crisis. The assessment is robust to the definition of the financial system.

123. The CoVaR measure of comovement in tail returns is affected by distress in individual banking institutions. The coefficient related to the dynamics of individual bank returns is always significant and enhances the ability of the model to forecast the tail performance of the financial system portfolio.[52] The coefficient related to individual stress is always significant. Among the different state variables used as controlling variables, market volatility and liquidity pressures exhibit

[51] The starting date of the sample is determined by the incorporation of Raiffeisen Bank International to the sample.

[52] Figure 34 shows the median of the coefficient estimates, the median of the t-statistics for the individual significance of the estimated coefficients, and the median of the pseudo-R2.

the strongest predictive power in statistical terms.[53] The median elasticity of the system to individual tail returns reaches 0.96 when the distress bank is deleveraging. Interestingly, the amplification effect from bank deleveraging[54] increases with a bank's systemic importance, measured by its delta CoVaR.

Table 6. Financial System for CoVaR Analysis

Banking System "EBA"

Country	Bank Name	Ticker
Austria	EBS AV Equity	EBS
Austria	RBI AV Equity	RBI
Belgium	KBC BB Equity	KBC
Denmark	DANSKE DC Equity	DAN
Denmark	JYSK DC Equity	JYS
France	BNP FP Equity	BNP
France	GLE FP Equity	GLE
France	ACA FP Equity	ACA
Germany	DBK GR Equity	DBK
Germany	CBK GR Equity	CBK
Hungary	OTP HB Equity	OTP
Ireland	ALBK ID Equity	ALB
Ireland	BKIR ID Equity	BKI
Italy	ISP IM Equity	ISP
Italy	UCG IM Equity	UCG
Italy	BMPS IM Equity	BMP
Italy	UBI IM Equity	UBI
Netherlands	INGA NA Equity	ING
Norway	DNB NO Equity	DNB
Poland	PKO PW Equity	PKO
Spain	SAN SM Equity	SAN
Spain	BBVA SM Equity	BBV
Spain	SAB SM Equity	SAB
Spain	POP SM Equity	POP
Sweden	NDA SS Equity	NDA
Sweden	SHBA SS Equity	SHB
Sweden	SWEDA SS Equity	SWE
Sweden	SEBA SS Equity	SEB
UK	HSBA LN Equity	HSB
UK	BARC LN Equity	BAR
UK	LLOY LN Equity	LLO
UK	RBS LN Equity	RBS

Banking System "Peer Local"

Country	Bank Name	Ticker
Belgium	KBC GROEP NV	KBC BB Equity
France	BNP PARIBAS	BNP FP Equity
Hungary	OTP BANK PLC	OTP HB Equity
Ireland	ALLIED IRISH BANKS PLC	ALBK ID Equity
Ireland	BANK OF IRELAND	BKIR ID Equity
Netherlands	ING GROEP NV-CVA	INGA NA Equity

Banking System "Belgium"

Country	Bank Name	Ticker
Belgium	KBC GROEP NV	KBC BB Equity
France	BNP PARIBAS	BNP FP Equity
Netherlands	ING GROEP NV-CVA	INGA NA Equity

Banking System "Peer CESEE"

Country	Bank Name	Ticker
Austria	ERSTE GROUP BANK AG	EBS AV Equity
Austria	RAIFFEISEN BANK INTERNATION	RBI AV Equity
Belgium	KBC GROEP NV	KBC BB Equity
France	BNP PARIBAS	BNP FP Equity
Netherlands	ING GROEP NV-CVA	INGA NA Equity

Source: Bloomberg.

124. **The risk of cross-border spillovers between the listed Belgian banking institutions and other peer banks appears moderate.** The CoVaR analysis suggests that, on average, the risk that severe distress affecting the listed Belgian bank is transmitted to large European banks is moderate.[55] The contribution to systemic stress is time-varying. While Figure 22 shows the median

[53] Allowing for deleveraging effects in the response of the VaR of the system portfolio to individual returns leads to an enhancement in the overall fit of the model.

[54] This is measured by the difference between the median estimate of the coefficient of negative returns and that of positive returns.

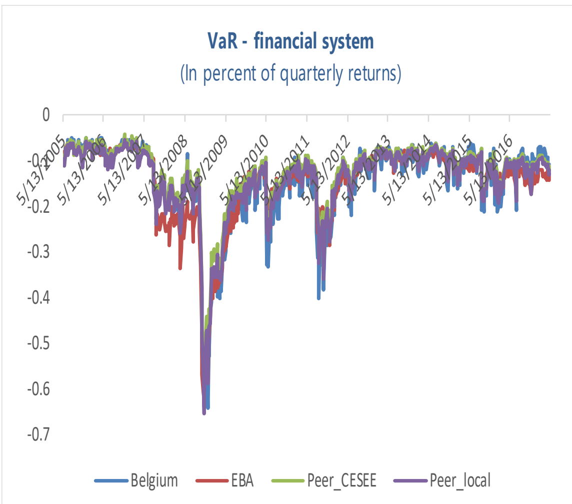
[55] An institution experiences severe distress when it reaches its VaR in weekly returns. Under the main specification, equity returns are used. Results are robust to the characterization of the financial system of Belgian peer banks, confidence levels, and banks' performance in terms of market-implied asset returns.

delta CoVaR over the entire period June 2005-May 2017, the ranking of the delta CoVaR for the Belgian bank is robust to calculating the median impact during the global financial crisis (Aug 2007–Aug 2009) and the European sovereign debt crisis (May 2010–Dec 2012).

Figure 22. Market-based Contagion

The risk of the financial system based on market-based CoVaR has come down from crisis levels. The contribution to systemic risk of the listed Belgian banking institution is contained.

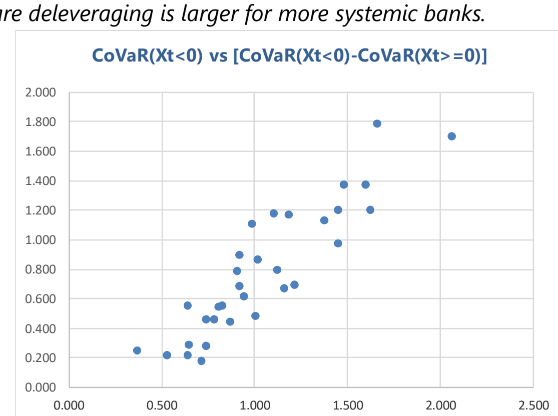
VaR returns have edged down to around -12 percent from a peak of -65 percent during the GFC.



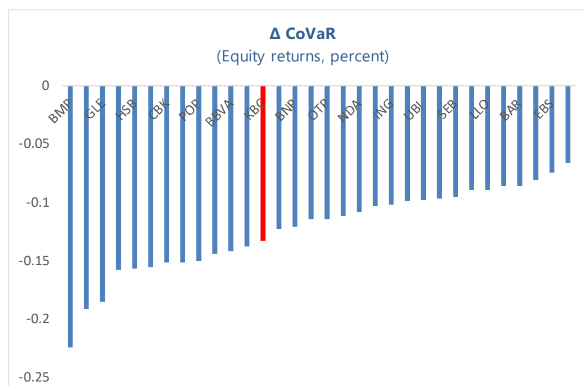
The most relevant drivers of contribution to systemic risk measured by ΔCoVaR are volatility, liquidity risk, and stress in peer banks.

	Symmetric	Asymmetric
Constant	-0.008 (-1.423)	0.001 (0.177)
Volatility	-0.002 (-7.931)	-0.002 (-7.792)
Δ Corp Spread	-0.055 (-1.674)	-0.012 (-0.598)
Δ Euro Stoxx	0.000 (-0.243)	0.000 (-0.019)
Δ T-bill	-0.022 (-0.223)	0.025 (0.501)
Δ Slope	-0.056 (-2.213)	-0.015 (-0.672)
Liquidity spread	-0.027 (-6.711)	-0.022 (-3.940)
Sov spread over swap	0.002 (0.688)	0.003 (0.667)
X_t^i	0.557 (8.722)	
$X_t^i I_{(X_t^i<0)}$		0.995 (14.634)
$X_t^i I_{(X_t^i\geq 0)}$		0.275 (3.124)
Pseudo-R2	0.660	0.697

The increase in contribution to systemic risk when banks are deleveraging is larger for more systemic banks.



The average contribution to European banking systemic risk of the listed Belgian bank is contained.



Source: IMF Staff Estimates based on Bloomberg data.
Note:The sample of banks included the 32 largest listed EU banks included in the 2018 EU-wide stress testing sample. The analysis is based on weekly data from June 2005 through May 2017, The charts show the averge contribution to systemic risk during the overall period.

Box 2. Overview of the CoVaR Methodology

The CoVaR is defined as the maximum expected loss in the banking system for a given confidence level and time horizon, conditional on the maximum expected loss of an individual bank at a specific confidence level and time horizon. More formally, the $(1-\lambda)\%$ CoVaR of system j given the $(1-\lambda)\%$ VaR of bank *i*, denoted $CoVaR^{j|i}_{\lambda,t}$, is defined as the λ quantile of the conditional loss function:

$$\Pr\left(X_t^j \leq CoVaR^{j|\Phi\left(X_t^i\right)} \middle| \Phi\left(X_t^i\right)\right) \tag{1}$$

where X_t^j and X_t^i denote system and individual bank returns.

A bank's individual contribution to systemic risk can be approximated by its ΔCoVaR:

$$\Delta CoVaR^i_{\lambda,t} = CoVaR^{j|i}_{\lambda,t} - VaR^j_{\lambda,t} \tag{2}$$

which captures how much risk bank i adds to overall systemic risk when it reaches its VaR.

For each conditioning event, we construct a different banking system to avoid spurious correlation. The banking system is defined as the weighted average returns of the remaining banks in the sample, once we exclude the bank in distress. In particular, the returns of the banking system given bank *i*'s distress are constructed as:

$$X_t^{S,i} = \sum_{j=1, j\neq i}^{n} \omega_{t,j} X_t^j, \quad \omega_{t,j} = W_t^j \left(\sum_{j=1, j\neq i}^{n} W_t^j\right)^{-1} \tag{3}$$

where X_t^j refers to the returns of the *j*-th bank and W_t^j is the book value of total assets.

The existence of risk spillovers is captured through the estimates of the $\delta_{\lambda,i}$ parameter. The left tail of the banking system can be predicted by observing the distribution of bank i's returns. The symmetric specification can be approximated by:

$$X_t^{S,i} = Z'_{t-1}\beta_\lambda + \delta_{\lambda,i} X_t^i + u_{\lambda,t} \tag{4}$$

We check for possible asymmetries in the specification. Since the interest of our analysis is clearly on the behaviour of the left tail, for which 5 percent VaR is expected to be a negative value, the basic specification (4) neglects an important feature of the conditioning: the final prediction is constructed on a negative value. If we factor in the reinforcing effects from credit constraints in a downward market, the model is likely to yield parameter estimates of $\delta_{\lambda,i}$ which can significantly underestimate the impact on the system of a negative shock in the balance sheet of a bank. We estimate the asymmetric specification:

$$X_t^{S,i} = Z'_{t-1}\beta_\lambda + \delta^-_{\lambda,i} X_t^i I_{\left(X_t^i<0\right)} + \delta^+_{\lambda,i} X_t^i I_{\left(X_t^i\geq 0\right)} + u_{\lambda,t} \tag{5}$$

The econometric specification of the contribution of bank *i*'s distress to the distress of the banking system is approached by:

$$\Delta CoVaR^i_{\lambda,t} = \hat{\delta}_{\lambda,i}\left(VaR_i^t(\lambda) - VaR_i^t(50\%)\right) \tag{6}$$

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See Adrian and Brunnermeier (2016), and Lopez-Espinosa, Moreno, Rubia and Valderrama (2012, 2015).

INSURANCE SOLVENCY TESTS

A. Scope of the Test

125. Solvency II[56] was implemented in the European Union in 2016 and forms the basis for the insurance stress test. As a general principle of Solvency II, assets and liabilities are valued mark-to-market. However, some notable deviations from the market-consistent framework are allowed for the liabilities, especially with regard to the discount rate which incorporates long-term guarantee (LTG) measures and transitional measures. The reference date for the ST exercises was set to end-2016.

126. Eight insurance companies participated in the ST, accounting for a representative sample of the market. In the Belgian insurance sector, which is characterized by high concentration, a coverage of 78 percent in terms of total balance sheet assets is reached by including eight undertakings. Among those eight undertakings are the seven largest companies as well as all insurers which form part of a financial conglomerate. Six companies apply the Solvency II standard formula, while the remaining two companies have implemented either a partial or a full internal model.

127. The stress test was run at the solo entity level and thereby excluded business performed by foreign subsidiaries. Nevertheless, for those few Belgian insurance groups with foreign activities, these are mostly limited, so that by focusing on the Belgian entity a fairly comprehensive view on relevant risks can be achieved.

B. Scenario Specification

128. The bottom-up (BU) stress test included two scenarios, for which participating insurance companies calculated the impact on their solvency position. One of these scenarios is taken from the NBB regulatory stress test ("low-for-long") and the other one is designed fairly in line with the IMF's adverse scenario also used for the banking sector stress test ("IMF adverse"). The top-down (TD) exercise included only the IMF adverse scenario.

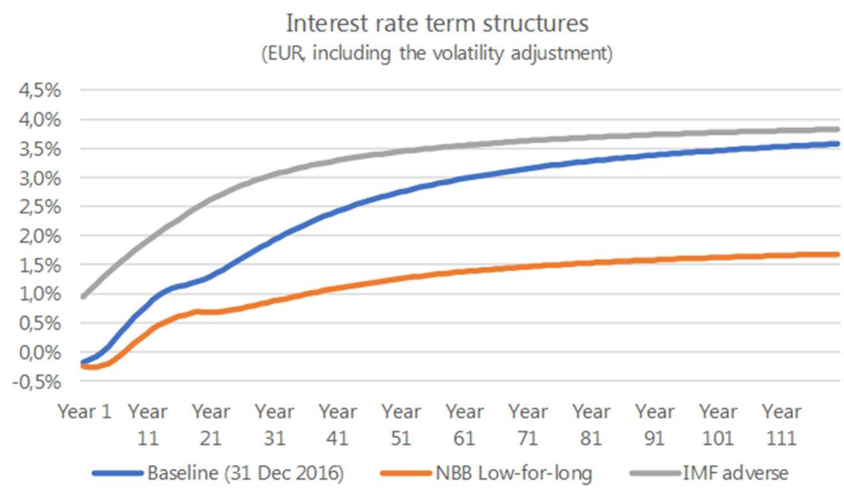
129. The stress test by the NBB is used as input for decisions on microprudential supervisory measures. The results of the NBB's low-for-long scenario are taken into account when assessing the possibility to exempt a company from building up an additional provision for the risks resulting from a prolonged environment of low yields. Although this stress test is mandatory only for the seven largest companies, the majority of domestic undertakings active in life insurance or long-term workers' compensation business took part in the 2017 exercise. In the remainder of this note, however, reference is made only to those eight undertakings which also performed the BU calculations for the IMF adverse scenario. The NBB's scenario foresees a drop in the Euro interest rate term structure to the lowest level observed during the last two years[57] plus an additional drop

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

[57] Observed in September 2016.

of 15 basis points for the first 20 years of the term structure. After these 20 years (the “last liquid point”), instead of using an extrapolation for the term structure towards an ultimate forward rate of 4.2 percent, the extrapolation is made towards a rate of only 2 percent (Figure 23).

Figure 23. Scenarios for the EUR Interest Rate Term Structure



Source: EIOPA, NBB, IMF staff calculations
Notes: The baseline term structure for the Euro, as determined under Solvency II, is based on observed market rates up to a maturity of 20 years (the so-called last-liquid point). After 20 years, the term structure converges towards an ultimate forward rate set at 4.2 percent. The term structure includes the volatility adjustment.

130. The macrofinancial scenario specified by the IMF for the banking sector stress test was in some aspects slightly adjusted and amended for the purpose of the insurance stress test. The scenario’s narrative which centers around

- an increase in general risk aversion in global markets,
- a large correction in the Belgian real estate market, and
- a reassessment of regional sovereign risk,

is highly relevant also for the insurance sector. Nevertheless, some simplifications were made in order to make the scenario easier to apply by ST participants. While the scenario includes a projection of macro and market variables for the next five years, for the insurance stress test all shocks were assumed to occur at the beginning of the first year (instantaneous shock). Market shocks, like e.g., on equity and property prices, have therefore been front-loaded so that the maximum drawdown during the projection horizon of the macrofinancial scenario is already realized right after the reference date.

131. To cover the most relevant risk factors for an insurer’s balance sheet, specifically the market risk shocks have been defined more granularly. The scenario includes shocks to the risk-free interest rate, equity and property prices, credit spreads of corporate and sovereign bonds, losses on mortgage loans, as well as a shock to the external value of the Euro (Table 7). Given the increase of credit spreads in the scenario, also the volatility adjustment (VA) increases, following the

Solvency II calculation method. In effect, this offsets to some degree the negative impact of the credit spread shock.

Table 7. Specification of Market and Credit Risk Shocks for the Insurance Stress Test
(IMF adverse scenario)

Equity	Haircut
Equity, Belgium and advanced economies	-16.2%
Equity, Emerging/developing economies	-25.0%

Real estate	Haircut
Real estate, Belgium	-20.0%
Real estate, elsewhere	-15.0%

Mortgage loans	Haircut
Mortgage loans	-2.0%

Change of EUR against...	
USD	-5.7%
GBP	-9.4%
CZK	-7.1%

Corporate bonds and securitisations	Spread change
AAA	0.50%
AA	0.80%
A	1.20%
BBB	1.80%
BB or lower	3.00%
Unrated	2.00%

Sovereign bonds	Spread change
Belgium	1.47%
EA high-spread countries	2.00%
EA low spread countries	0.50%
Other advanced economies	1.00%
Emerging/developing economies	2.00%

Source: IMF staff.

132. **Insurance undertakings were also requested to provide the sensitivity of their own funds to a range of additional risk factors.** The outcome of these shocks is not added to the results of the macrofinancial scenario:

- Insurers calculated the sensitivities for longevity (modeled as a permanent 20 percent decrease in mortality rates, applied to all policies) and mortality shocks (modeled as a permanent 15 percent increase in mortality rates, applied to all policies) as well as a pandemic event with higher morbidity rates (modeled as a temporary 35 percent increase in disability-morbidity rates as well as a temporary 10 percent increase in mortality rates for the next 12 months).

- Insurers further provided an estimate of the impact of two individual catastrophic events, specifically two windstorms which had hit the Benelux region in the past. Insurers were requested to assume a repetition of storms Lothar (1999) and Xynthia (2010), based on current exposures. In addition, for each catastrophic event, insurance undertakings provided the reinsurance recoverables from the participant's five largest reinsurers (on a group basis).

C. Capital Standards and Modelling Assumptions

133. **The main output of the stress test calculations is the effect on available own funds, eligible for the coverage of the solvency capital requirement (SCR).** As the stresses might also affect the capital requirement, participating undertakings were requested to recalculate the SCR after stress.

134. **Insurance companies have a broad range of risk-mitigating mechanisms in place which the ST aimed to make transparent.** The loss-absorbing effects of technical provisions (via profit

sharing) and deferred taxes were reported separately, as well as the measures of the long-term guarantee package (LTG). In Belgium, the use of LTG measures is mainly restricted to the volatility adjustment (VA) without which the solvency ratios would look considerably less favorable for some companies.[58] Management actions could only be included by companies in the BU calculations as far as these were non-discretionary rules already in place at the reference date.

135. Undertakings were requested to provide a three-year projection of business development under the baseline and the IMF's adverse scenario. Key figures to be projected included gross written premiums, gross claims, lapse rates, investment returns, net earnings, gross technical provisions, own funds, and the SCR. Projections had to be made in line with the macrofinancial scenario while the market value of investments was assumed to stay constant after the occurrence of shocks at the reference date which marks the beginning of the first year of the projection horizon (instantaneous shock). Therefore, any recovery in profitability, and ultimately solvency, would be driven solely by the underwriting business and recurring investment income from interest, dividends and rents.

136. To benchmark the results of the BU stress test, an additional TD stress test was run by the FSAP team, based on input data received from the NBB and the companies. Data required from the insurance undertakings included:

- A granular breakdown of investment assets, specifically on the geographical breakdown of sovereign and corporate bond holdings, the rating distribution of the bond portfolio, as well as maturities and coupon rates of fixed-income investments.
- Cash-flow projections for the upcoming 50 years in line with the Solvency II contract boundaries.

137. For the TD stress test, scenarios were applied to the investment assets and insurance liabilities. Haircuts in line with scenarios were applied to the market value of assets, and a re-valuation of fixed-income assets was undertaken with the stressed term structure (per currency). Similarly, technical provisions were re-valued with the stressed term structure including the volatility adjustment. The re-calculation of the SCR was limited to the market risk component. All other components, including the capital charge for life underwriting risks were assumed unchanged. For those companies which use a full or partial internal model, the TD calculations were made in a simplified approach broadly in line with the standard formula.

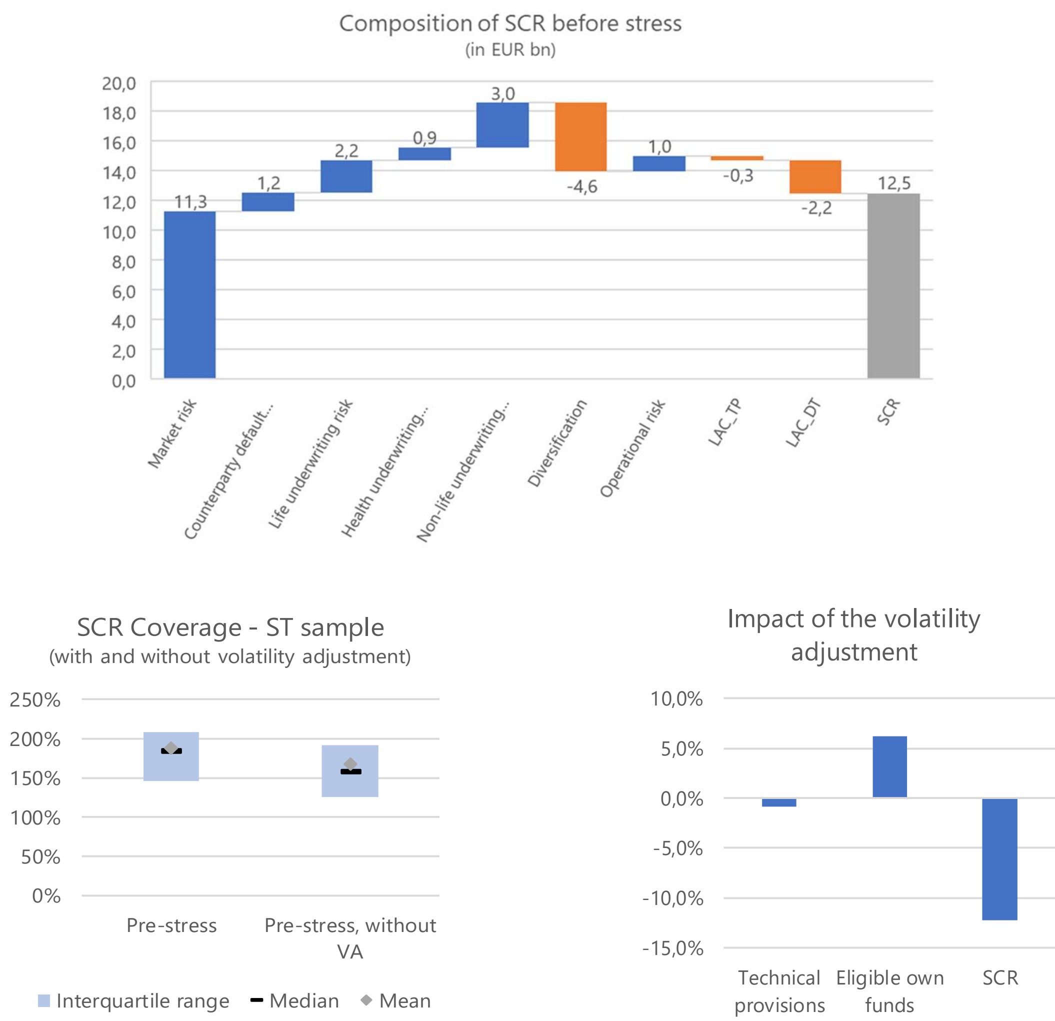
D. Results

138. The industry is able to withstand severe asset price shocks according to the Solvency II framework, despite vulnerabilities on the asset side. In the IMF adverse scenario, the median solvency ratio drops from 184 to 124 percent, according to the BU calculations, while in the NBB low-for-long scenario the ratio declines to 145 percent (Figure 25). The aggregated solvency surplus

[58] The NBB is, in general, very restrictive with regard to long-term guarantee measures and transitional measures within the Solvency II framework. Only one company in the market uses the 16-year transition period for technical provisions, and only about one half uses the volatility adjustment, which however has a material effect in the Belgian market, as shown also in the 2016 EIOPA stress test, and in particular for some individual undertakings.

of the participating companies amounts to €10.2 billion before stress, and drops to €4.1 billion and €6.2 billion in the IMF adverse scenario and the NBB low-for-long scenario, respectively. In each scenario, one company drops marginally below a solvency ratio of 100 percent, but the capital needed to restore a full coverage of solvency capital requirements amounts in each case to less than €10 million. Most companies benefit from the assumed increase of the VA in the IMF adverse scenario which, in the vein of Solvency II, immunizes them against excessive spikes in credit spreads which are not driven purely by a deterioration in underlying credit risks.

Figure 24. Composition of the SCR and Impact of the Volatility Adjustment



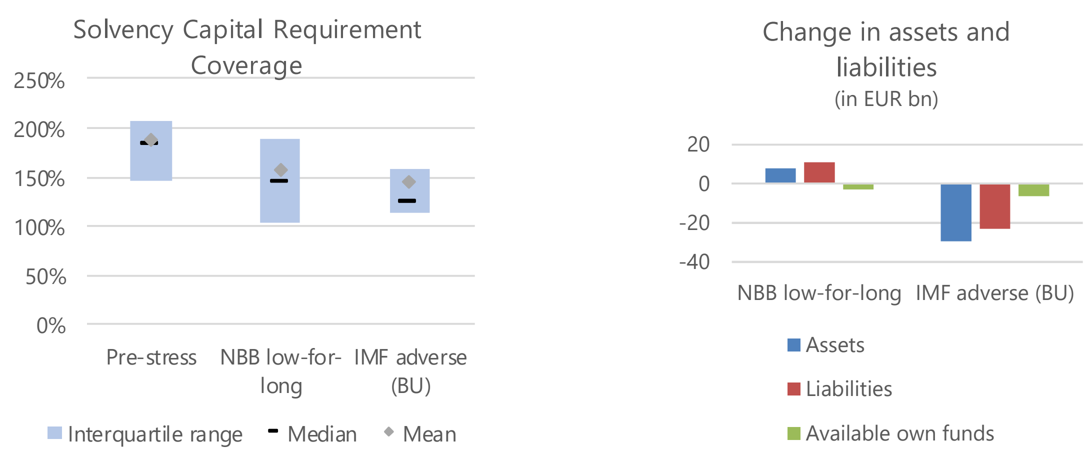
Source: IMF staff calculations based on company submissions.

Notes: The upper panel also includes SCR components of partial and full internal model users. The scope of their SCR modules can differ slightly from the modules used in the Solvency II standard formula. Specifically, the loss-absorbing capacity of deferred taxes (LAC_DT) and technical provisions (LAC_TP) of internal model users is either calculated by them in a separate module or as part of the relevant underwriting risk modules. The graph includes LAC_DT and LAC_TP whenever a separate module for those exists or when companies were able to provide an estimate of the loss-absorbing capacity already included in one of the underwriting risk modules.

139. The TD calculations broadly confirm the BU results. Taking into account a few simplifications which need to be used in the TD modelling, the results are in line with those from the BU exercise. Overall, the interquartile distribution and the mean solvency ratio are slightly below the BU numbers, mainly driven by those companies with larger derivative holdings used for hedging purposes—their risk-mitigating effect cannot be modelled in the TD stress test. Two companies would face an SCR coverage below 100 percent the IMF adverse scenario with an aggregated capital shortfall of less than €400 million.

140. Effects of the stresses are observed on both the asset and the liability side of the balance sheet. In the IMF adverse scenario, the aggregated market value of assets declines by 12 percent while the value of liabilities declines by 10 percent. This results in an excess of assets over liabilities which is 29 percent lower after stress. Contrary to this, the NBB low-for-long scenario results in an increase in the value of assets and liabilities of 3 and 5 percent, respectively, lowering the excess of assets over liabilities by 14 percent.

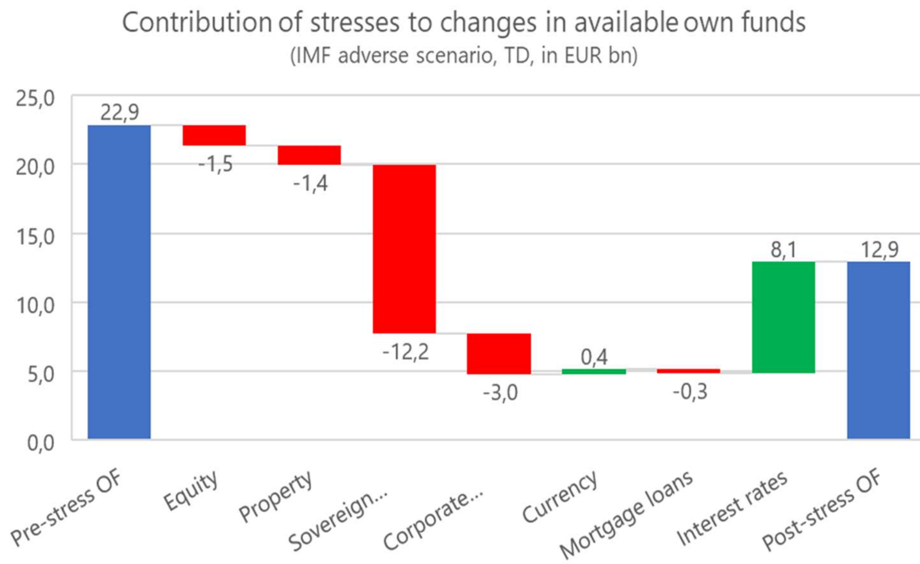
Figure 25. Overview of Insurance ST Results



Source: IMF staff calculations based on company submissions

141. Most of the solvency impact can be attributed to the increase in Belgian sovereign bond yields. While in the NBB low-for-long scenario, (risk-free) interest rates are the sole driver of changes in the solvency position, the most relevant factor in the IMF adverse scenario is the combination of higher risk-free rates and the substantially higher credit spreads for the Belgian sovereign (Figure 26). This effect is only partially offset by decreasing insurance liabilities and lower capital requirements after stress.

Figure 26. Composition of the Effect on Own Funds in the IMF Adverse Scenario (Top-Down)

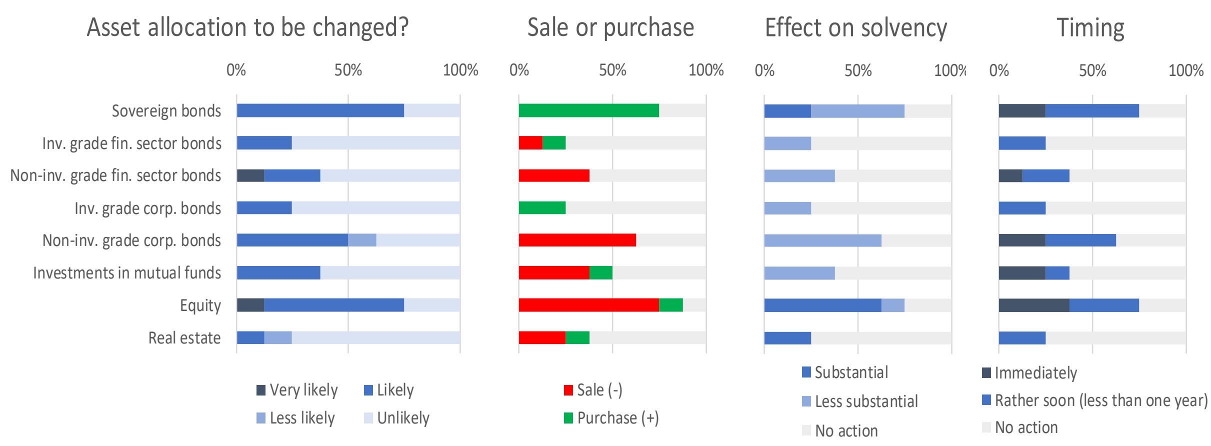


Source: Fund staff calculations based on company submissions.

142. Stress tests on insurance companies also focused on the sector's capacity to absorb rather than amplify the impact of macroeconomic and financial shocks. Given the size of the Belgian insurance sector and its critical role in providing funding for the public and the financial sector, the exercise looked at the companies' possible reactions aimed at restoring solvency and profitability after the materialization of the adverse scenario, as well as the potential negative external effects related to these.

143. Overall, the insurance sector seems capable to withstand the losses simulated under the adverse scenarios without materially amplifying market risks or tightening market liquidity. While companies are considering some changes in their asset allocation after shock in order to reduce their capital requirement and thereby improve their solvency position, such actions would unlikely be taken in a disruptive manner, but actually spread over several weeks or even months—especially as the need for action is limited for the large majority of undertakings. Assets likely being divested include equity and corporate bonds below investment grade, and instead investments in sovereign bonds would be increased (Figure 27).

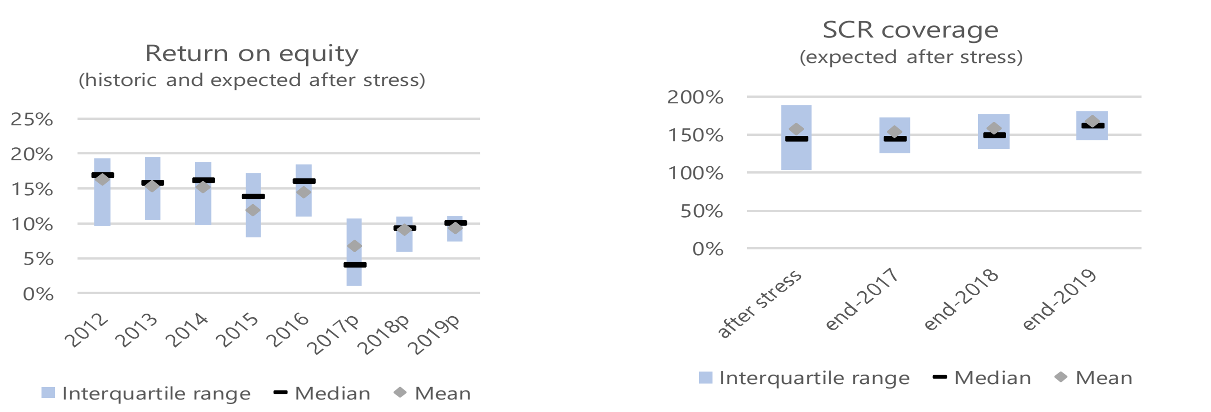
Figure 27. Expected Changes in Asset Allocation after Stress



Source: IMF staff calculations based on company submissions.

144. After the materialization of the stress scenario, insurance companies are expected to recover rather quickly and to restore profitability. The IMF adverse scenario would reduce the mean return on equity from around 15 percent to less than 7 percent in the first year of the projection horizon. However, although assuming no recovery of financial markets after the instantaneous stress event, insurers expect net income to improve to levels slightly below 10 percent in the following years. As a result of profits remaining positive even after stress, solvency coverage is recovering steadily from the instantaneous stress impact, but mostly only in 2019 (Figure 28).

Figure 28. Medium-Term Projections

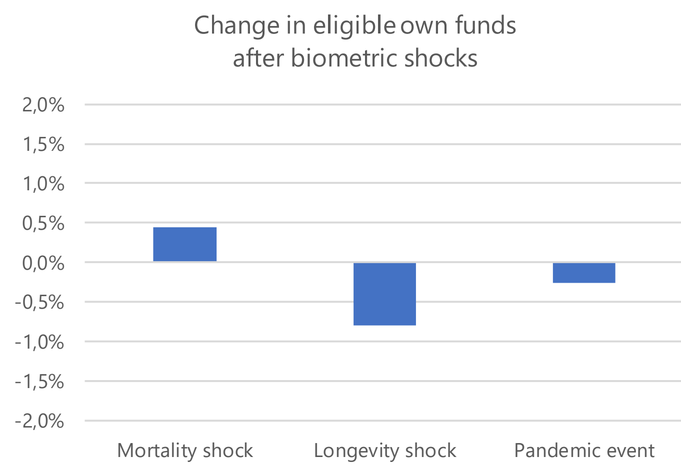


Source: IMF staff calculations based on company submissions.

145. On the underwriting side, life insurers are resilient to severe shocks if they occur in isolation. Among life insurers, the sensitivity to a longevity shock, i.e., a permanent 20 percent decrease in mortality rates, would result in a decline of own funds by less than 1 percent. A severe pandemic would affect own funds even less, and a permanent 15 percent increase in mortality rates would even have a marginal positive impact on the sector (Figure 29).

146. Non-life business would be only marginally affected by a repetition of two historic windstorms. In case of a windstorm similar to Lothar (1999) or Xynthia (2010), the median company would suffer a loss in own funds of less than 1 percent. Most of this impact would have to be borne by the primary insurers as losses are below the retention levels agreed upon with reinsurers. In general, exposure to catastrophic events seems well managed via diversified reinsurance contracts. As a result of the climate change, however, the sector is becoming more exposed to a higher frequency of loss events.

Figure 29. Sensitivity Analyses



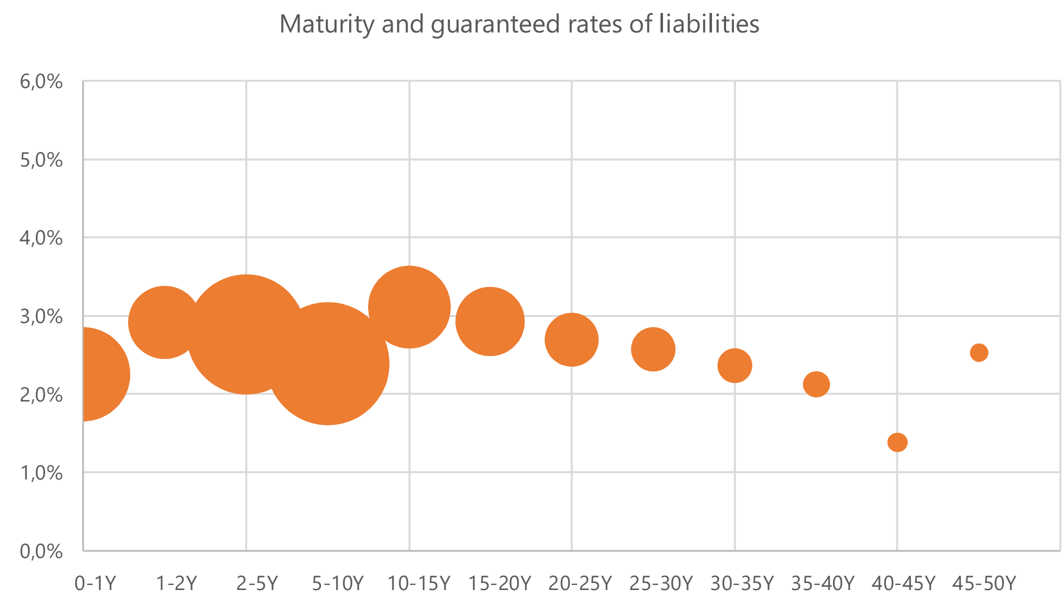
Source: IMF staff calculations based on company submissions.

E. Challenges in a Prolonged Low-Yield Environment

147. For most European life and composite insurers, including those in Belgium, the prolonged low interest rate environment presents a severe challenge. Life insurance liabilities have very long durations, which under a market-consistent valuation regime makes them highly sensitive to changes in interest rates which are used to discount future expected claims paid out to policyholders. While an exact match of assets and liabilities is usually not possible in the absence of very long-dated investment assets, Belgian insurers have closed their duration gaps in recent years by investing more extensively in long-running fixed-income assets and specifically domestic sovereign bonds.

148. Belgian life insurers have been active in recent years to adapt their product portfolio which on aggregate led to a decline in guaranteed interest rates, either by reducing guarantees offered in new business or increasing sales of unit-linked policies. One large company completely withdrew from offering any new policies with guaranteed rates. The average guaranteed interest rate as of end-2016 stood at 2.6 percent, down from 3.1 percent five years earlier. However, significant buckets of liabilities with guaranteed rates well above 2 percent and maturities of 30 years and more are still on the insurers' balance sheets (Figure 30).

Figure 30. Guaranteed Interest Rates

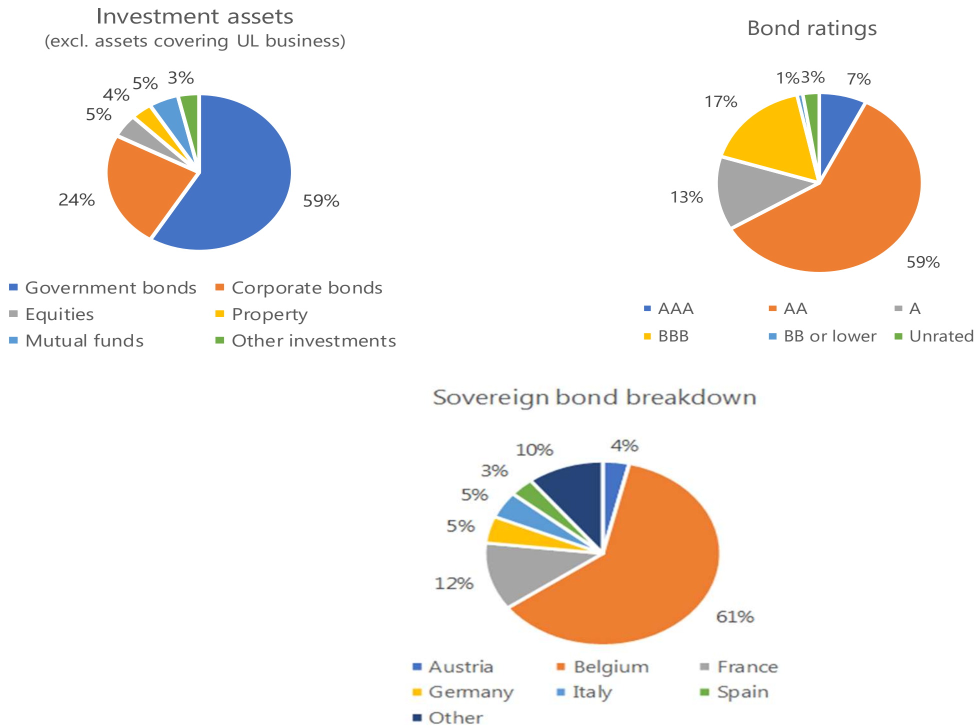


Source: IMF staff calculations based on company submissions.
Notes: Each bubble represents the value of insurance liabilities (size) and the average guaranteed interest rate due in a given time bucket.

149. Over a medium-term horizon, insurers will face declining investment returns as higher-coupon bonds they hold expire. On aggregate, the Belgian insurance sector still records positive spreads of investment returns over guaranteed interest rates, and is also expected to remain profitable after the materialization of the IMF adverse scenario, but significant differences exist across companies. While insurers which are more active in non-life and unit-linked life business are less affected and could sustain the current low-yield environment for a prolonged period, companies with a high stock of guarantees on their policies are likely to experience a drain on their profitability.

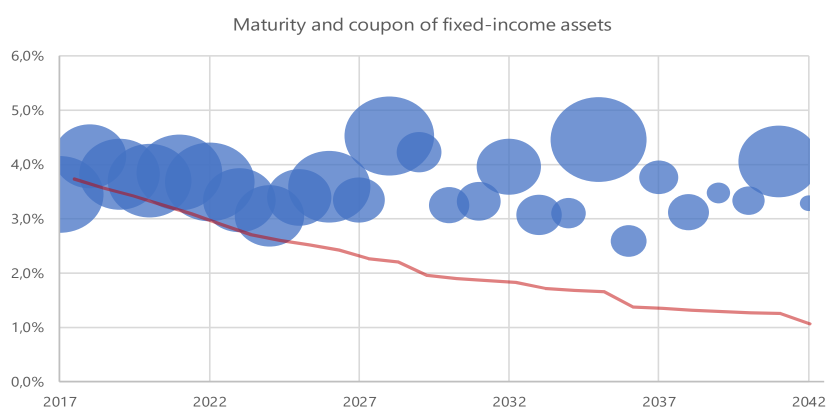
150. Substantial parts of the fixed-income portfolio with relatively high coupon rates are going to expire in the upcoming years (Figure 32). For the aggregate of insurance companies included in the stress test exercise, 50 percent of all investments with a fixed coupon will mature between 2017 and 2025—these assets pay a coupon of 3.6 percent on average. While such a coupon rate is still considerably above the average guaranteed interest rate of 2.6 percent, the current yield environment will make it difficult to find assets with sufficiently high yields without taking on undue credit risk. Assuming that expiring instruments can only be reinvested at a coupon of 1 percent, the average coupon for the fixed-income portfolio will drop to 2.5 percent by 2025, and further to 1.9 percent in 2030.

Figure 31. Breakdown of Investments (for Insurance Stress Test Participants)



Source: IMF staff calculations based on company submissions
Note: Figures shown in this panel relate only to insurance companies participating in the stress test.

Figure 32. Reinvestment Risks



Source: IMF staff calculations based on company submissions
Notes: Each bubble represents the nominal value (size) and the coupon of fixed-income instruments expiring in a given year. The red line shows a projection of the average coupon, assuming that all maturing instruments are reinvested at a rate of 1 percent.

EFFECT OF STRESS ON FINANCIAL CONGLOMERATES

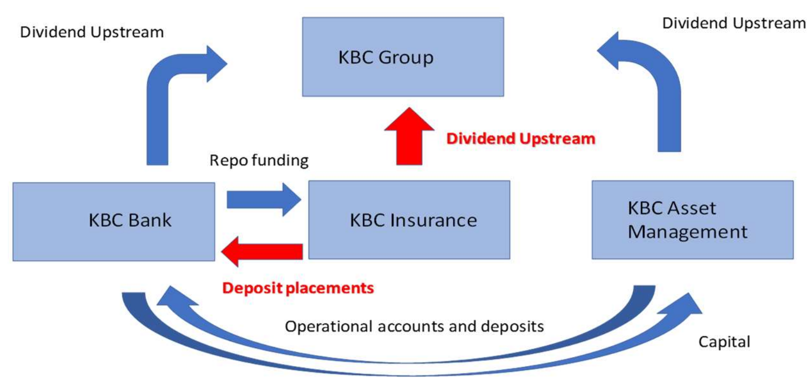
A. The Structure of Financial Conglomerates in Belgium

151. There are currently three banking-led financial conglomerates operating in Belgium. This implies that the banking sector is the most important sector within Belgian financial conglomerates. One conglomerate is headed by a credit institution, while the other two conglomerates are headed by a financial holding company. The three financial groups are significant institutions as defined by the SSM Regulation.

152. The perimeter of the solvency stress test for the banking sector included two financial conglomerates as well as the banking sector of the third conglomerate. The two financial conglomerates are Belfius and KBC Group while the banking sector is Argenta Spaarbank which belongs to Investar. Belfius, KBC Group, and Investar are designated as financial conglomerates with significant banking and insurance activities and have to comply with the Financial Conglomerate Directive.

Figure 33. Structure of KBC Financial Conglomerate

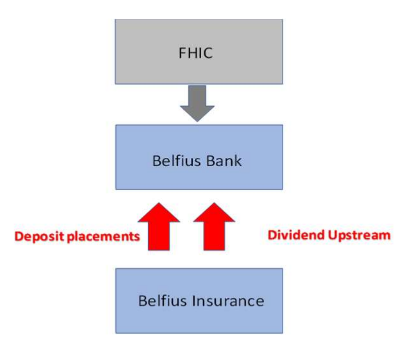
KBC Group is a financial conglomerate with KBC Bank, KBC Insurance, and KBC Asset Management.



Sources: KBC Group.

Figure 34. Structure of Belfius Financial Conglomerate

Belfius is a Belgian banking and insurance group wholly owned by the Belgian federal state through the Federal Holding and Investment Company (FHIC).



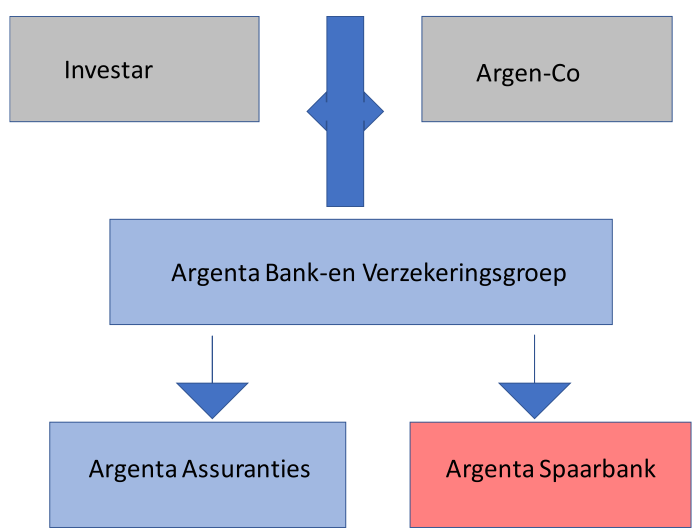
Sources: Belfius Bank.

153. Belfius, KBC Group, and Investar received a waiver from the NBB allowing them to use the Danish Compromise method. For the regulatory scope of reporting, solvency is reported on the basis of a 370 percent risk weighting being applied to the holdings of own fund instruments of the insurance company, after having deconsolidated the insurance entity from the group figures. Intragroup exposures and risk concentration are treated as supplementary risk categories for Pillar 2 capital requirements.

154. Stress tests were conducted separately for banks and insurers, but the overall impact of insurance stress test results on the resilience of the conglomerate was assessed. While stress tests could be implemented at the conglomerate level, the FSAP team conducted two independent tests for the banking and insurance sectors of the conglomerate. These tests were implemented in a consistent manner and based on a common stress scenario to have consistent results. Spillover effects from the insurance firm to the bank-led conglomerate were assessed to identify potential amplification effects. The transmission channels examined in the test are explained below.

Figure 35. Structure of Investar Financial Conglomerate

Investar is a fully-fledged retail bank-insurer.



Sources: Argenta Bank.

B. Overall Impact of Stress Tests on Financial Conglomerates

155. Different transmission channels for risks exist in a financial conglomerate. The most direct impact would be felt via the capital channel where the parent undertaking would feel obliged to recapitalize a subsidiary after material stress. A second transmission channel exists through regular payments by the subsidiary to the parent, e.g., dividends or distribution fees, which could be lower in a stress situation. Finally, intra-group transactions can take on various forms and include on- and off-balance exposures which are subject to counterparty default risk.

156. Stress test results suggest that insurance firms are not major conduits of stress at the conglomerate level. The insurance stress test results for the three entities being part of a financial conglomerate are favorable and none of them drops below the 100 percent SCR coverage, therefore no additional capital would be needed from the parent or other group entities. Additionally, all three also remain profitable after stress so that dividend payments can be expected to continue at the levels of previous years.

157. Insurance firms should also be able to maintain operational balances, long-term deposits, and outstanding placements at local bank entities. While exposures from banking entities towards the insurance entities are less substantial, insurers hold sizable deposits with related banks. In addition, operational links exist which go beyond distribution channels, e.g., in the case of KBC where risk management is highly integrated across sectors. Stress test results suggest that the insurance sector should be able to play a stabilizing role on the funding structure of the financial conglomerate.

158. Yet profitability could be somewhat challenged through subdued fees and commission income. Less conclusive is the insurance stress test on fees being paid to banking entities within the conglomerate. While premiums especially in the life insurance sector have been declining for the last years, the IMF adverse scenario is not seen as a disruptive event which would significantly reduce premium volumes and distribution fees related to it further.

CONCLUDING REMARKS

159. The FSAP stress test results suggest that major Belgian banks are resilient to a global economic downturn. The FSAP macroeconomic stress scenario would reduce the aggregate CET1 ratio from 15.1 percent to a low point of 11.4 percent. All banks would meet minimum capital requirements and none would need to draw down their capital conservation buffer. Banks' resilience is explained partly by strong initial capital buffers and limited exposure to market risk. Belgian banks have almost doubled their risk-weighted capital ratios from pre-crisis levels, and have engaged in widespread de-risking through reductions in banks' international exposures, including trading activities and non-core operations.

160. Banks' more stable funding structures are also reflected in the positive liquidity stress test results, although asset encumbrance warrants continued monitoring. Banks' resilience in the face of a systemic tightening of liquidity conditions reflects their shift to traditional funding patterns and holdings of high quality assets. Belgian banks' relatively low vulnerability to systemic stress is due to the high quality of their liquidity buffers and reliance on deposits. However, the stability of retail deposits varies across banks and their volatility may change. As a result, Belgian banks are relatively vulnerable to idiosyncratic liquidity stress. Also, although asset encumbrance for the sector is manageable, it represents a potential source of liquidity risk for a few large banks, which warrants continued monitoring.

161. The risk of contagion from a bank default through interbank exposures in Belgium is contained. These results reflect the fact that interbank exposures are small compared to banks' capital levels and that connectivity of the network is low. A caveat of the analysis is that it does not include cross-border exposures among credit institutions domiciled in other jurisdictions, or knock-on effects from the behavioral response to stressed conditions by non-bank financial institutions.

162. The FSAP stress test results should, however, be interpreted with caution. A caveat is that stress test scenarios are calibrated using historical data which identify extreme "tail events" based on a historical distribution, even though it is well known that the nature of crises is to have unanticipated shocks and unexpected interrelationships where the past offers limited guidance. While some nonlinear effects can be captured in stress tests, it is always possible that unknown patterns emerge, especially if extreme shocks materialize.

163. The NBB is encouraged to expand its stress testing capabilities to strengthen the monitoring of financial stability risks. Macroprudential stress tests would allow policymakers to assess the financial system's ability to withstand losses triggered by a deterioration in cyclical macrofinancial conditions or structural changes to banks' business models and support the real economy if a stress does materialize. The incorporation of feedback loops with the real economy would help support the calibration of macroprudential policy. This is particularly relevant given the strong local presence of systemic subsidiaries of large euro area banks.

164. The NBB should continue strengthening vigilance on intersectoral flows, intragroup transactions, collateral flows, and cross-border operations. Although systemic risk indicators have eased following recent crisis episodes, this could reverse if there is a sudden sizable tightening of accommodative conditions or an abrupt reversal of investment sentiment. A sudden volatility burst could activate channels of financial contagion through fire sales and liquidity shocks from financial firms, including asset managers and CCPs, generating amplification effects on Belgian banks.

165. Insurance stress test results suggest that insurance firms are capable to withstand the losses simulated under the adverse scenarios without materially amplifying market risks or tightening market liquidity. While companies are considering some changes in their asset allocation after shock in order to reduce their capital requirement and thereby improve their solvency position, such actions would unlikely be taken in a disruptive manner, but actually spread over several weeks or even months—especially as the need for action is limited for the large majority of undertakings. Assets likely being divested include equity and corporate bonds below investment grade, and instead investments in sovereign bonds would be increased.

166. The NBB is encouraged to further expand its set of regular macroprudential stress tests for insurance companies. Scenarios should incorporate a multi-period perspective, considering potential feedback loops and changes in policyholder behavior under stress. Companies' assumptions about potential shifts in the asset allocation should feed into the NBB's cross-sectoral macroprudential analysis, as in exceptionally adverse situations divestments by the insurance sector in certain asset classes could increase funding cost for the public or the banking sector. Stress test results should also be used to further strengthen microprudential supervision, challenging companies' Own Risk and Solvency Assessment (ORSA) and underlying projections for future business, specifically the expectations for premium growth and investment returns. As an intermediate step, it is recommended that the NBB undertakes horizontal analyses of companies' business plans and growth forecasts.

167. Furthermore, the NBB is recommended to set up a comprehensive monitoring framework for the risks arising from mortgage lending by insurers. Given the unusually high exposure of the sector towards real estate, the NBB should regularly analyze risk parameters of the loan portfolio, e.g., based on loan-to-value and debt-service-to-income ratios. Specifically, the potential for regulatory arbitrage between banks and insurers within a financial conglomerate should be duly explored. Should the NBB consider that the Solvency II Standard Formula does not adequately capture the risk profile of a company, e.g., due to large holdings in mortgage loans or due to a high concentration of the sovereign bond portfolio, the need for a Pillar 2 capital add-on should be assessed.

168. The NBB should continue the close monitoring of the use and impact of LTG measures, in particular the volatility adjustment. As EIOPA's calibration of the VA is currently not specifically tailored to the typical portfolio of Belgian insurers, changes in the VA might show atypical effects in the Belgian market. Against this background, the NBB should regularly assess the sensitivity of insurers' liability valuations and solvency positions to changes in the level of the VA, and monitor whether and how insurers are adjusting their portfolios in response to any perceived malfunctioning of the VA.

Appendix I. Risk Assessment Matrix (RAM)

Source of risk	Overall Level of Concern	
	Likelihood of severe realization in 1–3 years	**Expected impact on financial stability**
Sudden increase in global risk aversion.	***Low*** • Repricing in global fixed income markets triggered by an abrupt decompression of asset risk premia amplified by low secondary market liquidity, interacted with the reemergence of financial stress in the euro area. • Over the past few years, there has been a gradual reduction in market depth of some bond markets, with short-lived episodes of significant market corrections.	***Medium*** • This would lead to a sizeable pick-up in money market rates, a steepening of the yield curve, reductions in market liquidity, and broad-based financial market dislocation, leading to mounting losses in fair value instruments and pushing up funding costs. • Belgian banks' ability to issue debt securities in wholesale markets would be hampered by market disruptions exacerbating liquidity risk.
A large correction in the Belgian real estate market.	***Low*** • After picking up strongly in 2015, housing price increases slowed down in Belgium in 2016. Overvaluation estimates have stabilized at around 8 percent. • Although Belgian commercial property prices have been less buoyant than in other European countries, exposures to the construction and real estate sector have grown dynamically over the last decade with 10 percent of the loans granted to Belgian regulated real estate investment companies (REITS).	***High*** • A fall in real estate prices, would lead to higher impairment charges affecting primarily highly leveraged households given the relatively high share of risky mortgage loans in Belgium. Thus, a broader deterioration in credit risk would materialize. Insurers hold sizable mortgage loan portfolios compared to EU peers, amounting to almost 10 percent of assets. • The extension of the macroprudential measure to add a 5pp risk weight add-on for real estate mortgages by IRB banks has increased Belgian banks' capacity to absorb losses.
Reassessment of regional sovereign risk.	***Low*** • Financial stress in the euro area could re-emerge triggered by political uncertainty, faltering reforms, or confidence shocks over debt sustainability concerns.	***High*** • Re-emerging sovereign debt sustainability concerns would push down securities' market valuation, weaken banks' and insurers' balance sheets and worsen banks' funding costs. • Albeit the size of the sovereign bond portfolio has remained broadly stable, its relative importance in the fixed income securities portfolio of banks has increased to about 75 percent in 2016, while insurers hold nearly 60 percent of their assets in sovereign bonds.

Source of risk	Overall Level of Concern	
	Likelihood of severe realization in 1–3 years	**Expected impact on financial stability**
A prolonged period of low growth and low interest rates in the EA	***Medium*** • This could be driven inter alia, by i a retreat from cross-border integration, and ripple effects from Brexit. • Low nominal growth would impact Belgium through falls in export demand, financial linkages, and confidence effects.	***Medium*** • Low credit growth and low lending rates would adversely affect bank earnings through a compression of net interest income. Borrowers' creditworthiness would also be affected, leading to greater than expected defaults, write-offs, and loan impairment charges. • The adverse effect on net income could be amplified by large currency fluctuations in geographies material to large Belgian internationally active banks. • While insurers have partially shifted away from guaranteed life business and improved their ALM, low yields still weigh heavy on profitability.

Appendix II. Estimating Volatility Risk

We compute volatility in equity markets as a measure of realized volatility. We replicate the analysis of Garman and Klass (1980) and construct an efficient estimator of market volatility. We compute realized volatility as a 20-day period moving average on three equity indexes: EURSTOXX 50, BEL-20, and S&P 100, relevant for Belgian banks.

Consider the following notation: σ^2 = variance of price change, C_0 = previous closing price, C_1 = current closing price, O_1 = current opening price, H_1 = current highest price, L_1 = current lowest price, and f = fraction of the day that trading is closed. A classical estimation procedure of realized volatility focuses on changes to the closing price as follows:

$$\hat{\sigma}_0^2 = (C_1 - C_0)^2$$

This estimator ignores information provided by the opening price. By including the opening price in the estimation procedure the variance of the volatility estimate can be halved:

$$\hat{\sigma}_1^2 = \frac{(O_1 - C_0)^2}{2f} + \frac{(C_1 - O_1)^2}{2(1-f)}$$

Readings of high and low prices during the trading day convey more information regarding volatility than open and close prices do. Using normalized prices: $u = H_1 - O_1$, $d = L_1 - O_1$ and $c = C_1 - O_1$, Garman and Klass (1980) show that the best scale invariant estimator of price volatility under uninterrupted trading in the stock exchange is given by:

$$\hat{\sigma}_2^2 = 0.511(u-d)^2 - 0.019[c(u+d) - 2ud] - 0.383c^2$$

Yet trading hours of the S&P index are confined to 9.30h through 16.00h. This yields a fraction of market trading of 0.27. Nevertheless, significant volatility may realize in extended trading operations.[1] Under intermittent trading, the most efficient estimator is yielded by the composite ratio:

$$\hat{\sigma}_3^2 = 0.12\frac{(O_1 - C_0)^2}{f} + 0.88\frac{\hat{\sigma}_2^2}{(1-f)}$$

[1] Witness the sharp drop of 5.5 percent in JPMorgan Chase shares following the announcement of a $2 billion trading loss released in the evening of May 10, 2012. Though the stock price had risen 0.3 percent in regular trading hours during the day, the news set the stage for a weak opening across US markets with the shares of JPMorgan Chase opening 8.8 lower than the last closing price on May 11.

Appendix III. Banking Sector Stress Testing Matrix (STeM)

A Banking Sector: Solvency Test			
Domain		**Framework**	
		TD by NBB	**TD by FSAP Team**
1. Institutional perimeter	Institutions included	Six major banks: Argenta, AXA Bank Belgium, Belfius Banque, BNP Paribas Fortis, ING Belgium, and KBC Group. The criteria used to determine the institutional perimeter include: firms' balance sheet, firms' share in the domestic market, and firms' role in the Belgian payment system.	
	Market share	About 90 percent of total banking sector assets.	
	Data	Effective date: December 2016. Data: Supervisory data. Scope of consolidation: Projection of consolidated ratios based on solo estimates.	Effective date: December 2016. Data: Supervisory data, including NBB's pre-2014 reports and ECB post-2014 ITS templates. Supervisory data was complemented with public sources including: bank Pillar 3 disclosures, Bloomberg, Dealogic, Haver Analytics, Moody's KMV, Fitch, International Financial Statistics (IFS), IMF Global Assumptions (GAS), and IMF WEO. Scope of consolidation: Consolidated group basis. Treatment of insurance activities: Insurance-generated dividends and commissions are recognized in financial conglomerates' income statement. Bank P&L projections incorporate the results of the insurance stress test through the impact of the upstreaming of dividends and fees and commissions on net income.
	Stress testing process	The NBB conducted its own TD macroprudential stress test based on the WEO forecast (baseline) and IMF's Global Macrofinancial Model with shocks to residential and commercial real estate prices estimated outside the framework (adverse). NBB used its own satellite models for credit risk projections and P&L impact.	The FSAP team conducted its own TD macroprudential stress test based on the WEO forecast (baseline) and IMF's Global Macrofinancial Model with shocks to residential and commercial real estate prices estimated outside the framework (adverse). For IRB exposures, a separate credit risk model was calibrated for five Basel asset classes, core industry sectors, and eleven material geographies for internationally active banks including Belgium, Bulgaria, Czech Republic, France, Hungary, Ireland, Luxembourg, Netherlands, Slovakia, Switzerland and Turkey. For STA exposures, stressed NPL ratios, stressed coverage ratios, and a stressed transition matrix for performing exposures is projected. For market risk, stress to all sovereign issuers to which Belgian banks are exposed is modeled. A corporate benchmark index is modeled separately. The TD stress test included an assessment of the impact from a 'low-for-long' environment and a sensitivity test of the mortgage portfolio.

<table>
<tr><th colspan="4">A Banking Sector: Solvency Test</th></tr>
<tr><th colspan="2" rowspan="2">Domain</th><th colspan="2">Framework</th></tr>
<tr><th>TD by NBB</th><th>TD by FSAP Team</th></tr>
<tr><td>2. Channels of risk propagation</td><td>Methodology</td><td>Risks in the Belgium portfolio were projected using a variety of models (based on borrowers' stressed financials), and macro models (based on stressed projections for key macroeconomic and financial variables).

The NBB modeled the impact of a sharp rise in wholesale and retail funding costs, and how the increase in funding costs is passed on to customers drawing on econometric work.</td><td>A comprehensive battery of econometric and structural models was specifically developed and calibrated for the 2018 Belgium FSAP.
For credit risk, over 55 credit risk models and around 500 econometric specifications were estimated for PDs based on bank-specific regressions, panel regressions, and dynamic equations.
Net trading income on equity positions, debt instruments, and trading derivatives was projected using a Bayesian VAR approach at the bank level.
Bank funding costs were linked to euribor benchmark rates and bank spreads separately for deposits and outstanding debt instruments based on past behavior of yields at issuance under stressed conditions. Funding costs were estimated using a Bayesian VAR approach at the bank level and by instrument (i.e., deposits, debt instruments).
Lending rates were linked to OLO benchmark rates for mortgages, bank commercial spreads over stressed funding costs, and macrofinancial conditions.
Mark-to-market losses from full revaluation of sovereign securities were projected for twenty-three issuers and a BAA corporate index, excluding shocks to portfolio hedges for interest rate risk.</td></tr>
<tr><td>3. Tail shocks</td><td>Scenario analysis</td><td colspan="2">The adverse scenario is calibrated using the IMF's Global Macrofinancial Model and auxiliary models to estimate stressed paths for residential and commercial real estate prices.
The calibration of the scenario follows a layer-of-shocks approach characterized by the simultaneous realization of exogeneous shocks and the endogenous structural response of the economy which amplifies the initial macrofinancial impact of shocks. The narrative of the scenario features the re-emergence of financial stress and sovereign default risk in the euro area economies (money market spreads rise by 125 bps and 10y Belgium government bond yields increase by 150 bps), the effect of a tightening of global financial conditions (long-term yields raise by an average of 100bps and equity prices fall by 20 percent in the EA, Japan, the U.K. and the U.S.), and an autonomous domestic demand driven contraction in Belgium triggered by sovereign risk concerns and large property market corrections (private investment and private consumption drop by 12 percent and 3 percent, respectively; real residential property prices and commercial real estate prices fall by 20 percent peak-to-trough).
To capture stress in material geographies for Belgian internationally active banks, the scenario includes a regional layer of shocks from de-globalization initiatives affecting particularly Germany and Central and Eastern European Economies material for Belgian internationally active banks.
This scenario constitutes a 3.1 standard deviation move in two-year cumulative real GDP growth rate by 2019, calculated over 1990–2016.
Belgium output falls 8.1 percent below baseline by 2019, while consumption price inflation falls 3.5 percentage points below baseline by 2020, and the unemployment rate rises 2.2 percentage points above by 2019. Within the euro area, the output loss is concentrated in high spread economies, which experience a fall of 9.1 percent below baseline, versus 7.2 percent in low spread economies at the low point in 2019. Despite fiscal consolidation, the government debt ratio rises 17.9 percentage points above baseline in Belgium by 2021, given lower nominal output and higher debt service costs.</td></tr>
</table>

A Banking Sector: Solvency Test			
Domain		Framework	
		TD by NBB	TD by FSAP Team
		The scenario includes an additional idiosyncratic and system-wide funding risk shock triggered by dislocation of money markets and linked to banks' spreads over benchmark under stress.	
	Sensitivity analysis		Shocks to Belgium residential house prices impacting stressed LGDs. Shocks to the euro swap curve. Shocks to FX rates. Low-for-long environment. Shocks to concentration risk to single obligors. Interest sensitivity gap of the ALM book under a range of market scenarios. IRRBB excluding derivatives from the repricing gap schedule.
4. Risks and buffers	Positions/risk factors assessed	Credit risk Estimated according to the national implementation of the CRD IV framework. Positions include retail exposures, corporate exposures, sovereign/public sector exposures, and exposures to financial institutions. Covered bonds and securitization exposures are included. Off-balance sheet exposures using baseline and stressed Credit Conversion Factors (CCFs) are included. Sovereign risk Mark-to-market valuation of securities (from shocks to interest rates and credit spreads) in trading book and AFS/FVO linked to macro scenario. All sovereign issuers relevant for Belgian banks were included, namely Austria, Belgium, Bulgaria, Canada, Czech Rep., Germany, Spain, Finland, France, Hungary, Iceland, Ireland, Italy, Japana, Latvia, Lithuania, Luxembourg, Netherlands, Portugal, Slovak Rep, Slovenia, Singapore, and United States. Market risk other than sovereign risk Market stress from shocks to changes in interest rates, exchange rates, credit spreads, commodities, and equity prices. Profits For Belgian financial conglomerates, stressed revenues from insurance activities under the stress test of the insurance sector are projected. Net trading income from equity positions, debt instruments, and trading derivatives. Income from loans and non-loan activities. Interest income declines for the amount of lost income from defaulted loans. Interest income from non-defaulting loans is estimated according to satellite models. Interest expenses increase due to rising funding costs linked to the macroeconomic scenario with empirically estimated pass-through, and add-on funding stress from a market event with no pass-through to lending rates. Net fee and commission income and other income evolve with macroeconomic conditions and banks' balance sheets. No change in business models (no rebalancing of portfolio). Business models and balance sheets evolve over the stress horizon according to the scenario. Regulatory impact The effects of the phase-out of no-longer-eligible additional Tier 1 and Tier 2 capital are included. No conversion of additional Tier 1 capital is assumed during the stress horizon.	

A Banking Sector: Solvency Test			
Domain		Framework	
		TD by NBB	TD by FSAP Team
	Behavioral adjustments	Dynamic balance sheets Credit supply effects are disallowed to calibrate credit risk projections. Balance sheets evolve with key macroeconomic aggregates adjusting for credit demand effects. EAD under stress from off-balance sheet exposures increases about 5-10 percent on average, reflecting higher use of undrawn credit and liquidity facilities. As a conservative assumption, all facilities are assumed to be contractually irrevocable ("committed") to extend funds in the future. Maturing assets are replaced by exposures of the same type and risk. Dividends are linked to banks' net profits. Under positive profits, the dividend payout floor is set at 30 percent subject to dividend restrictions if banks breach their capital conservation buffer. If profits exceed 50 percent of profits at the reference date, the dividend payout ratio is set at 50 percent. If banks are making losses no dividend payout is assumed. The effective tax rate evolves with the macro scenario. Losses are recognized in the same year that a shock hits. If banks' capital ratio falls below regulatory minimum during the stress test horizon, no prompt corrective action is assumed.	
5. Regulatory and market-based standards and parameters	Calibration of risk parameters	Credit risk projections are based on loan loss provision ratios and non-performing exposures.	Parameter definition Point-in-time (PiT) PDs and LGDs for expected losses (P&L impact) and stressed regulatory PDs and LGDs on non-defaulted exposures for regulatory capital requirements (RWAs). Estimated non-defaulted PDs by Basel asset class and material geography. Non-defaulted LGDs calculated post-credit risk mitigation by Basel asset class based on ECB's generator engine (scenario analysis), and add-on adjustments for mortgages (sensitivity analysis). Parameter calibration For IRB exposures, shifts to PDs are informed by shocks to credit risk losses based on Moody's EDFs rates (non-mortgage portfolios), and credit register data (mortgage portfolio). PDs and LGDs evolve with the macroeconomic and financial variables of the scenario. For STA exposures, inflows into NPL categories are based on bank-specific and regression estimates based on supervisory data merging pre-2014 NBB supervisory reporting and post-2014 ECB ITS templates, including risk migration for performing exposures, and stressed coverage ratios.
	Regulatory standards	Capital definition according to Belgium implementation of CRD IV rulebook, including CET1, Tier 1, and total CAR. Capital components that are no longer eligible for additional Tier 1 and Tier 2 capital components follow CRR's transitional path.	

A Banking Sector: Solvency Test			
Domain		Framework	
		TD by NBB	TD by FSAP Team
		CET1/Tier 1/CAR ratio hurdle rate at 6.0/7.5/9.5 percent of RWAs for regulatory minimum capital of the Big-4 Belgian banks (including the O-SII fully implemented capital surcharge), and at 5.25/6.75/8.75 percent of RWAs for regulatory minimum capital of the other two O-SII Belgian banks with an additional 2.5 percent hurdle rate for the capital buffer breach. Leverage ratio (3 percent hurdle rate met with Tier 1 capital) using the Belgian implementation of CRD IV.	
6. Reporting format for results	Output presentation	Evolution of CET1, Tier 1, CAR, and leverage ratio, for the aggregate banking system. Contribution of key drivers to aggregate net profits and aggregate CET1 capital ratios. Number of banks and share of total assets below hurdle rates. Capital shortfall in terms of nominal GDP.	

Liquidity Stress Testing Matrix		
Domain		**Conducted with NBB**
1. Institutional perimeter	Institutions	All Belgian banking institutions for the LCR-based test including seven SIs, two significant subsidiaries of EU SIs, ten core LSIs, ten other LSIs, and four subsidiaries of EU SIs with presence in Belgium. Dexia is excluded as a run-off vehicle. All eight Belgian SIs for the cash-flow based test.
	Market share	Between 95 and 100 percent of banking sector total assets.
	Data and base date	Based on granular supervisory data. The contractual based tests are based on supervisory data as of June 30, 2017. The cash-flow liquidity stress tests are based June 30, 2017 except for the two significant subsidiaries of EU STs based on end-2016 data.
2. Channels of risk propagation	Methodology	Basel III measures of liquidity risk—the LCR conducted on four calibrated scenarios. Two implied cash flow tests under six alternative scenarios. Evolution and drivers of asset encumbrance ratio.
3. Risks and buffers	Risks	Funding risk, rollover risk, market liquidity risk, and liquidity risk related to systemic events, idiosyncratic risks, and margin requirements related to cash collateral for derivative positions, and government bonds for repo operations.
	Buffers	HQLA securities assessed at market values net of haircut on a security-by-security basis.
4. Tail shocks	Size of the shock	<u>Four separate scenarios for LCR-based tests:</u> • LCR Scenario under standard assumptions calibrated by BCBS. • A systemic stress scenario which applies lower market values and higher haircuts to HQLA assets and impact some net outflows (higher drawn on liquidity lines; reduced inflows from financial counterparts). • An idiosyncratic stress scenario which applies higher run-off rates to unsecured funding (with 10 percent run-off rates for stable deposits), and lower inflow rates. • A combined stress scenario of systemic and idiosyncratic risks which takes the most stressed haircuts/run-off rates from the previous scenarios (an LCR "Belgium wholesale stress" scenario). This scenario sums up the most severe manifestations of liquidity stress observed during the global financial crisis. It is characterized by: (i) a freeze of wholesale funding on the interbank market, secured funding market via repo and covered bonds, and the commercial paper market (with run-off rate for operational deposits of 75 percent and for not-fully covered corporate deposits of 100 percent), and (ii) liquidity risk from sizeable margin calls related to secured funding, derivatives and foreign currency funding due to market liquidity shocks, derivative assignments, and unwinds and disruptions in the FX swap market (with rollover of secured funding backed by other than Level 1 and Level 2A assets of up to 0 percent).

Liquidity Stress Testing Matrix

Domain		Conducted with NBB
		<u>Six separate scenarios for Implied cash-flow based tests.</u> They simulate a range of stress factors over eighteen maturity buckets ranging from one-day through twelve months (cumulative).: • S0: baseline. • S1: Contractual: excludes modeling adjustments to non-maturity assets and liabilities. • S2: Macroeconomic: includes lower inflows from debt issuance and monies due; incorporate higher haircuts on banks' counterbalancing capacity. • S3: Idiosyncratic: higher run-off rates to liabilities, including 10 percent run-off rates for stable deposits and 30 percent for other deposits. • S4: Idiosyncratic (no inflows): excludes most contractual inflows except for central banks and derivative receivables. S5: Combined scenario including S2 and S3 assumptions.
5. Regulatory standards	Regulatory standards	Counterbalancing capacity above net cash outflows under stress scenario. CRD IV full implementation for the LCR ratio at 100 percent.
6. Reporting format for results	Output presentation	Changes in average liquidity position and counterbalancing capacity for each scenario. Distribution of banks' liquidity position for each scenario. Number of banks with counterbalancing capacity below net cash outflows. Banks' post-shock net liquidity position. Liquidity shortfall in terms of banking system total liabilities.

Domain		Assumptions	
		Bottom-Up by Insurance Undertakings	Top-Down by IMF
INSURANCE SECTOR: SOLVENCY RISK			
1. Institutional perimeter	Institutions included	• 8 composite insurers.	• 8 composite insurers.
	Market share	• 78 percent of total balance sheet assets.	• 78 percent of total balance sheet assets.
	Data	• Regulatory reporting.	• Regulatory reporting.
	Reference date	• December 31, 2016.	• December 31, 2016.
2. Channels of risk propagation	Methodology	• Investment assets: market value changes after price shocks, affecting the solvency position. • Sensitivity analysis: effect on available capital and solvency position.	• Investment assets: market value changes after price shocks, affecting the solvency position.
	Time horizon	• Instantaneous shock. • 3-year projection (only in the baseline and the adverse scenario).	• Instantaneous shock.
3. Tail shocks	Scenario analysis	• Adverse scenario: interest rates +50 bps (EUR, parallel shift up to a maturity of 20 years); sovereign bond spread +147 bps (Belgium), +50 bps for other low-yield euro area countries, +200 bps for high-yield euro area countries; stock prices -16.2 percent (advanced economies), -25 percent (emerging and developing economies); property prices -20 percent (Belgium), -15 percent (other countries); corporate bond spreads between +50 bps (AAA) and +300 bps (BB and lower), 5.7 percent depreciation of EUR against USD. • NBB "low-for-long" scenario: interest rate term structure (up to 20 years) at minimum of the last 2 years minus 15 bps, beyond 20 years extrapolation towards an ultimate forward rate of 2.0 percent (instead of 4.2 percent as prescribed by Solvency II).	• Adverse scenario: interest rates +50 bps (EUR, parallel shift up to a maturity of 20 years); sovereign bond spread +147 bps (Belgium), +50 bps for other low-yield euro area countries, +200 bps for high-yield euro area countries; stock prices -16.2 percent (advanced economies), -25 percent (emerging and developing economies); property prices -20 percent (Belgium), -15 percent (other countries); corporate bond spreads between +50 bps (AAA) and +300 bps (BB and lower); 2 percent haircut on mortgage loan portfolio; 5.7 percent depreciation of EUR against USD.
	Sensitivity analysis	• Longevity shock: permanent 20 percent decline in mortality rates. • Mortality shock: permanent 15 increase in mortality rates. • Pandemic event: temporary 35 percent increase in disability/morbidity rates, temporary 10 percent increase in mortality rates.	• Variations of the interest rate term structure. • Default of largest financial counterparty.

Domain		Assumptions	
		Bottom-Up by Insurance Undertakings	Top-Down by IMF
		• Catastrophic events: (1) Windstorm Lothar (December 1999) (2), Windstorm Xynthia (February/March 2010).	
4. Risks and buffers	Risks/factors assessed	• Market risks: interest rates, share prices, property prices, FX rates, credit spreads. • Credit risks: default in mortgage loans. • Underwriting risks: longevity, mortality, pandemic event, catastrophic events. • Summation of risks, no diversification effects.	• Market risks: interest rates, share prices, property prices, FX rates, credit spreads. • Credit risks: default in mortgage loans; default of largest financial counterparty. • Summation of risks, no diversification effects.
	Buffers	• Product-specific.	• None.
	Behavioral adjustments	• Management actions limited to non-discretionary rules in place at the reference date.	• None.
5. Regulatory standards and parameters	Regulatory/accounting standards	• Solvency II. • National GAAP.	• Solvency II. • National GAAP.
6. Reporting format for results	Output presentation	• Impact on solvency ratios (including and excluding the effect of long-term guarantee measures). • Impact on net income. • Contribution of individual shocks. • Dispersion measures of solvency ratios and net income.	• Impact on solvency ratios (including and excluding the effect of long-term guarantee measures). • Impact on net income. • Contribution of individual shocks. • Dispersion measures of solvency ratios and net income.