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July 2018

TECHNICAL NOTE—STRESS TESTING THE BANKING SECTOR

This Technical Note on Stress Testing the Banking Sector for the euro area was prepared by a staff team of the International Monetary Fund. It is based on the information available at the time it was completed in June 2018.

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June 29, 2018

TECHNICAL NOTE

STRESS TESTING THE BANKING SECTOR

Prepared By
Monetary and Capital Markets Department

This Technical Note was prepared in the context of an IMF Financial Sector Assessment Program (FSAP) in the euro area in November 2017 and March 2018 led by Daniel Hardy. It contains technical analysis and detailed information underpinning the FSAP findings and recommendations. Further information on the FSAP program can be found at http://www.imf.org/external/np/fsap/fssa.aspx

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Glossary

ABS	Asset Backed Securities
ABSPP	ABS purchase program
AE	Asset Encumbrance
AFS	Available for Sale
ALM	Asset Liability Management
BMA	Bayesian Model Averaging
BRRD	Bank Recovery and Resolution Directive
BU	Bottom-up (stress test)
CAR	Capital Adequacy Ratio
CB	Central bank
CBC	Counterbalancing Capacity
CBPP	Covered bonds purchase program
CCBC	Cumulative Counterbalancing Capacity
CCP	Central Clearing Counterparty
CCR	Counterparty Credit Risk
CCyB	Countercyclical Buffer
CDS	Credit default swap
CET1	Core Equity Tier 1
CFLST	Cash Flow based Liquidity Stress Test
CFR	Core Funding Ratio
CNFG	Cumulative Net Funding Gap
COREP	Common Reporting template
CQS	Credit Quality Step
CRD	Capital Requirements Directive (EU)
CRE	Commercial Real Estate
CRR	Capital Requirements Regulation (EU)
CSD	Central Securities Depositories
CSPP	Corporate sector purchase program
CVA	Credit Valuation Adjustment
DRSK	Bloomberg Credit Risk Function
EA	Euro Area
EaD	Exposure at Default
EBA	European Banking Authority
ECB	European Central Bank
EDF	Expected Default Frequency
EL	Expected Loss
ELA	Emergency Liquidity Assistance
ESRB	European Systemic Risk Board
EU	European Union
EUR	Euro

EVE	Economic Value of Equity
FINREP	Financial Reporting template
FSAP	Financial Sector Assessment Program
FSB	Financial Stability Board
FX	Foreign Exchange
GAS	Global Assumptions
GDP	Gross domestic product
GFC	Global Financial Crisis
G-SIBs	Global Systemically Important Banks
HC	Haircut
HFT	Held for Trading
HQLA	High Quality Liquid Assets
HTM	Held to Maturity
HY	High Yield
IFRS	International Financial Reporting Standards
IG	Investment Grade
IRB	Internal Ratings-Based Approach
IRRBB	Interest Rate Risk in the Banking Book
JST	Joint Supervisory Team
LCR	Liquidity Coverage Ratio
LGD	Loss Given Default
LIBOR	London Interbank Offered Rate
LT	Long-term
LTRO	Long-Term Refinancing Operations
LTV	Loan to Value Ratio
MIR	Monetary Interest Rates
NFG	Net Funding Gap
NII	Net Interest Income
NIM	Net Interest Margin
NPL	Nonperforming Loan
NSFR	Net Stable Funding Ratio
OCI	Other Comprehensive Income
O-SII	Other Systemically Important Institutions
OTC	Over-the-Counter
P&L	Profit and Loss
PD	Probability of default
PiT	Point-in-Time
PNFC	Private Non-Financial Corporation
PPNR	Pre-Provisioning Net Revenue
PSPP	Public-sector purchase program
PTB	Price-to-book ratio
QE	Quantitative Easing
RAM	Risk Assessment Matrix

RMBS	Residential Mortgage-Backed Securities
ROA	Return on Assets
ROE	Return on Equity
RWA	Risk-weighted Assets
SME	Small- and Medium-sized Enterprises
SSM	Single Supervisory Mechanism
ST	Short-Term
STA	Standardized Approach
STE	Short Term Exercise
STeM	Stress Test Matrix (for FSAP stress tests)
sVaR	Stressed Value at Risk
TA	Total Assets
TD	Top-down (stress test)
TED	Difference between interbank loan rate and T-bill rate
TLTRO	Targeted Long-Term Refinancing Operations
TTC	Through-the-Cycle
USD	United States Dollar
VAR	Vector Auto-regression
VIX	Volatility Index
WEO	World Economic Outlook
YTM	Yield to Maturity

EXECUTIVE SUMMARY

The FSAP team undertook a thorough top-down stress testing analysis using end-2017 data. This note covers the methodology and results of the scenario-based solvency tests, the single factor sensitivity tests, and the liquidity tests. The stress test exercise was carried out on a sample of major euro area banks supervised by the Single Supervisory Mechanism (SSM). The analysis is heavily dependent on comprehensive and granular supervisory data on individual banks' positions shared by the European Central Bank (ECB). While FSAP results are not directly comparable to the 2018 EU-wide stress test results due to differences in scenarios, methodologies, and objectives, they provide an assessment of the system-wide resilience of the euro area banking sector at the current juncture.

Overall the solvency of large euro area banks has improved, but important and heterogeneous vulnerabilities are exposed in stress scenarios. In the test, adverse conditions reduce the aggregate common equity tier 1 (CET1) ratio from 13.9 percent at the end of 2017 to a low point of 10.0 percent in 2020. Comparable results are obtained using alternative solvency metrics. Aggregate capital buffers are sizeable relative to immediate threats, but some banks are especially vulnerable to credit risk while others are more exposed to market risks from risk premia decompression, basis risk, and valuation shocks. Strains related to business risk from lower-than-expected volumes or interest margins are also relevant for some banks.

Results suggest that large, but less complex, internationally-active banks are more robust to a deterioration in economic and financial conditions. Banks that have succeeded in diversifying credit risk and income sources, and cut their exposure to complex securities are more equipped to absorb adverse macrofinancial conditions. Because G-SIBs' business models generally emphasize trading and capital markets-related activities, they are disproportionately affected by market and funding liquidity risks, especially in foreign currencies. In contrast, domestically-oriented banks are more vulnerable to deteriorations in domestic macroeconomic conditions, and in some instances, also to market-wide liquidity shocks.

The resilience of the system to liquidity shocks has increased in recent years, yet multiple banks may face liquidity challenges in extreme scenarios, assuming only marketable securities are available. The EuroSystem's extraordinary operations have changed the composition of banks liabilities and the structure of their counterbalancing capacity (CBC) by increasing banks' reliance on ECB support. At the same time, banks differ notably in terms of funding structures, dependence on foreign currency funding, asset encumbrance, and the amount and composition of CBC. Due to the G-SIBs' funding structure and trading activities, they are more vulnerable to market runs, but they generally have sufficient CBC to cope with funding liquidity shocks; at the same time some banks may face challenges in replacing central bank funding with market alternatives.

The analysis suggests that solvency and liquidity risk may feed on each other. Sensitivity tests show that an abrupt and sharp increase in rates can have a material impact on bank capital, as funding costs outpace the repricing of assets and valuation effects erode buffers, particularly when fair value hedges are ineffective. Banks that are more dependent on central bank refinancing operations and those with lower quality collateral are most at risk of facing higher funding costs. Solvency-funding loops are exacerbated by non-linear interactions among credit, liquidity, and market shocks. Funding outflows triggered by solvency concerns are likely to result in some banks breaching their capital requirements and facing negative CBC positions.

The ECB's stress testing analytical framework—already very sophisticated—could be enhanced along several dimensions. Further integrating supervisory data, especially related to market risk and cash flow based liquidity risks, into the existing stress testing infrastructure would facilitate higher frequency and more comprehensive risk monitoring. The analysis of risk interactions could also be deepened to examine their role in aggravating systemic risk. To the extent that the failure of a significant subsidiary could cause major disruption of the euro area financial system, and that sufficient granular supervisory data is available, ECB's macroprudential stress testing framework should be expanded to include them.

The initiative to collect cash-flow data for all significant currencies is a welcome step; more data are needed to monitor market, funding, and contingent liquidity risks. Cash flow data needs to be collected by significant jurisdictions to help supervisors monitor the availability and transferability of collateral. Stepping-up efforts on data collection on securities financing transactions and derivatives would enhance the monitoring and supervision of market and contingent liquidity risks, including those associated with the flow of collateral via central clearing counterparties (CCPs) and cyber risks.

Table 1. Euro Area: Main Recommendations on Stress Testing

Recommendations	Timing*
Solvency Stress Testing	
Make further use of supervisory data for stress testing, enhancing analysis, and feeding back into supervision	ST
Deepen analysis of banking group risks by extending the perimeter of macroprudential stress tests to cover systemic subsidiaries of EA significant institutions and significant investment firms.	MT
Continue enhancing the assessment of bank's risk interactions across various risk categories (i.e. credit risk, market risk, basis risk, liquidity risk).	MT
Liquidity Stress Testing	
Use cash-flow data for all significant currencies and significant jurisdictions to refine liquidity monitoring and stress testing	I
Enhance collection of data on, and analysis and supervision of contingent liquidity risks associated with the cross-border flow of collateral, securities funding transactions, and cyber risks	ST
* I (immediate) = within one year; ST (short term) = 1–2 years; MT (medium term) = 3–5 years	

INTRODUCTION[1]

A. A Complex Financial System

1. The euro area is home to a large, complex, and globally interconnected financial system. Of the thirty global systemically important banks (G-SIBs), seven are located in the euro area: BNP Paribas (FR), Deutsche Bank (DE), Credit Agricole (FR), ING (NL), Santander (ES), Societe General (FR), and UniCredit (IT). The interbank and cross-border connections of the euro area banking system are extensive, although they have contracted since the global crisis.

2. Euro area banks represent around two-thirds of total banking system assets in Europe. Banks are the most important financial intermediaries for households, nonfinancial corporates (NFC), and the public sector. Since the global financial crisis, nonbanks and financial markets are playing a greater role, particularly in funding larger nonfinancial firms.

3. In 2017, total assets of the euro area banking sector, including foreign subsidiaries and branches, stood at around €35 trillion on a consolidated basis. The financial crisis ended a period of strong growth in banking sector assets in many euro area countries. This adjustment occurred mainly through a reduction in business volumes and some progress in consolidation, particularly in countries more affected by the crisis. Large euro area banks have also become more selective in their international banking activities and have become more focused geographically in their core markets. In addition, banks have shifted towards safer and less complex assets, notwithstanding some legacy portfolios, and towards more stable funding sources.

B. Banking Sector Trends

4. Banks have benefited from a benign funding environment with stable or improving market access in recent years but this trend might reverse. Of the top euro area banks, the number of banks carrying a positive outlook outweighs the number of negative outlooks on the back of improving economic fundamentals and balance sheet strengthening.[2] Yet, in some cases, banks' current outlook depends on further progress on profitability and reduction of nonperforming assets. Investors' perception of bank risk has lagged sovereigns although it remains more volatile than corporates.[3]

5. Euro area bank net interest margins have been resilient in recent years. This has been supported by accommodative financial conditions which have eased funding costs helping to offset falling interest income. However, the flat yield curve has enhanced banks' reliance on

[1] This Technical Note was prepared by Laura Valderrama and Mindaugas Leika (both Monetary and Capital Markets Department, IMF), and Stefan Schmitz (external consultant).

[2] S&P Global Ratings (2018), "The Top Trends Shaping Major European Banks in 2018", January.

[3] Moody's (2017), "Banks – Europe, 2018 Outlook", December.

commercial margins to secure interest income which might narrow due to heightened competition, including from nonbank sources.

6. **Although improving macroeconomic fundamentals should support headline income, performance might remain subdued for some banks.** While asset quality has generally improved and therefore loan impairment charges have been contained on aggregate, there is business risk associated with the management of legacy assets, nonperforming loan (NPL) strategies including NPL provisioning and write-offs, fluctuations in client flows, repricing of risk in financial markets, and ongoing restructuring costs in some banks.

C. Supervisory Stress Tests in the Euro Area

7. **The resilience of the euro area banking sector has recently been examined by the 2016 EBA stress test and the 2017 ECB Sensitivity Analysis of the Interest Rate Risk in the Banking Book (IRRBB).** Whereas the 2016 EBA stress test was a scenario-based stress test, the 2017 IRRBB sensitivity test focused on the impact of shocks to interest rates on banks' net interest income (NII) and economic value of equity (EVE). The 2016 EBA stress test found that the EU banking sector is resilient to shocks with a capital depletion of 380 bps on average. The 2017 IRRBB test concluded that while interest rate risk is adequately managed at most of the major banks, IRRBB is a risk difficult to assess given the reliance on modelling assumptions. Results point at the increasing trade-off between the NII and EVE approach.[4] EBA launched its 2018 EU-wide stress test on January 2018, and results are expected to be published by November 2018.

8. **While the top-down FSAP stress tests are complementary to the bottom-up stress tests coordinated by EBA, they differ in crucial ways (Box 1).** While both EBA and FSAP tests provide a quantitative assessment of banks' risk profiles across various risk categories for a large sample of large significant institutions. The approach of the EBA exercise is that of a constrained bottom-up stress test where banks are required to project the impact of the scenarios on their projected capital position and P&L but subject to strict constraints defined in the common methodology. By contrast, the FSAP stress test is a top-down exercise with projections generated by in-house models developed by the FSAP team. While the FSAP and EBA scenarios broadly share a consistent narrative of risks, the FSAP excludes conduct risk and other operational risks unlike the EBA test. They also differ with regard to the coverage of geographies and variables, and more importantly to the calibration of shocks. Comparing stress test results (once published) will provide an indication of sensitivities, non-linear effects, and interactions among risk factors.

[4] For most banks, the two metrics point in different directions. While a parallel upward shift across the yield curve will show an improvement in NII, most banks would suffer an EVE decline given the long duration of financial assets relative to liabilities.

Box 1. The 2018 EU-Wide Stress Test and the FSAP Solvency Stress Tests

The 2018 EU-wide stress test and the FSAP solvency stress tests share key similarities:

- Both adverse scenarios assume the materialization of systemic risks leading to a balance sheet recession in the euro area, with the FSAP scenario featuring long-lived shocks (U-shape) and the EBA scenario incorporating deep (V-shape) shocks. The implied real GDP growth rate in the euro area amounts to -1.6 percent (-2.2 percent) at year t+2 under the FSAP (EU-wide) stress test by 2019. While the recession is more pronounced under the EU-wide test, it's more protracted under the FSAP scenario with a -0.3 percent growth rate posted by 2020. Both tests include a traded risk scenario, with paths for financial variables linked to the macroeconomic scenario.
- Both tests incorporate a high degree of granularity to capture credit risk from domestic and foreign exposures, and valuation impact from sovereign exposures at the issuer level. Credit risk from exposures in 37 jurisdictions under IRB-A, IRB-F, and STA approaches are modeled separately to project loan impairment charges and capital requirements. All sovereign debt securities held in the 'held for trading', 'designated at fair value', and available for sale' are repriced at fair value covering all issuers.
- Both exercises exclude any management actions in response to the stress scenarios (e.g., portfolio rebalancing or liquidation of positions).

At the same time, the EBA and the FSAP stress tests differ in a number of ways:

- Stress testing approach: EBA uses a constrained balance sheet approach, with the SSM challenging banks' bottom-up submissions and synthesizing outputs of different supervisory models. The FSAP test is based on a top-down (TD) approach using in-house models. The two tests use different methodologies to calculate credit risk, market risk, pre-provisioning net revenue (PPNR), and RWA impact.
- Risk weighted assets (RWAs): While the EU-wide stress test is conducted on the assumption of a static balance sheet, the FSAP test assumes constrained balance sheets whereby credit demand declines relative to the baseline but supply effects are disallowed. It also includes foreign exchange (FX) shocks to foreign claims which drive loan dynamics, as well as a credit rating downgrades on standardized exposures which contribute to stressed capital requirements. While the FSAP test applies Point-in-Time (PiT) PD shifts to compute RWAs, EBA test uses Through-the-Cycle (TTC) PD shifts. Under the FSAP approach, capital requirements for market risk evolve with balance sheet assumptions rather than with stressed market risk factors.
- Interest rate risk: The FSAP stress test conducted a granular assessment of interest rate risk using SSM's IRRBB data templates. Shocks to funding costs and lending rates were calibrated at the bank and portfolio level linked to the scenario and informed by statistical analysis to project idiosyncratic risk. The EBA approach allows banks to project net interest income which is constrained by a series of caps and floors laid out in EBA methodological note.
- Market risk: The FSAP test stressed the fair valuation on marked-to-market positions using SSM's market risk sensitivities ("greeks") reported under the STE. Hedges on trading positions were considered inefficient under stress on concerns over basis risk. EBA stress test incorporates a bottom-up (BU) detailed assessment of market risk at the portfolio level, including hedges, and covers counterparty credit risk (CCR) losses and stressed credit valuation adjustment (CVA).
- Risk coverage: By contrast with the FSAP stress test, the EBA stress test includes projections for conduct risk and other operational risks.
- IFRS 9: The EBA test assumes that for banks commencing to report under IFRS 9 in the first quarter of 2018, the impact of the introduction of IFRS 9 is included in starting point data as well as in the projections of banks. By contrast, the FSAP stress test uses the accounting regime valid at end-2017 to make credit risk projections.

D. Stress Testing in the FSAP

9. The FSAP team conducted a range of top-down stress tests to assess the euro area banking system ability to withstand system-wide shocks. The FSAP stress tests contribute to the objective of ensuring that banks have the capacity to absorb losses without engaging in deleveraging or amplification of market and liquidity stress. These tests were designed to identify macroprudential concerns and complement the bottom-up EBA exercise, which serves microprudential and supervisory purposes.

10. Stress test results should be interpreted with caution. The FSAP stress test results are based on end-2017 supervisory data. These data were complemented by supervisory historical data starting in September 2014 when the SSM was established. The FSAP team had to merge post-September 2014 SSM reporting templates with data sourced from publicly available sources as it did not have access to long series of supervisory data needed to conduct econometric work. Public data sources were also required to fill data gaps (e.g., portfolio composition of the trading book). 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 subject to caveats.

11. Additional challenges are posed by the use of proxy variables. 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 reduce duration. Probability of default (PD) projections for selected portfolios was based on econometric analysis conducted using Moody's expected default frequency (EDFs) series which tend to display greater volatility than regulatory PDs and are based on a corporate representative portfolio. Market risk projections were based on banks' market risk sensitivities to risk factors calculated on the value of net exposures after hedging, which limited the estimation of basis risk under stressed conditions.

12. A broader caveat is that stress test scenarios are calibrated using historical data which identify "tail events" based on a historical distribution. Yet it is well known that the nature of crises is to have unanticipated shocks and unexpected interrelationships where the past offers limited guidance. This is particularly relevant for the effect of a possible hard Brexit, the implementation of IFRS 9 and other regulatory changes, repricing risk due to basis risk and optionality, and liquidity risk associated to contingent liabilities (e.g., margin calls or pipeline risk). While some nonlinear effects can be captured in stress tests, it is always possible that unknown patterns emerge, especially if extreme shocks materialize.

E. Sample of Banks

13. The FSAP stress test is carried out on a sample of 28 (29) large euro area banks for the solvency (liquidity) test covering broadly 65 percent (70 percent) of banking system

assets.[5] The list of 28 (29) covered banks are headquartered in nine-euro area jurisdictions, and account for over 15 (16) trillion euros. The criteria chose are similar to EBA's criteria to select the sample of large banks participating in the EU-wide stress test (including coverage of around 70 percent of euro area banking system assets, and minimum size of 30 billion euros). The FSAP sample of banks for the solvency stress test covers around 85 percent of the 2018 EBA sample. Of the excluded banks relative to the 2018 EBA sample, three are German, two are French, and one of each is domiciled in Italy and the Netherlands.

14. The sample of banks include major euro area G-SIBs. The FSAP sample for solvency (liquidity) stress test includes six (seven) G-SIBS of the 30 G-SIBs identified by the FSB in November 2017. Banks are heterogeneous in terms of their size, business mix and international presence. Among the G-SIBs that are more internationally diversified, three remain focused mainly on lending activities while the others have a more balanced business mix, including capital market activities.

15. To track patterns, identify trends, and enable simple benchmarking, the 29 euro area banks were grouped into three broad categories. To find suitable peer groups of banks structurally similar across jurisdictions, a combination of quantitative decision rules (e.g., size, complexity, size of trading books, derivative instruments, foreign subsidiaries) and expert judgment was applied. Different business models were identified with three broad categories: G-SIBs, large, but less complex, internationally-active banks, and relatively smaller domestically-focused banks (Table 2).

[5] Due to data limitations, Credit Agricole had to be excluded from the final list of participating banks in the solvency test.

Table 2. Euro Area: Sample of Banks and Material Geographies

The sample of banks covered in the stress test are grouped into three broad categories for peer benchmarking.

G-SIB (7)			Large internationally active (10)			Smaller, more domestic-focused (12)		
Country	**Bank**	**Assets (billions of euros)**	**Country**	**Bank**	**Assets (billions of euros)**	**Country**	**Bank**	**Assets (billions of euros)**
FR	BNP Paribas	1,750	FR	Groupe BPCE	1,161	DE	DZ Bank	417
DE	Deutsche Bank	1,480	ES	BBVA	673	ES	CaixaBank	336
FR	Credit Agricole	1,402	FR	Credit Mutuel	664	DE	Baden-Württemberg	235
ES	Banco Santander	1,431	IT	Intesa Sanpaolo	648	ES	Banco de Sabadell	221
FR	Société Générale	1,138	NL	Rabobank	603	ES	BFA Tenedora de Acciones	218
IT	UniCredit	862	DE	Commerzbank	452	DE	Bayerische Landesbank	215
NL	ING	846	NL	ABN AMRO	390	DE	Norddeutsche Landesbank	168
			BE	KBC Group	260	IT	Banco BPM	161
			AT	Erste Group	220	BE	Belfius Banque	149
			AT	Raiffeisen Bank Int	135	FI	OP Financial Group	118
						IE	Bank of Ireland Group	106
						IE	Allied Irish Bank	90
	Sub-total	**8,910**		**Sub-total**	**5,207**		**Sub-total**	**2,433**

Note: Actual data end-2017. There is one G-SIB in FSB designated bucket 3 (2.0 percent capital surcharge), one G-SIB in bucket 2 (1.5 percent capital surcharge), and 4 G-SIB in bucket 1 (1.0 percent capital surcharge).

Material geographies for the sample of banks include nine home euro area countries, eleven other EU countries, and seventeen countries outside the EU.

37 Material geographies

Core EA (9)		Other EU (11)		Outside EU (17)	
Austria	AT	Bulgaria	BG	Australia	AU
Belgium	BE	Croatia	HR	Brazil	BR
Finland	FI	CzechRepublic	CZ	Canada	CA
France	FR	Hungary	HU	Chile	CH
Germany	DE	Luxembourg	LU	China	CN
Ireland	IE	Poland	PL	Colombia	CO
Italy	IT	Portugal	PT	Egypt	EG
Netherlands	NL	Romania	RO	India	IN
Spain	ES	Slovakia	SK	Japan	JP
		Sweden	SE	Mexico	MX
		United Kingdom	GB	New Zealand	NZ
				Peru	PE
				Russia	RU
				Singapore	SG
				Switzerland	CH
				Turkey	TR
				United States	US

Source: Banks' Pillar 3 disclosures, and IMF staff calculation.

F. FSAP Stress Testing Strategy

16. The resilience of the euro area banking system was assessed using a battery of stress tests. The assessment followed a two-pronged approach:

- *A battery of solvency stress tests including a fully-fledged scenario-based test, a range of sensitivity tests, and a targeted reverse stress test to assess the banking 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 wide range of sensitivity tests was conducted to further explore the resilience of the euro area banking system to wider shifts to risk factors. A reverse stress test on opaque complex assets assessed the valuation shock from soft mispricing required to exhaust capital buffers of G-SIBs.

- *A wide range of liquidity stress tests to assess bank resilience to structural and idiosyncratic liquidity risks which lead to sudden, sizable withdrawals of funding. The* analysis was based on: (i) structural liquidity analysis, that is, a Liquidity Coverage ratio (LCR), Net Stable Funding Ratio (NSFR), Asset Encumbrance, and funding concentration, and (ii) a cash-flow test applied under an array of alternative scenarios, simulating a range of stress factors over five-day, one- and three-months maturity buckets.

G. Banking Sector Risks

17. Financial vulnerabilities in the euro area remain significant,[6] though unevenly distributed across countries and segments of their financial systems:

- In certain euro area countries, households, nonfinancial firms, and government bear heavy debt burdens, making them vulnerable to a tightening of rollover conditions and limiting the buffers available to deal with contingencies.

- Global rising asset prices and compressed spreads are raising increasing concerns in the context of historically low market volatility and ultra-low "safe" interest rates. Some indications suggest that credit and market risks may be being downplayed, particularly in the high-yield fixed income market and possibly equity markets.[7] Residential real estate prices continue to rise, particularly in some regions.

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[6] Vulnerabilities are related to increasing exposures towards riskier segments (stretched borrowers), market risk from risk taking in financial markets, business risk from margin contraction and fluctuations in client revenue, and operational risk from litigation.

[7] Risky asset valuations appear overstretched across markets compared with historical norms, ranging from global equities and credit markets (including leveraged loans) to expanding crypto assets. See Global Financial Stability Report (2018), "A Bumpy Road Ahead," April, for an overview of key indicators substantiating this assessment.

18. The euro area banking system faces a possible confluence of external and domestic risk factors involving tighter financial conditions, a return to weaker growth, as well as policy and geopolitical uncertainties. These risks, which could be mutually reinforcing, are summarized in the Risk Assessment Matrix (RAM, Appendix I) and entail:

- Tighter global financial conditions: A reassessment of fundamentals amid global monetary policy normalization could trigger abrupt financial market movements, which may be amplified by a resurgence of concern over sovereign, bank, and corporate creditworthiness, with adverse knock-on effects to the real economy. Higher risk premia (including a possible decompression in term premia associated with an upside inflation surprise) and lower asset prices imply valuation losses and a reduction in the value of collateral and recoveries. Given vulnerabilities and other risk factors, distress in a single major institution or group of institutions could create contagious investor uncertainty.

- Weaker global growth: A relapse of growth in advanced economies or a significant slowdown in China and other larger emerging market countries could have a sustained negative impact on euro area exports, investment, and consumption, thereby bringing the recent growth surge to a halt. The impact on public and private debt sustainability may contribute to higher risk premia.

- Heightened policy and geopolitical uncertainty: Political and policy uncertainty—especially over Brexit negotiations—combined with a wide-scale retreat from cross-border integration, spurred on by rising protectionism, as well as geopolitical tail risks would reduce policy collaboration, dampen the flow of capital and liquidity across countries, increase risk aversion, and could abruptly undermine the cyclical recovery.

SOLVENCY STRESS TEST

A. Key Elements of the Stress Test

19. The IMF stress test was conducted on end-2017 data at the highest level of consolidation in the euro area. The perimeter of consolidation of the banking group is specified in CRD IV. While insurance activities were excluded, banking associates were included. To select the banks included in the exercise, a combination of criteria was used including the sample of banks covered in the 2018 EU-wide stress test, banks' share in the domestic market, and banks' role in the euro area payment system.

20. Stress tests were based on ECB confidential supervisory data post-June 2014. The ECB shared all supervisory data templates including EBA's Implementing Technical Standards (ITS) which cover FINREP and common reporting templates (COREP) as well as data gathered via the ECB's STE with detailed quarterly reporting on interest rate risk in the banking book and banks' elasticities to market risk factors. The composition of bank's debt securities portfolio was extracted from EBA's 2016 and 2017 transparency exercise, banks' annual reports, and Pillar 3 disclosures. Other public data sources included ECB's MIR statistics, financial data vendors (i.e. Bloomberg, Dealogic, Haver Analytics, Moody's KMV, Fitch), and IMF's World Economic Outlook (WEO).

21. The assessment criteria ("hurdle rate") includes the capital standards implemented via the Capital Requirements Regulation (CRR) and the phased-in buffers. The hurdle rate applied in the FSAP stress test was set at the CET1 regulatory minimum of a 4.5 percent Pillar 1 requirement, a fully-phased capital conservation buffer (CCB), and a phased-in buffer for G-SIBs and other systemically important institutions (O-SIIs). This led to a CET1 hurdle rate ranging between 7.0 and 7.5 percent. The hurdle rate also includes a 3 percent Tier 1 ratio based on the CRR leverage framework. Attention is also paid to other measures of soundness, such as headline income, own equity funds, and other regulatory capital definitions (i.e. Tier 1, total regulatory capital).

B. Scenarios

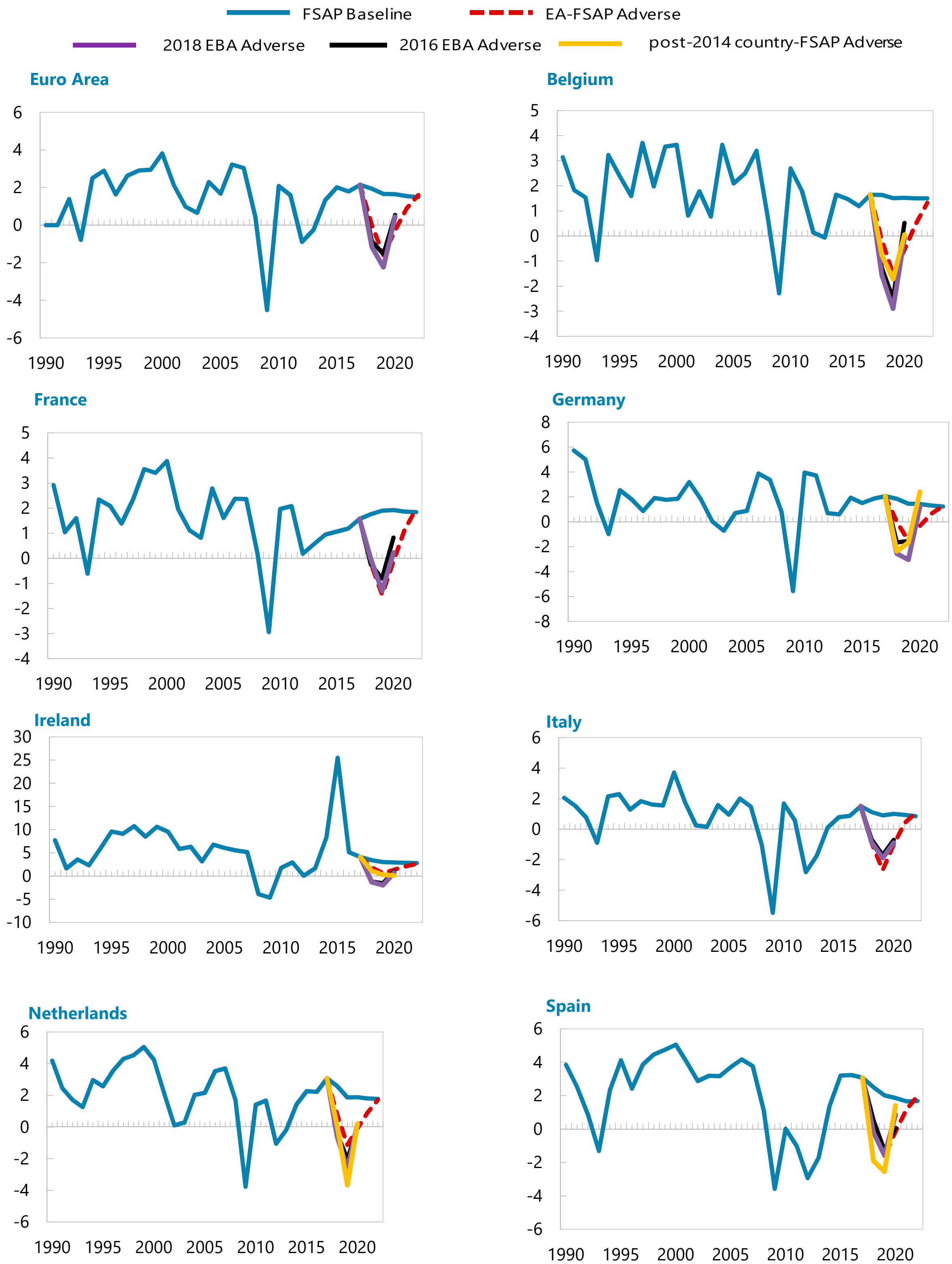
22. The scenario-based stress test included a baseline scenario and a stress scenario projected over a three-year horizon. The scenario starts in the first quarter of 2018 and extends through the fourth quarter of 2020 to enhance comparability with EU-wide stress test. The baseline scenario was based on the October 2017 WEO.

23. The adverse scenario was designed by the FSAP team in cooperation with the ECB to explore the impact of global and domestic risks on major euro area banks. The adverse scenario was simulated using IMF staff's Global Macrofinancial Model, a structural macroeconometric model of the world economy, disaggregated into forty national economies.[8]

24. The scenario covers the risk factors presented in the RAM, and the calibration of shocks is in line with tests undertaken as part of past euro area country FSAPs. Accordingly, the scenario incorporates a widespread growth slowdown; heightened uncertainty reflected in trade, productivity and investment shock; higher risk premia and money market rates; and valuation losses on real estate, equity, and other assets. The severity of the economic contraction in this scenario is comparable to those in other euro area country FSAPs and the authorities' EU-wide stress tests (Figure 1). The overall scenario is expected to have a strong effect on banks' profits and capital because it combines a macroeconomic recession with financial market tightening, when fiscal and monetary policy buffers are largely exhausted in the euro area.

[8] Vitek, F. (2015), Macrofinancial analysis in the world economy: A panel dynamic stochastic general equilibrium approach, *International Monetary Fund Working Paper*, 227.

Figure 1. Euro Area: Projected GDP Growth Rates Across Scenarios



Source: EBA, IMF, and IMF staff calculations.

Note: Selected euro area countries include the largest home jurisdictions for the sample of banks or those that have undertaken a recent IMF FSAP.

Macroeconomic Risk Components

25. The adverse scenario is characterized by a severe global recession in which the euro area experiences a balance sheet recession, concentrated in high-spread economies.[9] Overall, output contracts by 7.1 percent relative to the baseline by 2020, while consumer price inflation falls by 3.3 percentage points. This output loss is somewhat concentrated in high spread economies, which experience a contraction of 7.6 percent, versus 6.9 percent in low-spread economies. The assumed increases in bank funding costs in the form of higher money market interest rate spreads, together with higher credit loss rates, induce bank lending interest rate to increase, which in turn induce contractions in bank credit. Total employment falls by 5.9 percent in the euro area, the government debt ratio rises by 18.4 percentage points in high spread economies and by 13.3 percentage points in low spread.

26. Each scenario includes 370 core macrofinancial variables encompassing domestic and international economic activity. Projections include paths for core macrofinancial variables in all material geographies for large euro area banks. Core variables for each geography include growth, inflation, real investment, unemployment, policy rate, yield curve, equity prices, foreign exchange, credit growth, and residential real estate prices. Global assumptions include world GDP growth, growth in the euro area, growth in emerging markets, fuel prices, non-fuel prices, euro area swap curve, and credit spreads by major index.

Market Risk Components

27. The stress test scenario features financial market stress, amplified by heightened uncertainty and confidence losses. De-globalization initiatives in Europe and the United States limit or reverse international trade and financial integration, generating a sell-off in stock markets on profitability concerns and reduced risk appetite, with the real equity price falling by 20 percent in the euro area, United Kingdom, and United States over two years.[10] Elevated global capital market volatility widens money market spreads by 75 bps in the euro area, and by 50 bps in the United Kingdom and United States.

28. The impact of financial tightening conditions on bond yields is, on average, larger than that prescribed by the 2018 EU-wide stress test. Term premium decompression in Europe and the United States, together with the re-emergence of sovereign stress in high spread euro area economies, raises long term government bond yields, by 150 bps in high spread euro area economies, by 75 bps in low spread euro area economies, and by 100 bps in the United Kingdom and United States. While the re-emergence of public debt sustainability concerns leads to an increase in the level and dispersion of government bond yields in the 2018 EU-wide stress test, the impact of government yield shocks under the FSAP scenario is larger. This is consistent

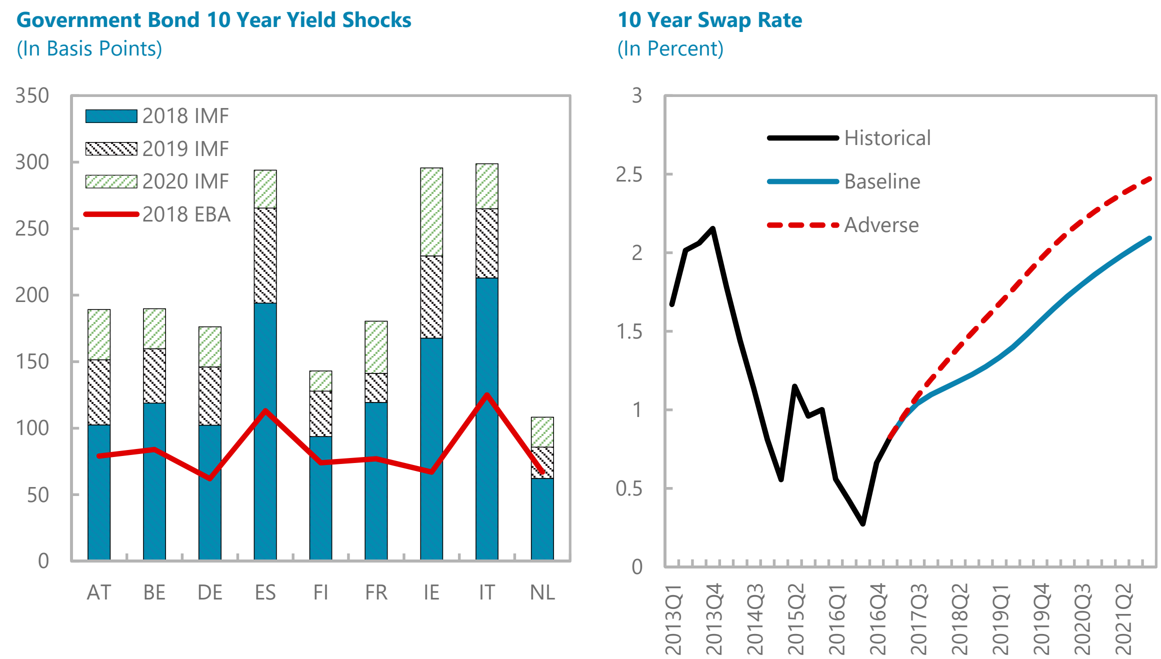
[9] The high-spread euro area economies are Greece, Italy, Portugal and Spain, while the low-spread euro area economies are Austria, Belgium, Finland, France, Germany, Ireland, and the Netherlands.

[10] Throughout, the assumed shocks are in addition to the endogenous movements in these variables.

with other FSAPs and is due to the cumulative nature of shocks in the FSAP test in contrast with the instantaneous shock approach under the 2018 EU-wide stress test (Figure 2).

Figure 2. Euro Area: Traded Risk Scenario

The adverse scenario features tightening financial conditions on government yields and euro swap rates.



Source: EBA, and IMF staff estimates. The bars in the LHS chart show IMF adverse projections over 2018–20.

29. The yield curve was constructed using polynomial interpolation methods. The yield curve for each of the covered public debt markets was built using the polynomial of the lowest possible degree between the projected short- and long-end of the curve. The euro are swap curve was spanned based on a constrained VAR forecasting approach using the exogenous path for the policy rate and benchmark curves in the euro area and the United States. A similar methodology was used to generate the projected paths for European iTraxx indices, as well as European corporate bond yields by sector (financial, non-financial) and rating (investment grade, high-yield) based on the exogenous path for policy rates and government spreads. Missing data on some geographies was estimated using benchmark data from comparator economies.

C. Credit Risk Modelling Approach

Relevance of Credit Risk

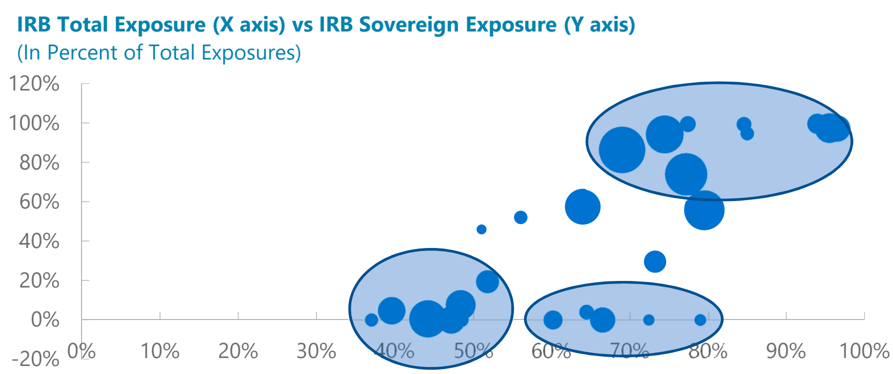
30. Credit risk accounts for the largest regulatory capital requirement of euro area banks. At end-2017, the size of the largest 28 banks reached €15.0 trillion, with RWAs of €5.6 trillion, representing around 37 percent risk density. Over 85 percent of capital is required to cover unexpected losses from credit risk. By contrast, market risk represents under 10 percent of capital requirements which partly reflects banks' reactions to new regulatory initiatives, including restrictions on proprietary trading by banks, as well as changes in business models.

31. 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 PD, and the loss-given default (LGD). For exposures under the STA approach, a deterioration in credit risk is reflected in higher specific and collective allowances from higher default rates and lower creditworthiness of performing loans, as well as in higher capital requirements from credit risk downgrades of the underlying exposures.

32. The reliance of euro area banks on IRB models varies across banks and portfolios. On aggregate, two-thirds of credit risk exposures were booked under the IRB approach, however, there is a wide dispersion of practices across banks and portfolios. There is a cluster of banks that shows greater reliance on standardized models for exposures to central banks and general governments than for other credit portfolios (Figure 3).[11]

Figure 3. Euro Area: Banks' Reliance on IRB Models for Credit Risk

On aggregate, two thirds of credit risk exposures are booked under the IRB approach, with wide variation across banks. Actual end-2017 data.



Note: The size of a bank's bubble is proportional to its total assets. Banks are clustered in three groups, circled in shaded circles, according to their relative reliance on IRB models to book sovereign exposures relative to other exposures.

[11] 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 zero percent. Until December 31, 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.

Credit Risk Model for IRB Exposures

33. The impact of the economic scenarios on risk parameters was conducted by country segment and exposure class. Overall, there are 37 material geographies for the sample of large euro area banks, including 9 home (headquarter) jurisdictions, 11 other EU countries, and 17 geographies outside the EU[12] (Table 2). Covered COREP exposure categories include seven portfolios including central governments or central banks, institutions, corporate—SME, corporate—specialized lending, corporate—other, retail—secured by real estate, retail—other. Other non-credit obligations assets and default fund contributions were treated as corporate—other. A separate credit risk model was estimated for each bank's material geography and regulatory portfolio.

34. To calculate expected losses and capital requirements (RWAs), the FSAP team projected its own stressed risk parameters using in-house internal models. Loan loss impairment charges are given by $EL_{i,t}^{j} = PD_{i,t}^{j} * LGD_{i,t}^{j} * EAD_{i,t}^{j}$ where *i* denotes the bank, *j* denotes the asset class, and *t* is the time dimension. Capital requirements $cap_{i,t}^{j}$ were calculated using the conditional expected loss laid out in Basel III's supervisory mapping function with asset correlations and maturity adjustments prescribed in CRR/CRD IV. PiT shifts were applied to regulatory PDs for non-defaulted exposures, and risk-weighted assets were defined as $RWA_{i,t}^{j} = 12.5 * cap_{i,t}^{j} * EAD_{i,t}^{j}$

35. Stressed projections were applied to around 10,000 initial credit risk parameters. The pool of parameters included four key risk parameters (PD, LGD, EaD, RWA) broken down by exposure class (7 portfolios), country (12 geographies), and bank (28 banks). Risk parameters assigned to the obligor pool by portfolio and geography in COREP 09.02 were complemented by worldwide parameters reported in COREP 08.02 according to banks' modeling approach (i.e. IRB-Foundation, IRB-Advanced), asset class (e.g. institutions, large corporates…), and obligor grade (internal rating scale). Obligor grades with an implied PD=1 were excluded. For credit exposures reported with geographic breakdown, the FSAP team subtracted the defaulted exposure from the original exposure and estimated implied non-defaulted PDs and LGDs. This process required making adjustments to address the fact that not all exposures are assigned to obligor grades or pools by obligor.[13]

36. Stressed credit risk parameters were applied to non-defaulted net exposures using regulatory parameters. The FSAP team applied stressed conditions to non-defaulted exposures. Although on aggregate, it did not compute an additional capital charge for defaulted assets to

[12] Projections include nine core euro area countries (i.e. Austria, Belgium, Finland, France, Germany, Ireland, Italy, Netherlands, and Spain); eleven other EU countries (i.e. Bulgaria, Croatia, Czech Republic, Hungary, Luxembourg, Poland, Portugal, Romania, Slovakia, Sweden, and the United Kingdom); and seventeen geographies outside the EU (i.e. Australia, Brazil, Canada, Chile, China, Colombia, Egypt, India, Japan, Mexico, New Zealand, Peru, Russia, Singapore, Switzerland, Turkey, and United States).

[13] 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.

cover systematic uncertainty in realized recovery rates for these exposures, it included an add-on capital surcharge on the value of the collateral for large defaulted portfolios.[14] Credit risk projections were applied to projected net exposures after credit risk mitigation techniques including SME-supporting factor.

37. The FSAP team used a two-step process to project stressed PDs:

- Based on the economic scenario, econometric methods were applied based on the historical relationship between economic and financial conditions and proxies on credit risk parameters for each aggregate portfolio and country of exposure;

- A statistical analysis was used to adjust bank-specific projections based on portfolio proxies at the aggregate level to banks' portfolios to capture the individual risk profile of underlying exposures, drawing on post-June 2014 supervisory data.[15]

38. The PD proxy for exposures to central governments was extracted from sovereign yields using a Merton-based approach.[16] The FSAP team used data from FINREP returns on the breakdown of financial assets by counterparty to back out banks' exposures to 'general governments' from the combined COREP category 'general governments or central banks'. It then applied a reduced-form structural model to extract PD estimates from the sovereign spreads projected in the scenario.[17] 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:

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

39. PDs for institutions, corporates (including specialized lending), and retail-unsecured were sourced from Moody's KMV using the one-year expected default EDF average estimate. The following categories were used: the financials group, the corporate group, the construction and real estate development group, and the consumer nondurables and services group. These categories were mapped to major COREP portfolios, i.e. institutions,[18]

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[14] This is equivalent to a forced discount of 20 percent over the downturn value of the collateral on foreclosed assets during the first year of the stress.

[15] A time series regression was specified to forecast bank-specific PDs using a combination of banks' Pillar 3 disclosures on PD bands and post-June 2014 supervisory data as the dependent variable and the projected series of aggregate PD proxies as the main driver.

[16] Note that an increase in sovereign issuer risk is reflected in higher loan loss impairment charges on HTM and AFS portfolios as well as in lower regulatory capital from marked-to-market valuations through other comprehensive income (OCI) for AFS portfolios.

[17] 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.

[18] 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 treated as exposures to general governments.

corporate (including SME and specialized lending), and retail unsecured (including qualifying revolving, and other than secured lending), respectively. For expected losses, the breakdown of loans and advances to non-financial corporations by NACE code in FINREP was mapped to Moody's sectoral (e.g., mining and quarrying was mapped to steel and metal products group).

40. To address the truncated nature of the default rate distribution, a logit transformation was applied before conducting the econometric analysis. This transformation addressed biases and ensures that the projected rate is contained within the 0-1 bound once the logit forward path is applied to the forecast.

41. Given the uncertainty associated to tail risk predictions, a robust econometric framework was implemented using a variety of approaches:

- A time series econometric technique using Newey-West HAC-robust standard errors to obtain consistent estimators when the error term is heteroskedastic, autocorrelated, or both, once the regressors are proved stationary;

- A quantile regression approach to address the concern that the drivers of the conditional mean might be different in the higher tail of the credit risk distribution. The distribution was divided in quartiles (four segments). Robustness of the results was checked using a distribution based on deciles (ten segments) to explore cliff-effects;

- A Bayesian Model Averaging (BMA) approach to address modeling uncertainty and the plausibility of different drivers of credit risk dynamics, using a Normal diffuse prior distribution.

42. Credit risk was linked to a set of local drivers, regional variables, and global factors. Arguably, credit risk, particularly for wholesale clients, is not only a country-specific type of risk but it is also driven by regional macroeconomic forces external to the country as well as by global funding conditions. To estimate credit risk, a statistical-type model was developed by country and portfolio level using the following set of drivers:

- *Local variables*: there are a number of possible economic forces that determine the risk profile of a portfolio including trends in real GDP, a GDP-based recession indicator (to capture non-linear effects), inflation, unemployment, the yield curve, the spread over swap rate, credit growth, equity prices, and real estate developments. Local drivers were forecasted for 37 geographies under baseline and adverse conditions;

- *Regional variables* to capture information about the state of the euro area and the growth outlook of emerging markets. Regional factors include GDP growth and inflation in the euro area and emerging economies, developments in the euro swap curve, 3-month euro repo rates, 3-month euro Libor, European corporate spreads, EMBIG spreads, Eurostoxx 50, and structural challenges from debt sustainability concerns (measured by sovereign debt spreads over the Bund);

- *Global financial market variables*: the ability of wholesale clients to repay also depends on the state of the global economy; in addition, shifts to global liquidity are likely to trigger default risk shocks. Global variables include world GDP growth, developments in commodity prices (fuel, non-fuel), changes in 3-month U.S. dollar Libor, TED spread, changes in U.S. investment-grade (IG) and high-yield (HY) corporate bond spreads, and U.S. equity prices.

43. Real house prices were projected using a long-run price and investment equations in an error correction framework.[19] The explanatory variables in the price equation (P_t) include real income (y_t), the stock of residential dwellings (s_t), and the real interest rate (r_t). Real house price indices were sourced from the OECD analytical house price database. Income was measured by real household disposable income. Interest rates are measured by the long-term real interest rate. The measure of new housing supply in the investment equation (I_t) was real residential investment defined as real gross fixed capital formation in dwellings (c_t) sourced from the OECD. The following system of equations is estimated for each euro area country:

$$P_t = \alpha_0 + \alpha_1 y_t + \alpha_2 s_t + \alpha_3 r_t + \xi_t^P$$
$$I_t = \beta_0 + \beta_1 c_{t-1} + \beta_2 P_{t-1} + \xi_t^I$$

44. From the initial set of determinants, the core set of drivers was chosen using a general-to-specific selection approach. For major portfolios, the final set of core determinants in the credit risk equations included: GDP growth, the slope of the yield curve, the 10-year government spread over the swap rate, the 3-month LIBOR-U.S. dollar spread over U.S. T-bill rate, real GDP growth in the euro area, and a dummy variable that takes the value of 1 if GDP growth is below its 15th percentile or negative, and zero otherwise; this dummy is multiplied by the size of the GDP shock. In addition, credit risk in real estate exposures was explained by real estate price developments, while credit risk equations for retail unsecured loans included credit growth projections. Credit risk in emerging markets was also explained by changes in inflation, FX developments, and EMBIG corporate spreads.

45. Regressions were run using different sample periods and lag structures. Regressions were run over two sample periods: a full sample to assess in-sample performance, and a truncated sample to assess out-of-sample performance.[20] Quarterly regressions included different lagged structures to test model performance.

46. Using time-series analysis, econometric results suggest that high-spread economies are particularly impacted by financial stress in the euro area. Annex Table 1 reports regressions for the PD corporate portfolio of a low-spread country where all the data is pooled in columns (1) through (3), while columns (4) through (6) report regressions based on the truncated sample. Corporate stress increases with low GDP growth, a steepening of the yield curve, and a

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[19] See Caldera, A., and Johansson, A. (2013), “The price responsiveness of housing supply in OECD countries’, Journal of Housing Economics 22, pp. 231–249.

[20] The full sample included quarterly data over 2005Q1 through 2016Q4 whereas the truncated sample was estimated over 2005Q1 through 2014Q4.

widening of money market spreads. Annex Table 2 show regressions for the corporate PD of a high-spread economy in columns (1) and (2), and another high-spread economy in columns (3) and (4). Results suggest that sovereign stress and the growth outlook in the euro area are relatively more significant.

47. Credit risk in emerging markets is also driven by rising long-term rates, foreign exchange shocks, and negative trend in regional growth. Annex Table 3 results suggest that stress in the corporate sector of a large emerging market is heightened with rising interest rates, a depreciation of the real relative to U.S. dollars, and lower GDP growth in emerging markets. This picture is consistent across the most relevant emerging markets for euro area banks including Brazil, Chile, China, Colombia, India, Mexico, Peru, Russia, and Turkey.

48. A quantile regression approach is used to project severe credit risk in the upper quantiles of the PD distribution. The empirical specification of the PD level of portfolio *j* in geography *i* is as follows:

$$PD_{\lambda,t}^{i,j} = Z_{t-1}^{i} \cdot \beta_{\lambda}^{i,j} + u_{\lambda,t}^{i,j}$$

where $Z_{t-1}^{i} \cdot$ is the set of lagged determinants including the country, regional, and global factors specified above, and $\lambda \cdot$ denotes the quantile of the conditional distribution.

49. Results suggest that credit risk projections are more severe using estimated coefficients from the upper quantiles of the PD distribution. Figure 4 presents a summary of quantile regression projections for corporate exposure PDs in a low-spread country under the adverse scenario. Credit risk increases from the 1.3 percent value observed in 2017 to a peak of 4.0 percent in 2019 conditional on the upper quantiles. This impact is softened to 1.8 percent at the lower quantiles.[21]

50. The quantile-based model identifies greater impact from sovereign stress and a cliff effects from GDP contraction in the upper tail of the distribution. Figure 4 reports the coefficients of credit risk determinants in the corporate portfolio of another low-spread country across quantiles. While the effect of GDP growth and the slope of the yield curve is comparable across percentiles, the effect of sovereign stress and the GDP-based recession indicator is more severe for higher PD grades.

51. A Bayesian VAR estimation (BVAR) analysis is applied to produce conditional forecasts based on the scenario. The model includes the country, regional, and global factors specified above. All the variables are endogenous except the global factors which are considered exogenous. The model relies on a normal-diffuse prior distribution. Projections were computed using the Bayesian estimation, analysis, and regression (BEAR) toolbox.[22]

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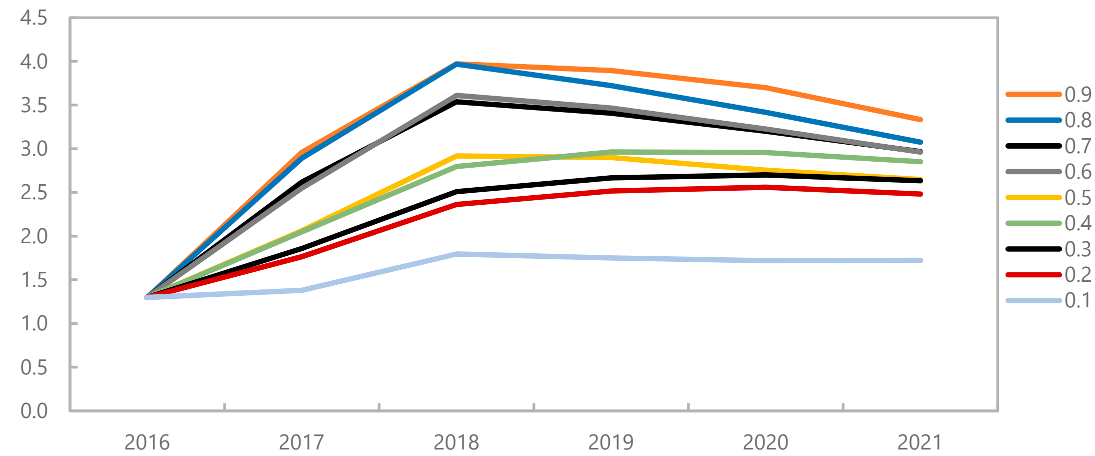
[21] PD projections using estimates from higher quantiles capture amplification effects under stressed conditions from adverse moves to determinants and higher elasticities to regressors.

[22] Developed by Dieppe, Legrand, and Van Roye (2016), ECB.

Figure 4. Euro Area: EDF Adverse Projections, Quantile Approach

Credit risk projections are more severe in the upper quantiles of the credit risk distribution.

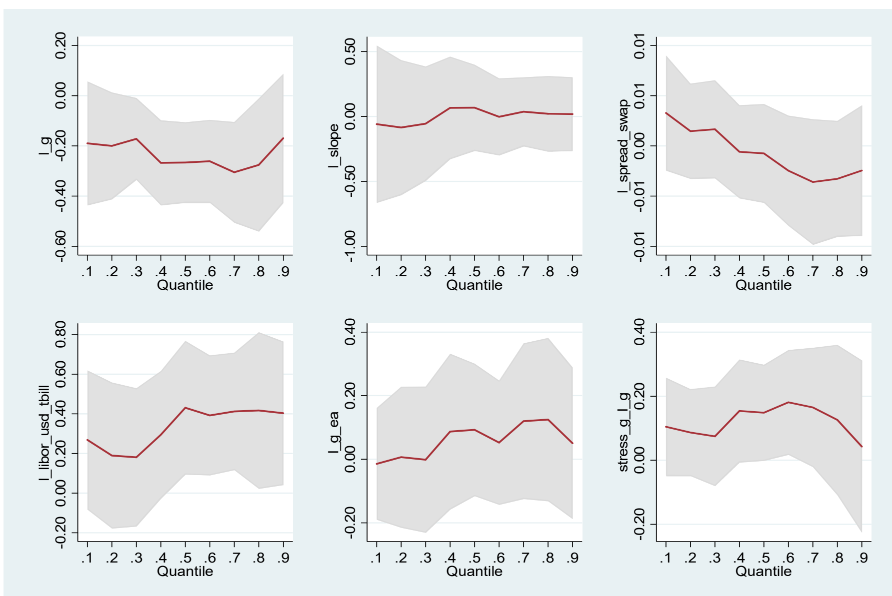
PD Corp Projections - Country 1
(Percent)



Source: IMF staff estimates. The chart shows PD quantile projections across deciles (0.1...0.9) for corporate exposures (Corp).

Sovereign stress and the GDP-based recession indicator dominate in the upper quantiles of the credit risk distribution.

PD Corp Determinants - Country 2
(Percent)



Source: IMF estimates. The panel shows the estimated coefficients across quantiles for lagged values of: GDP growth (l_g), the slope of the yield curve (l_slope), the spread of the 10-year sovereign yield over swap rate (l_spread_swap), the 3-month usd libor minus the 3-month US T-bill (l_libor_usd_tbill), GDP growth in the euro area (l_g_ea), and a dummy g | g<0 (stress_g_l_g).

52. **The BVAR approach suggests larger shifts to corporate PDs in the core relative to the periphery.** Figure 5 shows projections for the nine home euro area countries under the adverse scenario. Results suggest three clusters of PD shifts under stress: elevated impact in countries 1, 3, 6, and 9; moderate impact in countries 2, 5, and 8; and lower impact in countries 4 and 7. Projections were performed over a 5-year horizon to test the stability of the coefficients. These projections are, however, subject to wide confidence intervals in the outer years of the scenario.

53. **Final credit risk projections were based on a model selection routine which prioritized out-of-sample performance to avoid overfitting.** A combination of criteria was used to inform final projections using the following order: out-of-sample forecast performance, measured by the root mean squared error over the period 2015Q1–2016Q4; in-sample forecast performance for the overall period 2005Q1–2016Q4; goodness of fit of the regression; sign of coefficients according to theory; and expert judgment applied over the projected paths benchmarked against the 2008 financial crisis and the 2012 European sovereign debt crisis.

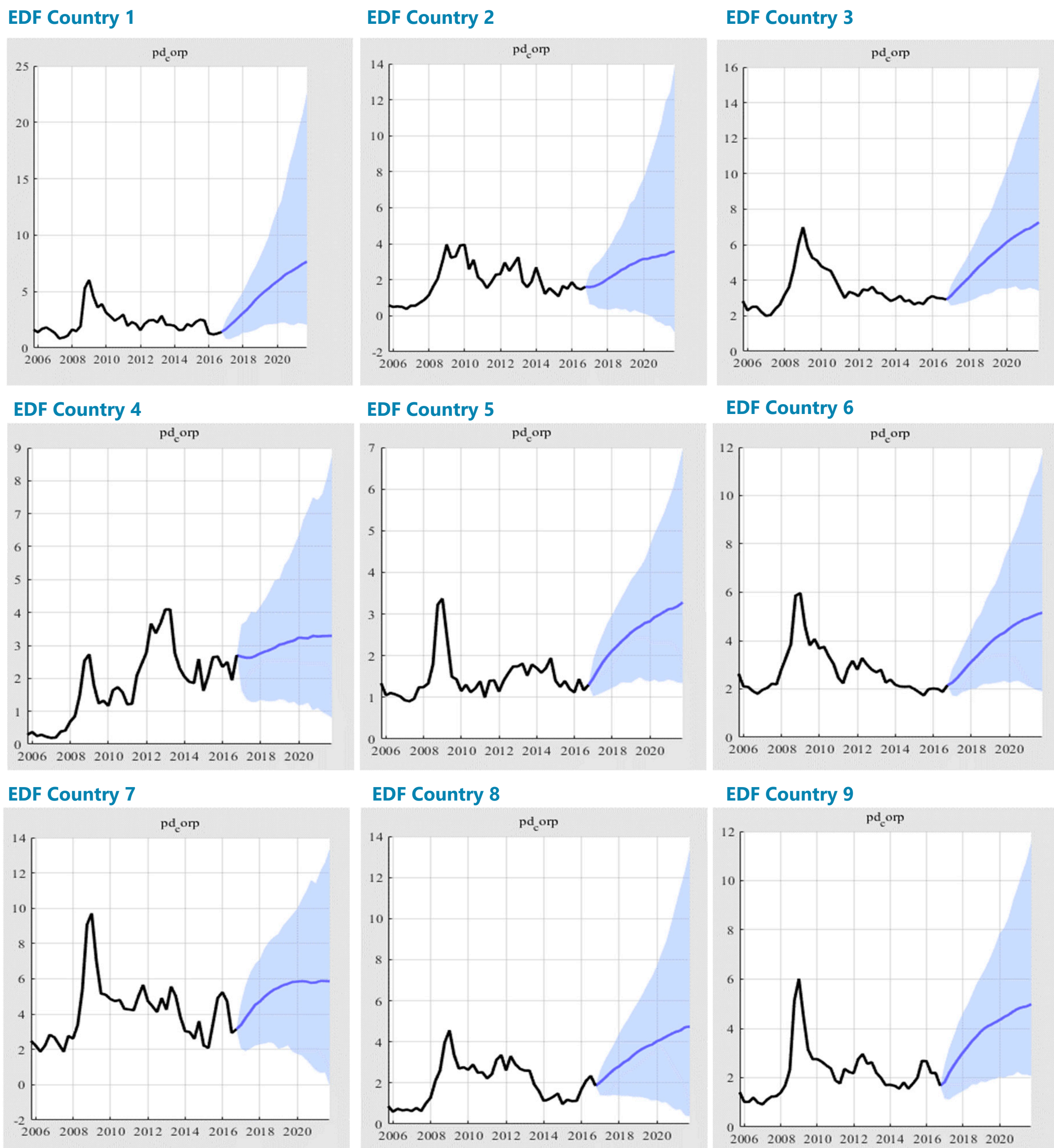
54. **Projections for credit risk in real estate were consistent with ECB staff's projections.**[23] The lack of a time series on default rates in retail mortgages motivated the use of the ratio of PD projections in mortgage loans relative to corporate PDs generated by ECB staff's modelling tool. This ratio was applied to the FSAP team's projected corporate PD paths to generate default rates on retail exposures secured by immovable property. LGD projections for loans collateralized by real estate were assumed not to decline under the baseline scenario despite the slight improvement in the outlook of real estate. The real estate correction assumed in the adverse scenario triggered an increase in LGD across geographies with the median LGD increasing by 50 percent relative to the starting point for residential real estate and 12 percent for commercial real estate.[24]

[23] By contrast to the ECB, the FSAP team did not have access to historical default rates on mortgage loans gathered via centralized collections coming from credit registers, to inform credit risk projections. ECB's modelling tool is presented in "STAMP€: Stress-Test Analytics for Macroprudential Purposes in the euro area," Chapter 4, 2017 (February).

[24] These projections mask some variation across countries related to their point in the business cycle and the exuberance in real estate markets. Countries with overheating real estate markets experience greater corrections and larger LGD impacts than countries where risks have abated by end-2017.

Figure 5. Euro Area: EDF Adverse Projections, Bayesian Modeling Averaging

(In Percent)



Source: IMF estimates. The panel shows the probability of default for corporate exposures (pd corp) by major country in the euro area.

55. Stressed LGD projections were informed by banks' reported projections on defaulted exposures and ECB staff's multipliers. LGD projections were derived using the ratio of LGDs on defaulted exposures over the LGD on non-defaulted exposures using bank supervisory data. They were also informed by aggregate shifts to LGDs provided by ECB staff broken down by portfolio and geography. The following approach was applied:

$$LGD_{i,t}^{c,j} = \max\left(\frac{LGD_{i,2017}^{c,j} \big| defaulted}{LGD_{i,2017}^{c,j} \big| non-defaulted}, multiplier_t^{c,j} \right) \cdot LGD_{i,2017}^{c,j} \big|$$

where $LGD_{i,t}^{c,j}$ is bank's *i* LGD for country *c*, portfolio *j* and time *t*, and *multiplier* is the credit risk benchmark provided by ECB staff calibrated to the FSAP scenario. The LGD for the non-defaulted portfolio was backed out from COREP 09.02 using information on the reported LGD for the aggregate portfolio and the LGD for defaulted exposures.

56. 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:

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

where *i* denotes the bank, *j* denotes the portfolio, *c* denotes the country of exposure, g_t^c is credit growth in country *c* (where demand effects are incorporated but supply effects are disallowed), f_i^c is the fraction of foreign currency loans, ΔFX_t^c is the depreciation of the foreign currency relative to the euro, $\left(1 - PD_{i,t-1}^{j}\right)$ represents the non-defaulted portfolio, $\Delta L_{i,t}^{j}$ is the shock to triggered credit lines and guarantees, and $UCL_{i,t-1}^{j}$ is the amount of undrawn guarantees. While paths for credit growth and FX shocks were generated by the scenario, stressed credit conversion factors on undrawn credit lines and guarantees were informed by historical behavior of off-balance sheet migration during stress periods drawing on banks' pillar 3 disclosures.

57. To compute capital requirements, 'hybrid' regulatory risk parameters were projected and applied to Basel III formula for IRB exposures. The regulatory credit risk parameters (PD, LGD, EaD) for banks' approved IRB models are typically "hybrid" estimates between 'pure PiT' and 'pure TTC' estimates, depending on each bank's methodological choice (model structure, method to calibrate on historical data, incorporation of time-varying 'central tendency'). The derivation of RWA expansion is dependent on stressed credit risk parameters, correlation assumptions, and effective maturity for each exposure. In line with the Basel III framework, RWAs were computed after applying the scaling factor of 1.06 to credit RWAs and using a 1.25 multiplier to the correlation parameter of all exposures to large regulated financial institutions and to all unregulated financial institutions. PiT shifts to PDs were used to feed stressed PDs into the IRB supervisory formula while LGDs were projected using a stressed recovery value on regulatory downturn LGDs.

Credit Risk Model for STA Exposures

58. The estimation of impairments and capital requirements for standardized exposures required the use of econometric analysis to estimate:

- the starting value of the risk parameters;
- the impact of the scenario on projected risk parameters;
- the computation of impairment flows and provisions;
- the impact on capital requirements based on credit rating assessments of claims.

59. Credit risk projections were applied to around 7,000 initial credit risk parameters. For each bank, a key segmentation is between defaulted and non-defaulted exposures. For each of these exposures, a further breakdown included the sixteen STA asset classes reported in COREP. These exposures were mapped to the seven portfolios constructed for IRB exposures: government (central government or central banks, regional governments, public sector entities, multilateral banks, and international institutions); institutions; corporate-SME, corporate-other (corporates excluding SME), retail unsecured (retail), retail secured (secured by mortgages on immovable property), and other exposures (items with high risk, covered bonds, claims with a short-term credit assessment, claims in the form of CIU, equity exposures, and other items). Credit risk parameters included credit risk adjustments (general and specific), exposures in default (by asset class), exposure value, and risk weights. Geographic coverage included all material geographies reported to EBA by each bank in the context of the 2016 EU-wide stress test.

60. Two approaches were used to construct the starting point for the default rate (PD) by portfolio and geography:

- *The default rate was calculated as the ratio of the stock of exposures in default to the amount of total exposures drawing on COREP 09.01.a. reporting*. To convert this stock-based metric into a flow-based measure, the accumulation of defaults over time was projected using a combination of statistical analysis using the flow of new defaults and write-offs reported in COREP 09.01.b by portfolio since 2014, and expert judgment based on individual banks' management of problem loans (drawing on information supplied by the ECB);
- *The 1-year expected default rate reported on IRB exposures for the same portfolio and geography was used drawing on COREP 09.02 reporting*. While this definition is a forward-looking measure rather than a realized measure, it has the advantage of being reported as a flow and therefore does not require additional assumptions on the flow of write-offs needed to project default rates and loan loss impairment charges.

61. The coverage ratio for defaulted exposures was floored at the LGD rate reported for the same portfolio under the IRB approach.[25] Banks report the general and specific provisions computed on defaulted exposures in COREP templates. This measure captures the eligible collateral and guarantees on defaulted claims in line with credit risk mitigation techniques. Under the adverse scenario, a 65 percent estimated coverage ratio was applied subject to the following constraint:[26]

$$LGD_t^{c,i} = \max\left\{ \max\left(\frac{general\ \ provision_t^{c,i} + specific\ \ provision_t^{c,i}}{\exp osure\ \ in\ default_t^{c,i}}, LGD_t^{c,i} \right) \cdot multiplier_t^{c,i}, 0.65 \right\}$$

62. To forecast the flow of exposures in default, the default rate was multiplied by the amount of performing exposures projected each period. General and specific credit risk adjustments were projected by multiplying the flow of new impairments by the stressed LGD by geography and portfolio. The flow of new impairments was projected using the same econometric approach applied to IRB exposures. In line with balance sheet assumptions for the IRB portfolio, the stock of performing exposures was driven by the growth of the loan book, structural FX risk in foreign exposures, triggered credit lines and guarantees, and the flow of new impairments.

63. Regulatory capital requirements were computed using three steps:

- The risk weight of exposures in default, excluding exposures at zero percent risk weight, was computed for each portfolio drawing on COREP 09.01.a;

- The risk weight on the new flow of exposures in default was computed as:

$$RW_t^{c,i} \middle| default = \max\left\{ RW_{2017}^{c,i} \middle| default, 100\% \right\}$$

- For the non-defaulted portfolio, one-notch downgrade of the underlying exposure was assumed under the adverse scenario.[27] The initial risk-weight density reported by banks for non-defaulted exposures in COREP 09.01.a was mapped to the external rating by portfolio laid out by Basel, and one-notch downgrade was added to calculate the projected risk-weight density.[28]

[25] This floor covers all exposure classes except claims on central government, central banks, regional governments, public sector entities, multilateral development banks, and international organizations which were floored at 40 percent.

[26] This ratio was calibrated using Basel findings on NPL coverage ratios during the global financial crisis.

[27] This is informed by the revised standardized approach for credit risk under Basel III which recommends assigning a risk weight at least one bucket higher than the risk weight determined by the external rating when the due diligence analysis reflects higher risk characteristics than that implied by the external rating bucket of the exposure (BIS, 2017). We expect this to hold under stressed conditions.

[28] This amounts to an average increase in the risk weight density for STA exposures of around 8 percent. See Basel Committee on Banking Supervision (2017), 'Basel III: Finalizing post-crisis reforms', December. Section 'Standardized approach for credit risk'.

Credit Risk Impact on Profit and Loss

64. **Starting regulatory risk parameters and point-in-time shifts were used to compute loan impairment charges.** Expected losses were calculated on all exposures including on-balance sheet and off-balance sheet exposures, taking into account migration of off-balance sheet commitments to on-balance sheet. Coverage included all asset classes for IRB and STA exposures reported in CRR. Initial credit risk parameters were those reported for regulatory purposes in COREP templates. Point-in-time shifts were informed by models calibrated on the scenario. These shifts were applied to banks' regulatory parameters to derive stressed expected losses and capital requirements.

65. **The IMF stress test allowed the draw-down of provisions built for non-defaulted exposures to cover expected loan losses over the stress test horizon.** The FSAP team constructed a measure of total provisions for non-defaulted exposures aggregating data on value adjustments and provisions on IRB exposures for obligor grades lower than 1, and data on general and specific credit risk adjustments on STA exposures excluding exposures in default. These provisions were used to mitigate the profit and loss (P&L) impact of credit losses over the 3-year stress test horizon. At the same time, provisions were re-built on the flow of new exposures using the scenario paths for credit risk drivers.

66. **The ratio of provisions for non-defaulted loans over unimpaired loans varies between 0.4 percent and 2.5 percent across jurisdictions.** The wide disparity in provisioning practices across major euro area banks is reflected in the differential impact of credit risk on P&L. There are no international principles that promote the adoption of specific prudential tools on (general) provisions.[29] While the ECB and the EC have proposed a system of prudential backstops for accounting provisions related to nonperforming loans,[30] provisioning practices on non-defaulted exposures vary widely across banks.[31] Under the IMF approach, banks with a greater deterioration in the obligor pool or lower built-up provisions for credit risk were hit more severely under stress.

67. **Interest payments were assumed to accrue only on performing exposures under both the baseline and adverse scenario.** The interest revenue on performing exposures was calculated on the gross carrying amount. While accounting rules allow banks accrue interest income on nonperforming exposures with provision required on the more delinquent and uncollectible assets, this practice distorts banks' coverage ratios and requires a dedicated assessment of the degree of delinquency of the loan under stress. The IMF approach is more

[29] Speech by Fernando Restoy, Chair of Financial Stability Institute, Bank of International Settlements 'The post-crisis regulatory agenda: What is missing?', February 2018.

[30] See European Commission, Consultation document: statutory prudential backstops addressing insufficient provisioning for newly originated loans that turn nonperforming, November 2017; and ECB, Addendum to the ECB guidance to banks on nonperforming loans, March 2018.

[31] To strengthen the identification of problem assets, in 2017 the Basel Committee issued a guide which attempts to harmonize the definitions of nonperforming and forborne assets.

conservative than the 2018 EU-wide stress test methodology which allows banks to project income on nonperforming exposures on a net basis, i.e. on the value of the exposure net of provisions subject to the cap provided by the interest rate accrued at the reference date. The EBA choice is coherent with the IFRS 9 treatment of those assets.

68. The effective lending rate was computed on the amount of unimpaired assets at the 2017 reference date. To be consistent with the accrual assumption on performing exposures, the interest income from loans and receivables reported in the statement of profit and loss was allocated to unimpaired loans to compute the effective interest rate. This rate was subject to rate shocks under each scenario. The projected lending rate path was applied to the forecast volume of unimpaired loans to generate interest income on loans and advances.

D. Market Risk Approach

69. The scope of the market risk methodology covered all positions under fair value measurement. This includes financial assets held for trading (HFT), financial assets designated at fair value through profit and loss (FV), trading financial assets, as well as available-for-sale financial assets (AFS) which impact regulatory capital through other comprehensive income (OCI). The scope excludes amortized cost positions held in a hedge-accounting relationship, as well as hedge accounting derivatives. The traded risk scenario had an impact on capital resources while capital requirements for market risk evolve with balance sheet assumptions. Changes in CVA and CCR are excluded.

70. All accounting categories under a full or partial fair value measurement were revalued under baseline and adverse conditions over the 3-year horizon. This contrasts with the 2018 EBA methodology which assumes no market impact under the baseline scenario. The 2018 EBA methodology also assumes the full recognition of gains and losses from instantaneous market shocks in the first year of the stress test. Under the IMF approach, hedging instruments for interest rate risk associated to positions in the trading book and AFS portfolios are assumed to be ineffective under stress. While this is a conservative approach, the traded risk losses are partially reversed as asset prices recover after a sharp correction assumed during the first year of stress. Also, the severity of the correction increases as risks build and decrease after those risks abate, penalizing buffers built on risky securities.

71. Market risk factors include interest rates and credit spreads for debt instruments, equity prices, exchange rates, and commodities. Market risk losses arise owing to adverse moves in risk factors (market prices and interest rates) and default risk. The calibration of the traded risk component of the scenario is linked to the forward-looking scenario. The path for the market risk factors that were not included in the macroeconomic scenario (e.g., credit spreads, swap rates, yield curves for specific countries) was generated using satellite models broadly aligned to the macroeconomic scenario. For credit spreads on corporate bonds, the calibration was inspired by what happened in the 2008 financial crisis.

72. Revenue and cost changes in banks' investment banking business were included provided they were reported under interest income. Client revenues of trading assets include bid/ask spread, fees and commissions, and investment banking fees. There revenues were projected as net interest income by applying shocks to the effective implied rate at the cut-off date using the amount reported in interest income for HFT and FV assets. Client revenues reported by banks under gains on financial assets and liabilities held for trading in the FINREP statement of profit and loss were excluded as they could not be disentangled from the valuation impact of the trading position.

73. The market impact was computed using a combined approach of instantaneous and multi-year shocks. For derivative positions and equity instruments in the trading book an instantaneous shock was applied. For the valuation impact of debt instruments (repricing risk, credit spread risk) as well as the P&L impact of net open positions in market risk factors (e.g. foreign exchange, commodities), a multi-year shock was applied in line with the 3-year scenario. Losses were absorbed the same year the shock hits.

74. Banks' securities portfolio evolved 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.

Sovereign Exposures

75. A full revaluation of bank's sovereign exposure by issuer and accounting portfolio was implemented combining FINREP data with the 2016 EU-wide transparency exercise results. FINREP templates do not provide a breakdown of sovereign bonds by issuer. The most recent data at the issuer level is provided by the 2016 EU-wide transparency exercise which shows sovereign exposures by country, residual maturity, and accounting portfolio. A mapping table between end-2017 FINREP data and the 2016 EU-wide transparency exercise was built to match the aggregate amount of sovereign exposures at end-2017. Results were checked against the update provided in the 2017 EU-wide transparency exercise which shows a higher level of aggregation.[32] Market losses on sovereign exposures booked under HFT and FV were booked through profit and loss while valuation impact on AFS impacted regulatory capital through OCI.

76. While the average euro area bank holds around 75 percent of the sovereign portfolio in AFS, there is a wide dispersion across banks. Table 3 shows that euro area banks

[32] By contrast to the 2016 EU-wide transparency exercise results, the 2017 EU-wide transparency exercise does not show the breakdown of sovereign exposures by accounting portfolio and residual maturity. The 2017 transparency exercise was used for DZ Bank as this bank had not been included in the 2016 EU-wide stress test.

are subject to repricing risk in sovereign debt spreads as they hold around 90 percent of sovereign securities at fair value (i.e. AFS and HFT portfolios). This consideration does not consider IFRS 9 implementation. There is a wide dispersion of holdings across banks with some universal banks holding over 50 percent of sovereign exposures in the trading book making them particularly exposed to market impact through profit and losses (P&L).

77. Banks hold around 9 percent of total assets in sovereign debt securities of which 30 percent are to their own sovereign, as of June 2017 (Table 4). There are significant differences across banks domiciled in different countries with holdings of sovereign securities ranging between 3 percent (Finland) to 14 percent (Austria and Italy) of total assets. On average, 30 percent of exposure is to their domestic sovereign and another 30 percent to other euro area sovereigns. Own-sovereign exposure ranges between 5 percent (Finland) to just under two thirds (Ireland).

78. Own-sovereign exposure has come down in 2015–17 and reallocated mainly outside the euro area. Table 5 shows a synchronized reduction in own-sovereign exposures for most euro area banks over the last two years. While some banks have increased their sovereign holdings in 2015–17 (notably France, Germany, Italy, and Spain) they have reduced the exposure to their domestic sovereign (particularly Spain) by taking positions mainly outside the euro area.

Table 3. Euro Area: Bank Sovereign Exposures by Book, December 2015

	(In Million euros)			(In Percent)		
Banks in:	AFS	HFT	HTM	AFS	HFT	HTM
Austria	15,420	9,318	22,525	33	20	48
Belgium	17,520	2,080	28,959	36	4	60
Germany	103,015	53,954	0	66	34	0
Spain	205,159	48,880	6,255	79	19	2
Finland	3,332	645	0	84	16	0
France	243,369	24,955	21,556	84	9	7
Ireland	14,668	0	5,406	73	0	27
Italy	147,497	41,620	11,359	74	21	6
Netherlands	117,794	8,343	6,029	89	6	5
Total	867,774	189,797	102,089	75	16	9

Source: 2016 EU-wide stress testing Transparency Exercise, and IMF staff calculations.
Note: By contract to the 2016 EU-wide stress testing Transparency Exercise, the 2017 EBA Transparency Exercise did not show the breakdown of sovereign debt holdings by accounting book.

Table 4. Euro Area: Bank Sovereign Debt Security Exposures by Country, June 2017

(In Million euros)

Banks in:	All Countries	Own Country	Other Euro Area	*Of Which*	*Spain*	*Italy*	*Portugal*	Non-Euro Area
Austria	47,412	8,372	11,592		972	484	55	27,448
Belgium	52,139	17,460	20,611		2,660	4,480	258	14,069
Germany	211,995	62,767	52,131		5,869	18,217	2,319	97,097
Spain	305,471	85,928	40,730		85,928	28,751	10,385	125,128
Finland	3,897	197	2,953		0	0	1	747
France	425,011	123,732	138,062		15,733	38,055	2,293	163,217
Ireland	21,219	13,323	5,516		1,665	1,189	126	2,379
Italy	232,416	97,842	75,208		28,909	97,842	143	30,719
Netherlands	124,465	31,734	55,084		2,811	1,438	0	37,647
Total	1,424,025	441,355	401,887		144,547	190,457	15,579	498,450

(In Percent of Total)

Banks in:	All Countries	Own Country	Other Euro Area	*Of Which*	*Spain*	*Italy*	*Portugal*	Non-Euro Area
Austria	100	18	24		2	1	0	58
Belgium	100	33	40		5	9	0	27
Germany	100	30	25		3	9	1	46
Spain	100	28	13		28	9	3	41
Finland	100	5	76		0	0	0	19
France	100	29	32		4	9	1	38
Ireland	100	63	26		8	6	1	11
Italy	100	42	32		12	42	0	13
Netherlands	100	25	44		2	1	0	30
Total	100	31	28		10	13	1	35

Source: 2017 EBA Transparency Exercise, and IMF staff calculations.

Table 5. Euro Area: Change in Bank Holdings of Sovereign Debt Securities over 2015–2017

(In Percent of the portfolio)

Banks in:	All Countries	Own Country	Other Euro Area	*Of Which*	*Spain*	*Italy*	*Portugal*	Non-Euro Area
Austria	0	-8	11		-1	-58	-73	-1
Belgium	7	-12	27		6	-9	0	13
Germany	33	15	25		44	102	237	53
Spain	17	-32	12		-32	17	17	28
Finland	-2	4	-20		…	…	…	841
France	39	15	30		31	46	-4	78
Ireland	6	-2	-1		11	-20	-14	146
Italy	16	-5	8		35	-5	33	8
Netherlands	-6	-18	-12		-20	-63	-100	21
Total	21	-6	14		-16	9	23	41

Source: 2016 EU-wide stress testing Transparency Exercise, 2017 EBA Transparency Exercise, and IMF staff calculations.

79. The valuation impact on the sovereign securities portfolio is disaggregated into repricing risk and credit spread risk. The impact on P&L and capital is recognized over the stress test horizon. Although the notional value of exposures evolves with the balance sheet, banks are assumed to maintain the same structure of the portfolio throughout the stress testing horizon.

80. The impact of repricing risk depends on the shock to the risk-free curve and bond duration. Interest rate sensitivity is measured by the effective maturity of the bond proxied by duration. Duration is approximated by the residual maturity of the bond at the cut-off date. Under the full valuation approach, the change in the risk-free bond price is the result of multiplying modified duration by the shock to the risk-free rate:

$$\Delta P_t^i = -\frac{D^i}{\left(1 + r_t^i\right)} \cdot B_t \cdot \Delta r_t^i$$

where D^i denotes average duration of bond *i*, B_t denotes the carrying value of the debt security at time *t*, r_t^i captures the risk-free rate level and Δr_t^i the shock to the risk-free rate.

81. The risk-free curve is proxied by the Bund yield term structure. Figure 6 shows the projected yield curve in 2018 for the Bund. Term premium decompression in Europe and the United States together with the absence of flight-to-quality effects contribute to steepen the Bund yield curve with the 10-year rate rising by 75 bps in 2018 relative to the starting point. A polynomial interpolation method is applied to span the term structure between the 3-month and the 10-year rate generated in the macroeconomic scenario.

82. Term premium decompression together with the re-emergence of sovereign stress raises long term government bond yields further in high spread economies. Figure 6 shows the projected term structure under the baseline and adverse scenario for selected issuers against the yield curve in 2017. The 10-year yield on high-spread sovereign issuers reaches over 3 percent in 2018. For countries with monetary policy space at the starting point, the expansionary policy response assumed in the adverse scenario makes the yield curve pivot downwards mitigating the pricing impact at the short-end (e.g., Czech Republic, United States).

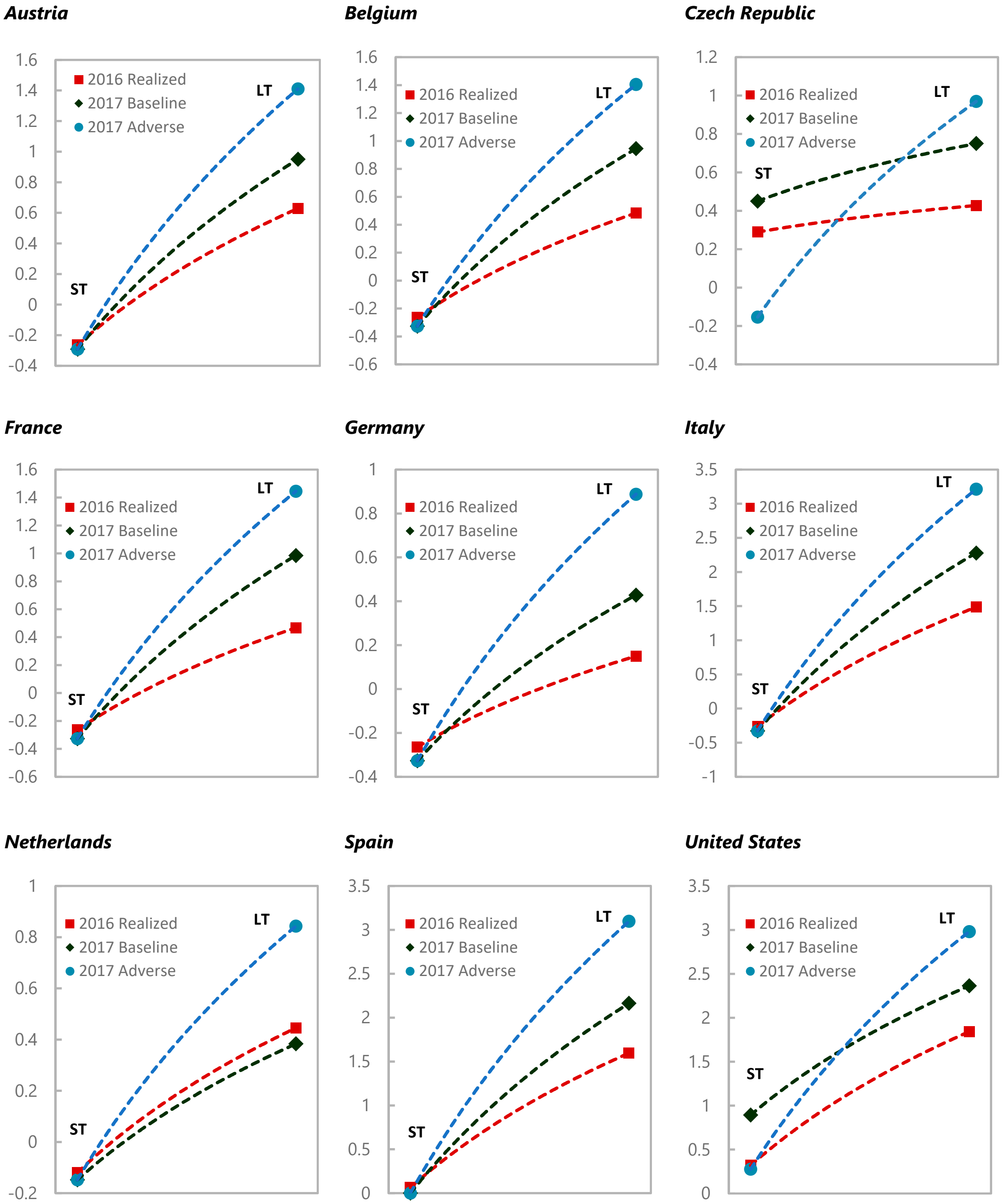
83. The full valuation impact for other than Bund holdings depends on shocks to credit spreads and bond duration. Using the modified duration approach, the FSAP team calculated the haircut for each fixed income instrument under each scenario by multiplying modified duration by the shocks to credit spreads:

$$\Delta P_t^j = -\frac{D^j}{\left(1 + r_t^i + cs_t^j\right)} \cdot B_t^j \cdot \Delta cs_t^j$$

where D^j denotes average duration of bond *j*, B_t^j denotes the carrying value of security *j* at time *t*, r_t^i shows the risk-free rate, cs_t^j denotes the credit spread, and Δcs_t^j the shock to credit spreads.

Figure 6. Euro Area: Sovereign Yield Projections under Adverse Scenario, Selected Issuers

(In Percent)



Source: IMF staff estimates. The panel shows the observed yield curve in 2016 (red dashed line), the projected curve in 2017 under the baseline (green dashed line) and the projected curve in 2017 under the adverse (blue dashed line). ST represents the 3-month Treasury bill rate and LT the 10-year government bond yield.

84. Although proxied duration is typically low across banks, particularly for traded securities, the relatively larger duration of some banks' debt holdings and the constrained monetary policy response in some countries exacerbates valuation impact in a few instances. Duration affects valuation through two channels. First, as the curve pivots downwards and steepens under stress, long-duration assets are hit by larger shocks. Second, the sensitivity of the portfolio to shocks increases with the duration of the portfolio. Relatively less monetary policy space in some jurisdictions (e.g., euro area) limits the downward shift of the yield curve increasing the relative impact of term premium decompression and sovereign stress.

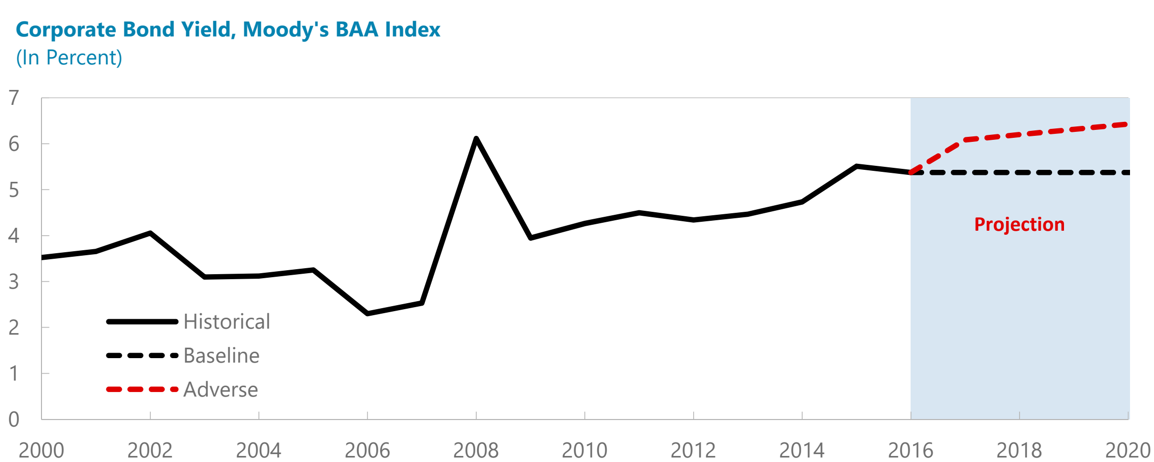
Corporate Exposures

85. Some euro area banks hold large positions in corporate debt instruments at fair value in their trading book and AFS portfolio. Corporate exposures include debt securities issued by credit institutions, other financial corporations, and non-financial corporations.[33] Exposures at fair value also include loans and advances held in the trading book. For some banks, the size of corporate exposures at fair value is significant reaching up to 15 percent of the balance sheet.

86. Corporate spread shocks to major corporate yield indices were projected by rating and counterparty. Banks' corporate exposures at fair value were split according to the credit rating (i.e. investment grade and high-yield), type of issuer (i.e. financial corporations and non-financial corporations), and geography (i.e. Europe, United States). Figure 7 illustrates the projection for the Moody's seasoned Baa corporate bond yield for U.S. corporate exposures based on statistical analysis during the financial crisis.

Figure 7. Euro Area: Corporate Bond Yields

The projection of credit spreads on corporate bonds is generated by a VAR-based approach using forecasts on policy rates and sovereign spreads. BAA corporate bond yields rise by 180 bps under stress.



Source: IMF staff estimates.

[33] The fair value of exposures to central banks was not subject to stress.

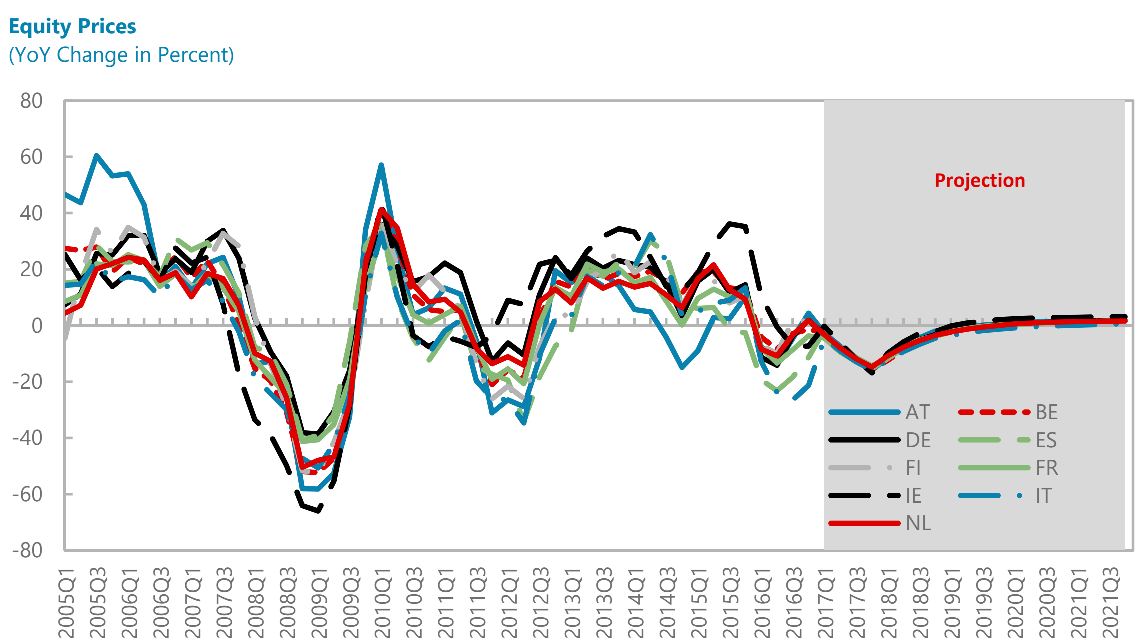
87. The average duration was extracted from the discounted expected cash-flow of outstanding bonds in the euro area. The modified duration (mid quote) of all active corporate bonds at end-2017 was computed for the nine home jurisdictions of the 28 banks covered in the exercise. The average duration, weighted by the face value of the bond, was used as a proxy of the duration of banks' corporate portfolio. Across euro area countries, the average duration of corporate bonds reached 3.6 years in 2017. This duration was adjusted downwards for exposures in the trading book in line with the residual maturity of the sovereign portfolio.

Equity Exposures

88. The FSAP team explored the impact from an equity price correction using complementary metrics. The scenario assumed a broad-based sell-off in stock markets, with equity prices falling by around 20 percent in the euro area (Figure 8). The loss of value on equity instruments arising from changes in market parameters was assessed on trading book transactions and AFS portfolios. Performance metrics included nominal positions (without netting effects), sensitivity (showing local risks), concentration, and holding period. Stressed market losses were benchmarked against the value-at-risk (VaR) and stressed VaR (SVaR) reported in COREP.[34] The confidence interval varied between 99.0 and 99.9 percent.

Figure 8. Euro Area: Equity Prices under the Adverse Scenario

The scenario features a generalized sell-off in stock markets with real equity prices falling by an average rate of 20 percent across major EA indices.



Source: IMF staff estimates.

[34] By contrast to the adverse scenario, the VaR assesses the potential losses on positions over the last year while the SVaR uses a fixed one-year historical window corresponding to a period of significant financial stress (typically the 2008 financial crisis).

89. For equities held with a trading intent, the fair value impact was floored using the 2018 EBA methodology. The market impact from full revaluation of equity holdings was floored using the following constraint:

$$\Delta Eq_t^j = 1.5 \cdot \left(-0.20\% \cdot \left(Equity_t^{long,j} + Equity_t^{short,j} \right) \right)$$

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

90. The FSAP team used banks' risk sensitivities to market risk factors to assess valuation impact under stress. The data is not part of regular supervisory reporting but is collected by the SSM in the scope of the STE for market risk benchmarking. The template included the option sensitivities to the price of the underlying (delta), first derivative of delta (gamma), and to changes in volatility (vega).

91. The assessment of equity impact included the hedges used by banks to decrease sensitivities to equity shocks. Hedges for equity risk were assumed effective under both the baseline and adverse scenario. Given data limitations from the STE, the FSAP team did not have access to market risk sensitives for cash and hedging positions separately. Banks that hold large equity trading books, tend to hedge their positions (i.e. they do not typically take directional trades), limiting the extent of the equity correction on asset valuation.

Derivatives

92. Despite the decrease of euro area banks' wholesale activities, some large euro area banks still hold large derivative books. In line with the post-global financial crisis (GFC) reduction of trading activities, the size of the derivative portfolio has shrunk across euro area banks. However, some euro area banks still hold large derivative books. In terms of market value, the size of the derivative portfolio in some banks reaches over 15 percent with an upper bound of 30 percent of on-balance sheet assets. Most of the derivatives are interest rate derivatives traded over-the-counter (OTC). Some banks active in non-euro area countries also hold FX-derivatives. It is worth noting that whereas some derivatives are classified in the IFRS category 'held for trading' some of them are economic hedges used to hedge a specific portfolio (e.g., in countries with fixed rate mortgages).

93. Some existing derivative positions are back-to-back contracts, and other derivatives are position hedging with residual risk. Some euro area banks agree new contracts with reverse features to neutralize their existing derivative positions (back-to-back) therefore the asset and liability side of the balance sheet develops in parallel. Other banks enter into derivative contracts to hedge a position against the risk of adverse market moves. While most of these positions do not reflect directional trading strategies there is some residual risk if an extreme market event materializes. Also, the ability to rollover some of the hedges under stressed conditions is untested.

94. A large number of derivatives traded by large banks do not have quoted prices in active markets. This is because most derivatives incorporate bespoke features or are traded OTC. For these products, fair value is determined using models based on valuation techniques including the Black-Sholes formula. Furthermore, some inputs used in the valuation methods are derived from observable market data while others are based on unobservable inputs (e.g., volatilities, correlations, recovery rate variance).

95. The strategy to assess valuation risk in derivatives included two approaches:

- The use of fair-value sensitivities of derivative contracts to market risk parameters including the greeks on changes in equity prices, interest rates, FX rates, and commodity prices. The scenarios included standardized moves to the underlying parameters, including 20 percent shift to equity prices, 100 bps increase in interest rates, 20 percent EUR/USD move, 10 percent increase in FX and equities volatility, and 20 percent increase in rates volatility

- The implementation of a reverse stress test on G-SIBs on hard-to-value assets which include many complex or long-dated derivatives (see section on sensitivity tests).

96. Hard-to-value assets include Level 3 and to some extent Level 2 assets. While euro area banks have de-risked their hard-to-value portfolios including through portfolio compression, some euro area G-SIBs still hold material portfolios in Level 3 assets carried at fair value on unobservable inputs. Level 3 instruments include derivatives with longer maturities than those usually trade, with tailored return profiles, or complex derivatives including equity, interest rate, and credit derivatives. The reverse stress test assessed the size of valuation shock on Level 2 and Level 3 assets that would deplete G-SIBs' capital buffers over SREP CET1 regulatory minimum.[35]

Capital Requirements Using the Standard Approach

97. The risk assessment included the capital impact from market risk measured under the standard approach. While most of large euro area banks' capital requirements related to market risk are determined using an internal model approach, the standard approach is also used for some structural FX risk.[36] Market shocks on global currency pairs (e.g., GBP, JPY, CHF, CAD, and USD), as well as local currencies in banks' material geographies were applied to net positions. The traded risk component of the scenario also included market risk from sharp corrections in equity positions and commodity prices for fuel and non-fuel commodities. Euro area banks, however, do not carry material short or long net positions under the standard approach for market risk, mitigating the impact.

[35] By contrast to scenario-based stress tests, reverse stress testing starts from a defined stress outcome (e.g., depletion of capital buffers) and works backward to identify the financial scenario (e.g., valuation shock) that could result in such an outcome. This test is intended to complement scenario-based stress tests by assuming "what-if" outcomes that could extend beyond the range normally considered, and thereby potentially challenge assumptions regarding severity and plausibility.

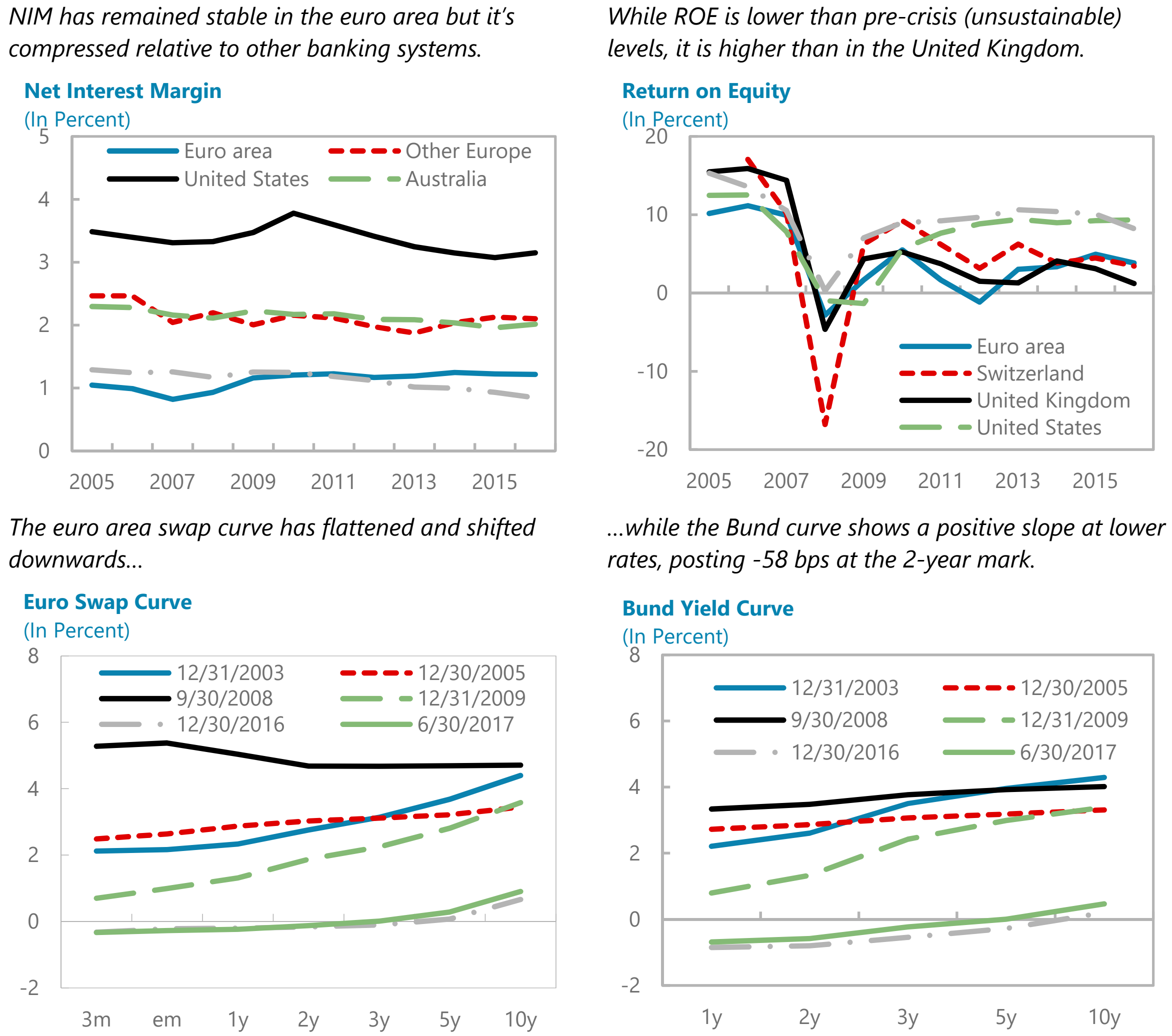
[36] Also some subsidiaries of large euro are banks use the standard approach to compute market risk as they have not received regulator's approval to use internal models.

E. Interest Rate Risk in the Banking Book

Setting the Stage

98. Euro area banks' net interest income has been compressed relative to peers. While, on aggregate, the net interest margin (NIM) in the euro area has remained steady under the low interest rate environment at around 120 bps, this is low compared to the 200 bps in Australia, 230 bps margin in the United Kingdom, and 315 bps in the United States, although it outperforms the 85 bps in Japan (Figure 9).[37] At the same time, deposit rates are close to the zero lower bound, eroding the advantage of banks to tap cheap deposit funding as this is only partly linked to market rates which have become negative at the short-end of the swap curve.

Figure 9. Euro Area: Bank Profitability and EA Interest Rate Environment



Source: BIS, National authorities, Bloomberg, and IMF staff calculations.

[37] Net interest margin is defined as net interest income to interest-earning assets.

99. In addition, the flattening of the swap curve has constrained banks' ability to widen the intermediation margin. The net interest margin has two components: the structural margin and the commercial margin.[38] While the level of interest rates constrains banks' ability to apply commercial margins, the slope of the euro swap curve is associated to banks' intermediation margin.[39] The swap curve has flattened from a slope of 180 bps in 2009 to 100 bps at end-2017. A similar pattern is observed with the Bund curve with a peak-to-trough flattening of 210 bps to 100 bps in 2017 (Figure 9).[40]

100. While a scenario in which interest rates rise gradually is likely to support profitability in the medium term, and abrupt and sharp increase in rates can erode margins further. The impact of gradual rising rates in bank profitability was explored in the baseline scenario. Under baseline conditions, the 6-month Euribor is expected to increase by 100 bps by 2021 from a negative rate of 32 bps at end 2017. Whereas an increase in rates might support margins, the overall impact on regulatory capital will depend on the offsetting valuation effects from assets at fair value. On the other hand, an unfavorable adverse scenario in which increasing funding costs outpace the repricing of assets would put pressure on net interest income, if banks are not adequately hedged against higher market rates.

101. Results from the 2017 ECB Sensitivity Analysis of IRRBB suggest that banks are well equipped to deal with rising rates (Box 2).[41] However, the test shows that two key assumptions for the positive impact of rising rates on NIM are the stability of deposits, and the reliability of banks' loan pre-payment models. Also, while, on average, net interest income would progressively recover with an increase in interest rates, EVE would be hit by a sharp rise of rates. In addition, hedges might become ineffective under stress on the back of basis risk. Basis risk arises typically from the discrepancy between interbank rates and sight and deposit rates. Another source of basis risk is linked to the fact that the reference rate for repricing variable rate mortgages is linked to the Euribor or government yields while the hedging is based on swap contracts.

[38] The structural margin reflects the positive maturity gap in banks' current portfolio (i.e. the gap between locked-in interest rates on assets and liabilities), while the commercial margin denotes the difference between bank rates and market interest rates.

[39] Commercial margins are also driven by competition in lending segments, banks' pricing policies, and credit underwriting standards.

[40] The slope of the curve is defined as the difference between EUSA10 and EUSA2 (euro swap curve) and between GTDEM10y and GTDEM2y (Bund curve).

[41] European Central Bank (2017), "Sensitivity Analysis of IRRBB – Stress test 2017; Final results," October 9.

Box 2. The 2017 ECB Sensitivity Analysis of IRRBB vs FSAP approach to IRRBB

Both the ECB sensitivity test of IRRBB and the FSAP assessment of IRRBB are based on the supervisory template collected for the short-term exercise conducted in 2017. This is a very rich template showing the repricing gaps for all assets and liabilities, including both on- and off-balance sheet items, with granular maturity buckets ranging from 'without specified maturity', 'overnight', '<1-month', through '>20-year'. Liabilities are split by type of contract (fixed rate with remaining contractual maturity; floating rate with repricing date), modeling approach, and currency. Instruments include deposits from corporates, retail deposits, deposits from other counterparties, debt instruments, and derivatives.

Results from the 2017 ECB Sensitivity Analysis of Interest Rate in the Banking Book (IRRBB) suggest that banks are well equipped to deal with rising rates. In particular, while the average decline in the EVE is severe under a hypothetical 200 bps parallel upward shift, with a -2.7 percent CET1 impact, on average, net interest income would progressively recover with an increase in interest rates. Under the 200 basis points parallel upward shift, aggregate net interest income would rise by 10.5 percent while under current conditions (the "year-end 2016" scenario), banks' aggregate net interest income would decrease by 7.5 percent by 2020. While, on aggregate, the use of hedges has shortened banking book duration thus mitigating EVE impact, hedges are costly. The ECB estimated that, on average, the impact of hedges contributes to a +1.7 percent EVE uplift with a negative average contribution to net interest income of -1.1 percent in 2016.[1]

The ECB and the FSAP assessment of IRRBB share the same approach:

- *Focus*: Both tests assess the impact of interest rate shocks on net interest income. The aim is to assess the risk to banks' earnings from adverse movements in interest rates that affect banks' banking book positions.
- *Time horizon*: Both tests used a constant portfolio structure over the same 3-year time horizon and drew on bank models of customer behavior.

On the other hand, the 2017 ECB sensitivity test and the FSAP exercise differ in a number of ways:

- *Coverage*: ECB's IRRBB exercise is conducted over a sample of 111 significant institutions while the FSAP test is implemented over the sample of 28 large banks in the euro area.
- *Balance sheet*: While the ECB's test assumes constant balance sheets as of end-2016, the IMF test assumes dynamic balance sheets with positions evolving in line with macrofinancial conditions.
- *Impact*: the ECB uses the same interest rate scenarios to assess the effect on banks' capital and earnings. The FSAP test uses the macro scenario-based assumptions to assess the fair value impact from adverse movements in risk-free curves and credit spreads on debt securities. This metric does not reflect the effect of a rate move on the next value of liabilities. At the same time, it uses a separately calibrated interest rate shocks to assess impact on P&L.
- *Calibration*: The ECB test was conducted on six hypothetical interest rate shocks including: 'the end-2016" curve (low-rates for long); two regulatory shocks: +-200 parallel moves; a steepener scenario with higher long-term rates than short-term rates; a flattener scenario and "the end-2010" curve. By contrast, the FSAP team calibrated separately the funding shock and the lending shock in line with the traded risk component of the scenario. Rate shocks incorporated systematic risk factors (from market moves) as well as idiosyncratic shocks based on banks' specific asset and liability structure and the historical behavior of rates using econometric analysis.

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[1] For the sample of banks, 55 percent of interest derivatives are net payer fixed positions to shorten banking book duration due for instance to long-term fixed rate mortgage loans. Under a payer swap, fixed interest payments are swapped into variable interest receipts. However, 45 percent of interest rate derivatives are net received-fixed swaps.

102. By contrast to the 2017 ECB test, the FSAP assessment of IRRBB followed a four-pronged approach (Box 2):

- The '*economic value approach*', which measures the valuation effect of an interest rate shock on the fair value of assets, and impacts EVE due to long duration (e.g., long-dated fixed rate bonds), was assessed using a market risk approach (see section on market risk). By contrast to the EVE measure, only marked-to-market assets were re-valued rather than all balance sheet positions;

- The '*earnings approach*', which measures the impact of an interest rate scenario on banks' future net interest income over a 3-year horizon was assessed against a range of interest rate shocks calibrated at the *bank/instrument* level. This contrasts with ECB's multiple heuristic approach using six hypothetical scenarios;

- The *scenario* includes a commercial margin and an intermediation margin. In particular, two components are included in the calibration of the interest rate shocks: a systematic risk factor (broadly aligned with the scenario) and an idiosyncratic component (linked to banks rates' historical behavior);

- As in the 2017 ECB test, shocks were applied to the *repricing structure* of assets and liabilities using the IRRBB template as of June 2017. Impact is measured separately for the stock of loans/liabilities and for the flow of new lending/funding instruments.

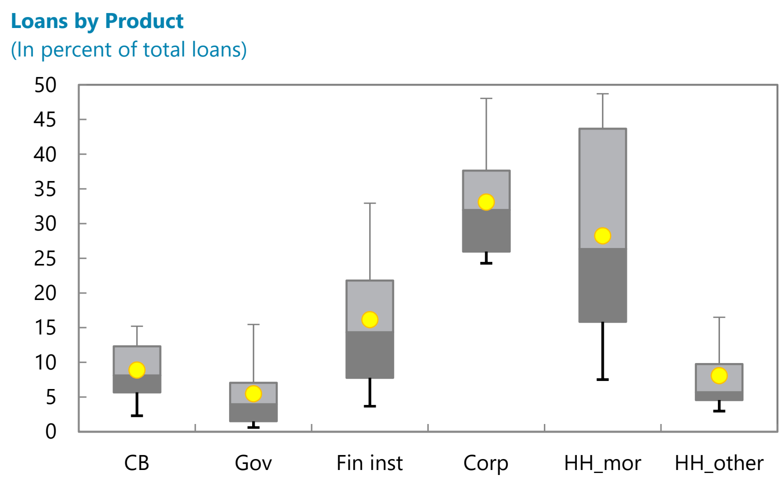
Structure of Assets and Liabilities

103. The exposure of banks' interest earnings to interest rate risk depends on changes in market rates as well as on banks' structure of assets and liabilities. The impact of a change in market rates on funding costs depends on the liability margin which varies across funding instruments (e.g., sight deposits vs debt securities). The impact of a rate shock on interest income depends on the commercial margin which differs across loan products (e.g., mortgage vs consumer loans). Margins are a function of banks' business model as well as the level of market competition in product markets.

104. For the sample of banks included in the stress test, exposures to the private non-financial sector (i.e. non-financial corporation and households) represent over two thirds of total loans (Figure 10). Half of this amount is exposure to households, mainly mortgage loans, and half to corporates. Around 15 percent of loans are exposures to financial corporations, 10 percent is loans to central banks, and over 5 percent loans to general governments. This hides however, important differences in the composition of the loan portfolio across banks, in line with their business model.

Figure 10. Euro Area: Bank Loans and Advances by Product

On average, loans to the private non-financial sector represent over two-thirds of total loans. This masks a wide variation across banks, particularly related to mortgage exposures, in line with banks' business models (i.e. retail lenders, diversified lenders, corporate/wholesale lenders, universal banks, or G-SIBs).



Note: The chart shows the breakdown of loans and advances by counterparty sector and product, where *CB* denotes central banks, *Gov* general governments, *Fin inst* financial institutions (credit and other financial), *Corp* other financial corporations, *HH_mor* households mortgage loans, and *HH_other* households non-mortgage loans. Boxplots include the mean (yellow dot), the 25th and 75th percentiles (grey box, with the change of shade indicating the median), and the 15th and 85th percentiles (whiskers).

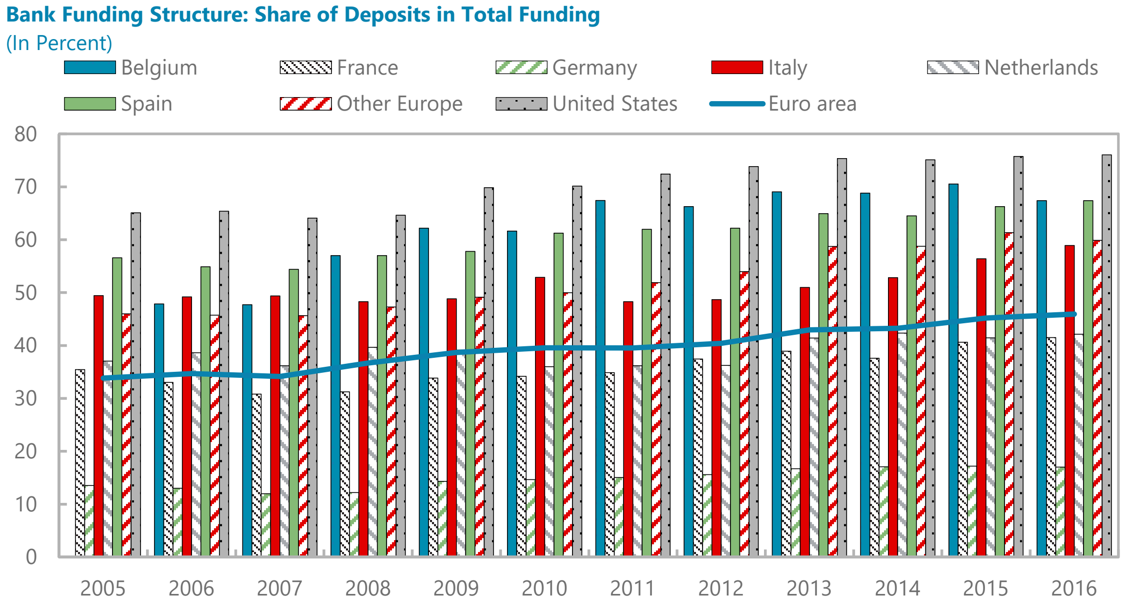
105. The evolution of banks' funding structure shows that euro area banks have tended to increase their reliance on customer deposit funding (Figure 11). In line with banks domiciled in other advanced economies, euro area banks have re-oriented their business away from trading and more complex activities, towards less capital-intensive activities, including commercial banking.[42] This pattern is evident in the changes in banks' asset portfolios, revenue mix as well as their increased reliance on customer deposit funding.

106. Specifically, in the stress testing sample, retail funding represents over half of interest-bearing liabilities (Figure 12). By contrast, reliance on less stable sources of funding ('wholesale funding') is moderate. Customer deposits from financial institutions and debt instruments contribute equally to overall funding at 20 percent. While average bank reliance on central bank funding is contained at 4 percent, this masks wide variability across banks.

[42] Germany may appear as an outlier in part because the sample includes the apex banks for the savings bank and cooperative bank "pillars."

Figure 11. Euro Area: Bank Funding Structure across Banking Systems

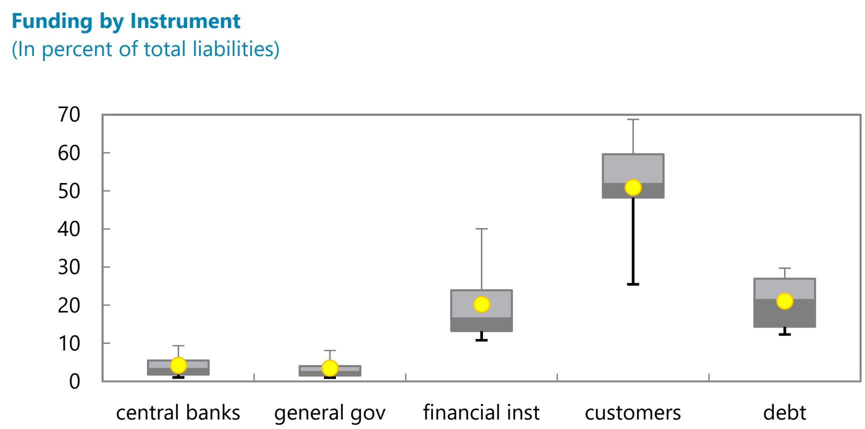
Euro area banks have increased their reliance on customer deposit funding in line with other advanced economies.



Source: BIS (2018), "Structural changes in banking after the crisis", Committee on the Global Financial System", January.
Note: The chart excludes deposits with banks. Total funding is measured as the sume of deposit funding, other borrowings and equity. Other Europe includes Sweden, Switzerland, and United Kingdom.

Figure 12. Euro Area: Funding Structure by Instrument

Retail funding represents over half of interest-bearing liabilities with deposits from financial institutions and debt instruments accounting for 20 percent each.



Note: Boxplots include the mean (yellow dot), the 25th and 75th percentiles (grey box, with the change of shade indicating the median), and the 15th and 85th percentiles (whiskers).

107. While the market sensitivity of central bank reserves and retail funding is low, they are subject to considerable uncertainty regarding behavioral assumptions. This is because they are partly motivated by the ultra-low interest rate environment, and therefore, are subject to change if rates start to raise.[43] Moreover, the decoupling of rates paid to depositors from market rates has increased the uncertainty of the pricing of these deposits if rates were to rise.[44]

108. Key dynamic effects were captured by the FSAP's IRRB assessment. Given that banks' capacity to generate substantial interest income depends significantly on dynamic effects, the FSAP team attempted to model explicitly changes in commercial margins, liability margins, and pass-through effects. Also, non-maturing deposits (e.g., current accounts) where modeled as overnight deposits. On the other hand, the team did not change the maturity profile of maturity positions at renewal, or customer behavior related to shifts between different types of deposits, in line with the constant portfolio nature of banks' balance sheets.[45]

Modelling Strategy

109. The FSAP team calculated net interest income by estimating line-by-line interest income and expense generated from interest-bearing assets and liabilities. Such an approach is heavily dependent on comprehensive data on individual banks' repricing maturities and hedging practices. This approach was feasible given the granular data provided in the IRRBB template, covering all banking book items including derivatives. The IRRBB repricing data were mapped to banks' asset and liability structure, as well as to the implicit interest rate received (paid) on interest-bearing assets (liabilities) using FINREP templates.

110. Two complementary modelling strategies were used to project bank net interest income conditional on the macrofinancial scenarios:

- *Strategy 1*: Projection of front-book interest rates at the individual country and portfolio level;
- *Strategy 2*: Projection of interest rates by loan product and funding instrument at the bank level.

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[43] During the current interest rate environment, the volume of sight deposits at the ECB has grown strongly for some banks reaching up to 20 percent of loans and advances. The volume of non-maturity deposits has also increased sharply given the lack of attractiveness of term deposits.

[44] For instance, Belgian banks' household deposits largely consist of savings deposits, for which the yield is floored by law at 11 basis points. A dynamic assessment of IRRBB behavior is examined in SNB (2016), Financial Stability Report.

[45] A strong increase in interest rates might lead to migration of sight deposits to fixed-term deposits at higher rates, increasing bank funding costs.

Strategy 1

111. The projection of funding rates was mapped to banks' breakdown of financial liabilities by product and counterparty using FINREP templates. The following eight portfolio segments were constructed: deposits from central banks, deposits from general governments, deposits from financial institutions, non-financial corporate deposits (overnight; with agreed maturity); household deposits (overnight; with agreed maturity); and, debt securities issued.[46] These portfolios were mapped to the following pricing paths:

- The pricing of central banks deposits from central banks and general governments followed changes to the monetary policy rate. Given the initial zero lower bound, the deflationary environment assumed in the scenario, and the endogenous monetary policy response, policy rates in the euro area remained unchanged under stress;[47]

- Rates paid on deposits from financial institutions (including credit and other financial institutions) followed the LIBOR rate path assumed in the scenario;

- The pricing of retail deposits was linked to the scenario. The econometric approach included thirty-six regressions for the nine euro area countries and four retail categories (i.e. corporate overnight, corporate term, household overnight, household term);

- Bond pricing of debt securities were benchmarked against the euro swap rate curve and a bank-specific spread over the reference rate for new debt issuance.

112. Country-level front-book interest rates on retail deposits were projected using ECB interest rates' statistics (MIR). Econometric modelling was developed for each euro area country and each portfolio linking the front-book rates to the macrofinancial variables projected in the scenario. Figure 13 shows the evolution of deposit rates for households and corporates in a low-spread country. The chart suggests a structural break in 2012. While corporate rates on deposits with agreed maturity comoved with household rates over 2005–11, there is evidence of decoupling starting in 2012 Q1 with corporate rates declining below overnight household rates entering into negative territory in 2016 Q3 and reaching -4 bps in end-2017.

113. The main drivers of interest rates on retail deposits include macroeconomic variables and market rates. The benchmark empirical strategy relied on a Newey-West time series approach to obtain consistent estimators when the error term is heteroskedastic and autocorrelated. The time series specification takes the general form:

$$i_t^{c,j} = \alpha + \delta \cdot i_{t-1}^{c,j} + \beta_{1,1}^{c,j} \cdot macro_{t-1}^{c} + \ldots + \beta_{1,k}^{c,j} \cdot macro_{t-k}^{c} + \beta_{2,1}^{c,j} \cdot fin_{t-1}^{c} + \ldots + \beta_{2,k}^{c,j} \cdot fin_{t-k}^{c} + \varepsilon_t^{c,j}$$

[46] Deposits redeemable at notice and repurchase agreements are treated as deposits with agreed maturity.

[47] This contrast with an environment of rising inflation or the effect of a monetary policy mistake that would lead to a tightening of monetary policy in the euro area.

where each funding cost rate is indexed by country c and instrument j, and the equation includes: an autoregressive component; a vector of macro variables, such as growth, inflation, and credit growth; and a vector of financial variables, such as the swap rate, the sovereign yield spread, the policy rate, the euro LIBOR rate, and the U.S. dollar LIBOR rate.[48] Regressors included 1 to k lags to address endogeneity.

114. Results suggest that corporate deposit rates are more sensitive to changes in macro conditions and money market stress while household deposit rates are more closely linked to the policy rate. Annex Table 4 shows regressions for two dependent variables, namely the front-book deposit rate in corporate and household deposit rates with agreed maturity. Results show that corporate rates are more responsive to GDP growth, credit developments, and euro and dollar interbank rates, while household rates are more sensitive to hikes in ECB rates. This result suggests a higher degree of pass-through from policy rates to household deposit rates.

115. Figure 14 shows the projections of front-book rates in a low-rated country based on the adverse scenario. The impact of adverse conditions is more severe for corporate deposit rates. Rates are projected to rise by up to 140 bps by end-2021. The delta for household rates is lower at 110 bps. The 30-bps gap in their starting point matches exactly the differential impact of stress, leading to the same end-point of 140 bps by the end of the horizon.

116. The projection of lending rates was mapped to banks' breakdown of loans and advances by product using FINREP data. Six portfolio segments were constructed: loans to central banks, loans to general governments, loans to non-financial corporates (including credit institutions and other financial institutions), loans to non-financial corporations, loans to households (mortgages), and other loans to households (consumer loans, other).[49] These portfolios were mapped to the following lending rates:

- Loans to the central banks followed the path for the policy rate. Similarly to the assumption made for ECB's main refinancing operations, the rate on the deposit facility is assumed to remain unchanged in the adverse scenario;

- The lending rate on loans to general governments was based on statistical analysis using MIR (country) statistics and FINREP (bank) returns First, the implicit rate on government loans received by the 28 banks of the sample was extracted using FINREP data. Second, this rate was proxied by a benchmark rate using MIR statistics. The rate that tracked most closely the government rate across euro area banks was the mortgage rate (Figure 14).

- The lending rate on loans to financial corporation, non-financial corporations, mortgage loans, and other household loans was projected using MIR data linked to the scenario.

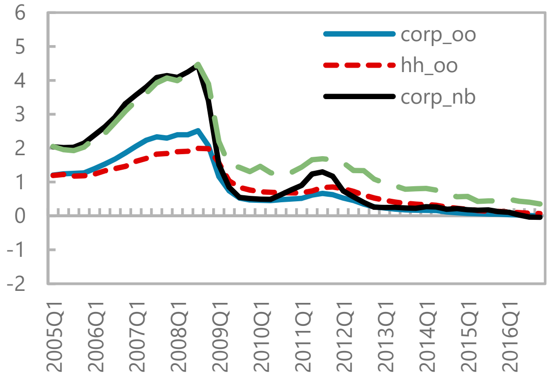
[48] The specification does not include bank specific variables as these are not captured in the scenario, and thus there is no information on their projected paths. Given that the econometric results are used for forecasting purposes rather than for policy analysis (for which the size of the estimated coefficients is the focus of the analysis) the potential bias related to omitted variables is not an issue of concern.

[49] Other household loans include other collateralized loans, and loans for house purchase.

Figure 13. Euro Area: Selected Bank Deposit Rates in a Low-Spread Country

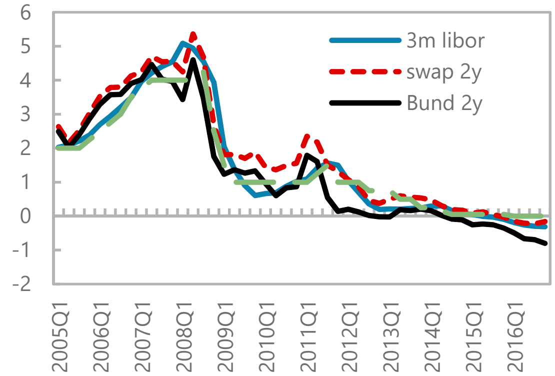
Post-crisis decoupling of term deposit rates, with household rates outperforming corporate rates.

Deposit Rates
(In Percent)



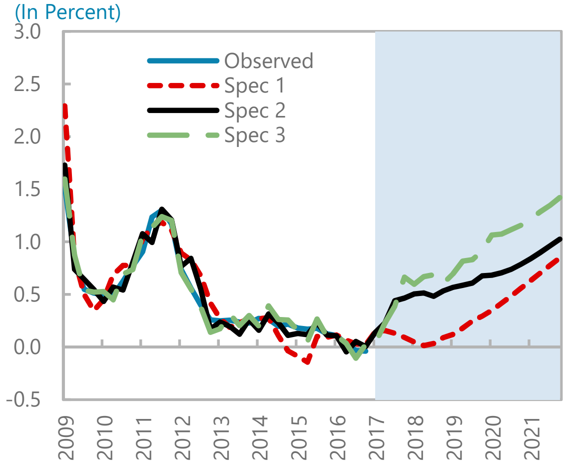
Flight-to-quality effects captured by the spread of the ECB policy rate over the Bund rate.

Market Rates
(In Percent)



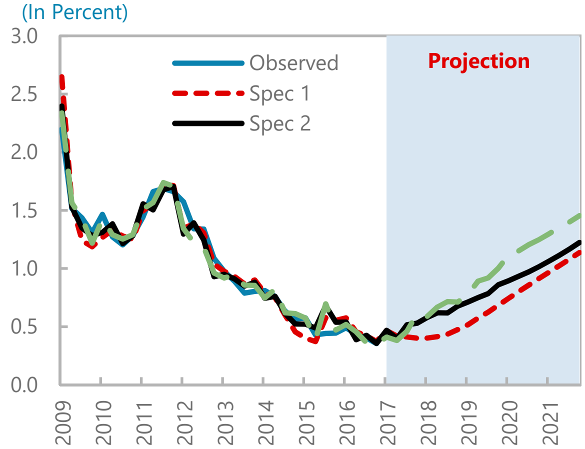
Corporate rates on term deposits are projected to rise by 140 bps by 2021…

Projections Corporate Deposit Rates, Adverse
(In Percent)



…while household rates on term deposits increase at a slower pace with a 110-bps shift by 2021.

Projections Household Deposit Rates, Adverse
(In Percent)

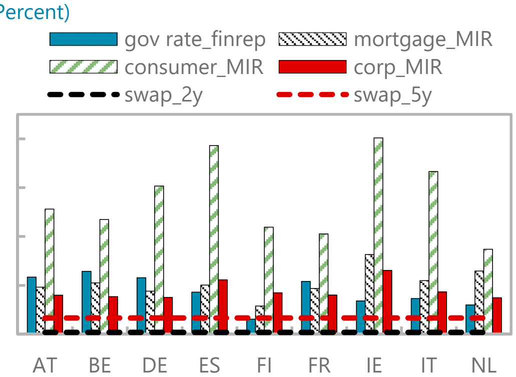


Source: ECB MIR statistics, IMF staff calculations, and IMF staff estimates.

Figure 14. Euro Area: Bank Lending Rates by Product

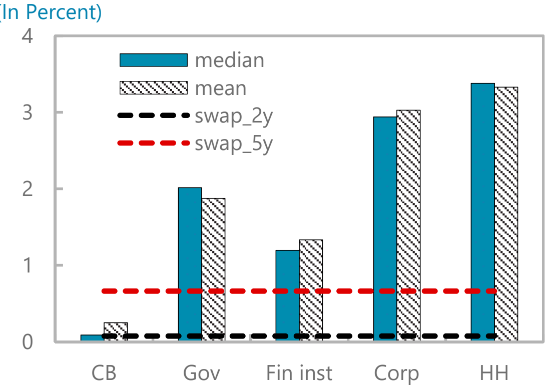
The average lending rate on government loans track mortgage rates more closely than other loan products.

Government Rate vs. Benchmark Rates, 2016
(In Percent)



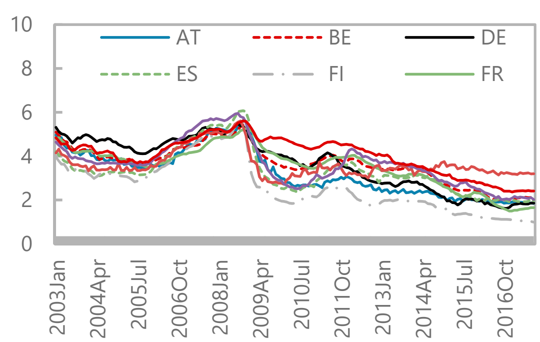
Net interest income is supported by household rates followed by corporate rates.

Lending Rates by Product, 2016
(In Percent)



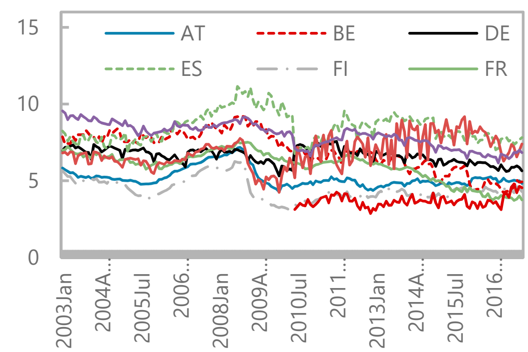
The average mortgage rate stood at 2.0 percent relative to 5.6 percent for consumer loans and 1.6 percent for corporate loans.

Mortgage Rates
(In Percent)



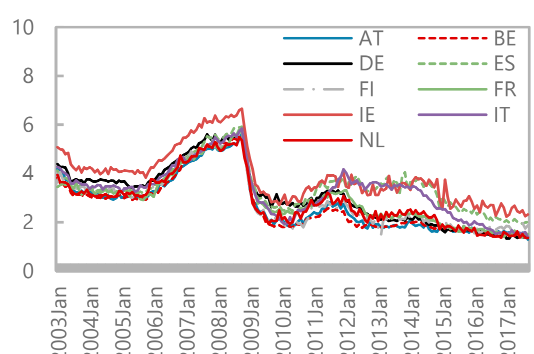
The dispersion of lending rates for consumer loans is higher than for other loan products pointing at idiosyncratic credit risk and lower market competition.

Consumer Rates
(In Percent)



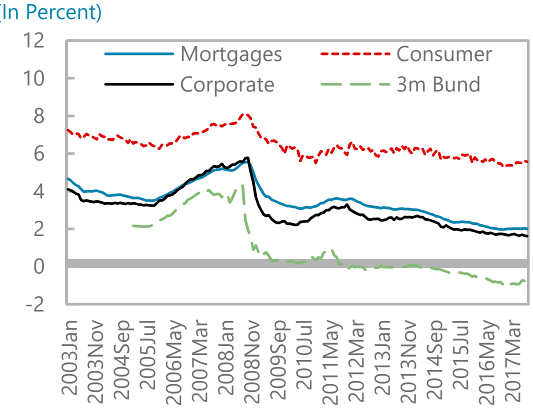
Corporate lending rates exhibit greater cyclical variation than other loan segments.

Corporate Rates
(In Percent)



Lending rates diverge significantly from risk-free curves. The average rate reached 320 bps against -75 bps for the 3m Bund rate.

Rates in the Euro Area
(In Percent)



Source: ECB MIR statistics, FINREP, and IMF staff calculations. The top LHS chart shows banks' implicit lending rates for loans and advances to general governments reported in FINREP (gov rate_finrep) and according to ECB's monetary interest rate (MIR) statistics for mortgage loans (mortgage_MIR), consumer loans (consumer_MIR), and corporate loans (corp_MIR).

117. The evolution of lending rates across the euro area suggests different lending practices across products. Figure 14 shows the level and dispersion of core lending rates across the nine euro area countries. The chart reveals the following insights: Figure 14: Use min-max or median for the time series—the individual lines are not distinguishable in any case.

- *Consumer loans carry a large component of credit risk premium.* For the same market rate developments, the average rate on consumer loans stood at 5.6 percent in June 2017 relative to a mortgage rate of 2.0 percent and a corporate rate of 1.6 percent.

- *The dispersion in lending rates for consumer loans is higher than for other loan products.* This suggests lower competition in consumer credit relative to the mortgage and corporate segments. While the standard deviation in 2017Q3 was 37 percent for corporate rates and 61 percent for mortgage rates, it reached 150 percent for consumer loans.

- *Lending rates diverge significantly from risk-free rates.* First, the cyclical variability of lending rates is quite limited, particularly for consumer loans. Second, while the average lending rate across product categories reached 320 bps in 2017, the Bund rate was negative at -75 bps.

118. Econometric modelling was developed to forecast lending rates in line with the macrofinancial variables projected in the scenario. Similarly to the modeling strategy for deposit rates, a Newey-West time series approach was followed using lagged regressors under the general specification:

$$l_t^{c,j} = \mu + \gamma \cdot l_{t-1}^{c,j} + \lambda_{1,1}^{c,j} \cdot macro_{t-1}^{c} + \ldots + \lambda_{1,k}^{c,j} \cdot macro_{t-k}^{c} + \lambda_{2,1}^{c,j} \cdot financial_{t-1}^{c} + \ldots + \lambda_{2,k}^{c,j} \cdot financial_{t-k}^{c} + $$
$$+ \lambda_{3,1}^{c,j} \cdot risk\ \ premium_{t-1}^{c} + \ldots + \lambda_{3,k}^{c,j} \cdot risk\ \ premium_{t-k}^{c} + \zeta_t^{c,j}$$

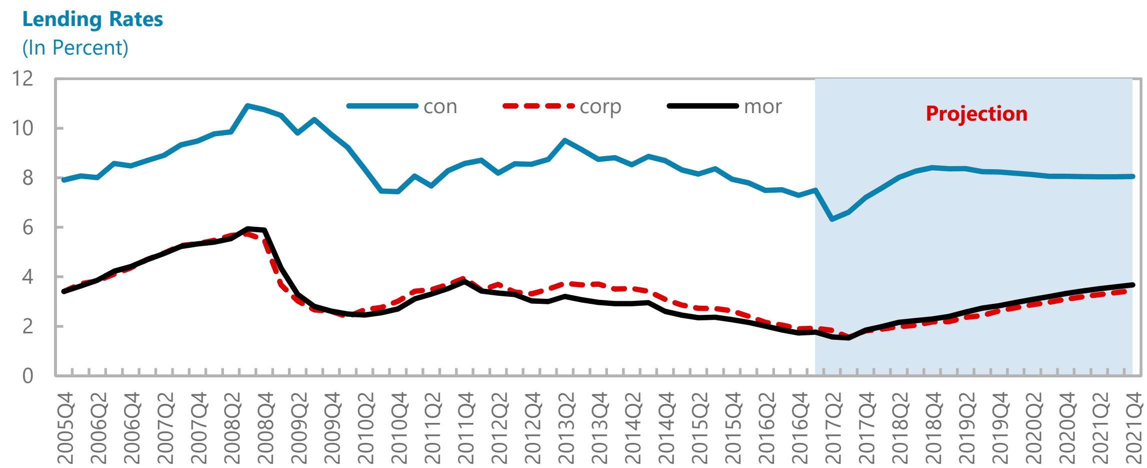
where the dependent variable is the lending rate by country *c* and product *j*. The set of regressors includes: an autoregressive variable; macro factors, such as the unemployment rate and credit growth; financial variables, such as the swap rate, the sovereign yield spread, the policy rate, the euro LIBOR rate, and the U.S. dollar LIBOR rate; and a risk premium proxied by Moody's EDF for corporates (for the corporate rate), EDF for consumer firms (for the consumer rate), and EDF for real estate firms (for mortgage rates). Lending rate regressions also included developments in house prices. Regressors included 1 to k lags to address endogeneity.

119. Results suggest that lending rates for corporates are more closely linked to wholesale funding costs while consumer rates are driven by risk premia and mortgage rates rise with tight credit conditions. Annex Table 5 presents regressions for core front-book lending rates in a high-spread country, including corporate, consumer, and mortgage loans. Results suggest that lending rates for corporate and mortgage loans are more responsive to cyclical economic conditions, whereas lending rates on consumer credit show higher persistence. Also, they are more sensitive to market conditions suggesting a higher pass-through of bank funding costs to customers. Both factors point at lower competition in consumer credit relative to other product segments. Mortgage rates' exposure to interbank rates is explained by the prevalence of floating-rate mortgages linked to the 12-month EURIBOR. This effect outweighs house price developments as a determinant of lending rates. The increase of corporate rates with a tightening of credit conditions suggest credit rationing under stress.

120. Figure 15 shows the projections of lending rates in a high-spread country under adverse conditions. During the first year of the stress, the impact is more severe for consumer loans with rates increasing by 110 bps, outpacing the increase in mortgage rates which rise by 60 bps and corporate rates which increase by 30 bps. However, as conditions deteriorate further, stress is transmitted to the corporate and mortgage segments which experience higher increases by the end of the horizon.

Figure 15. Euro Area: Bank Lending Rate Projections in a High-Spread Country

The effect of stress is front-loaded for consumer loans with rates increasing by 110 bps during the first year, relative to the sustained gradual increase of mortgage and corporate rates over the stress test horizon.



Source: IMF staff estimates.

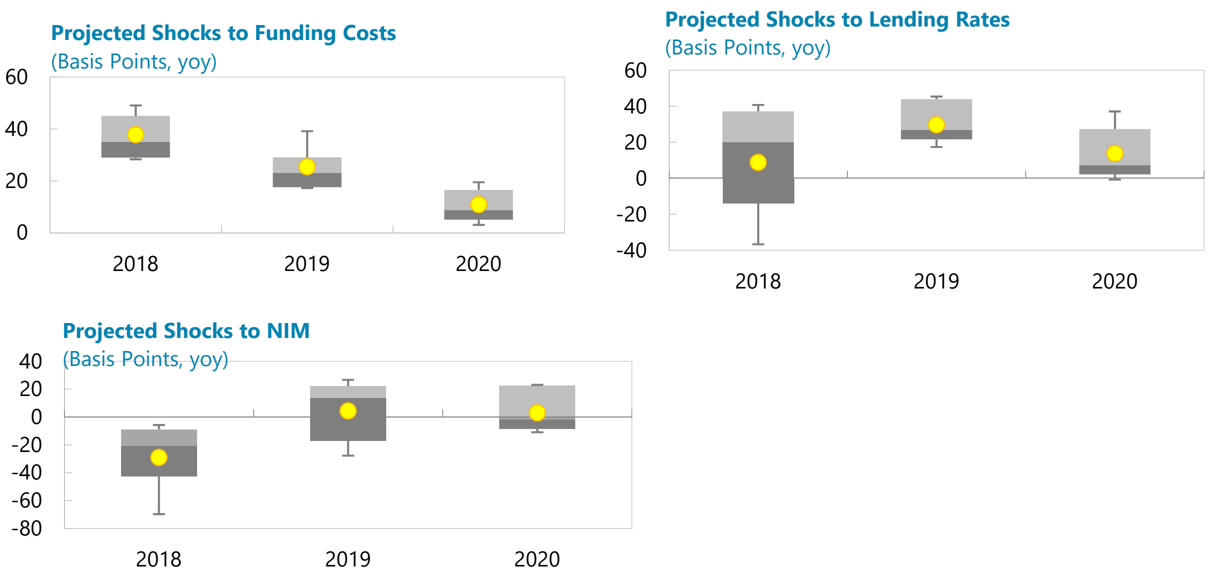
121. Funding cost and lending rates projections were applied to banks' asset and liability structure to forecast shifts to banks' net interest margins. Figure 16 shows the year-on-year impact of shocks to funding costs, lending rates, and margins. The results show that while funding costs rise sharply the first year of stress, lending rates follow with a lag. While, on average, funding costs rise by 40 bps in 2018, and lending rates adjust partially by 8 bps, banks hit by higher funding costs are on average less able than their peers to pass them onto customers. As a result, at the 90th percentile, the margin contracts by 75 bps.

Strategy 2

122. This modelling strategy addresses two major developments since the global financial crisis. First, funding market conditions have become heterogeneous across banks reversing a pre-crisis trend of lower and more similar rates. Second, there have been concerns over the policy rate pass-through to lending rates. Possible sources in the inefficient transmission of monetary policy have been attributed to the misalignment of policy rates and funding costs and to banks' internal transfer policies to set lending rates. Both aspects are examined in this section.

Figure 16. Euro Area: Distribution of Aggregate Interest Rates under the Adverse Scenario

On average, funding costs rise by 40 bps in 2018 with lending rates adjusting partially by 8 bps. However, banks hit by higher funding costs are also less equipped to pass on the increased funding costs to borrowers. At the 10th percentile, nim contraction reaches 75 bps.



Source: IMF staff estimates. Boxplots include the mean (yellow dot), the 25th and 75th percentiles (grey box, with the change of shade indicating the median), and the 15th and 85th percentiles (whiskers).

Funding Costs Modeling

123. A key contribution of this approach is to carefully construct an effective measure of funding costs. Interest rates paid on liabilities vary across banks depending on their funding patterns and liquidity management practices.[50] Given that core funding markets vary across the sample of banks, we expect different rates paid on deposits across banks. Another important determinant of interest expense is banks' liability margin which depends, among other factors, on the proximity to the zero lower bound.

124. The effective funding cost measure is built by matching the whole range of liabilities that banks use to fund their balance sheet with an interest rate path and a repricing structure:

- The pricing of deposits from central banks and general governments follow monetary policy rates which are unchanged under stress in the euro area (similarly to strategy 1);
- Funding from deposit liabilities (excluding central bank and general government deposits) is split between financial institutions and customers. Deposit from financial institutions are equivalent to interbank deposits. Interbank rates follow EURIBOR trends;

[50] It has been argued that to the extent that wholesale funding is used to finance the acquisition of assets outside of their home markets, the post-crisis' greater reliance on retail funding has led to more decentralization of funding as banks seek to increase local funding in the countries they operate (see BIS, 2010).

- Customer deposits include deposits from households and non-financial corporations. Deposit rates vary across institutions according to their deposit structure and liability margin. Rates evolve with economic conditions and benchmark rates;
- Debt securities for instruments at floating rate are repriced according to the swap rate. They include unsecured bonds (i.e. investment grade, high-yield, medium term notes), secured instruments (i.e. mortgage-backed securities, asset-backed securities, covered bonds), and preferred securities;
- The cost of debt securities at fixed rate is split into a reference rate and a spread at issuance. The coverage of instruments is the same as for floating rate instruments. That is, they include unsecured bonds, secured instruments, and preferred securities.

125. The starting point for interest expenses is matched with historical data sourced from Bloomberg, Fitch, and Dealogic. Implied rates by instrument and counterparty at the cut-off date is computed using FINREP returns and mapping banks' liability structure (F08.01.a) with banks' interest expense by counterparty (F16.01.a). The time series for EURIBOR rates at different tenors is sourced from Bloomberg. For customer deposits, historical rates are computed using Fitch data. For debt securities, the cost of issuance is obtained from Dealogic. Bonds are issued at the swap rate plus a mark-up over swap rate (spread).

126. It is essential to consider all sources of market funding given the behavior of issuance and yield differential between secured and unsecured debt. Figure 17 shows gross issuance of bonds by the 28 banks of the sample broken down by instrument, region, and bank from 2005 to 2018 Q1. The data reveal the following patterns:

- Over the sample period, unsecured issuance accounts for around 60 percent, mainly investment grade bonds, while 40 percent represents secured issuance split between ABS, MBS, and covered bonds. Issuance of preferred equity is insignificant;
- Aggregate issuance masks a marked cyclical pattern with quarterly issuance drying out during both the financial crisis (2008) and the sovereign crisis (2011Q3–2012Q2) to a quarterly average of €50 billion from a pre-crisis level of €130 billion;
- As the crisis attests, when bond spreads rose, gross issuance of senior unsecured bonds fell to near zero in the peripheral countries being replaced by covered bond issuance;[51]
- Alternative methods of funding carry very different cost of issuance, with the average spread of unsecured bonds at 130 bps more than doubling the 60-bps spread of secured bonds;[52]

[51] Core countries include Austria, Belgium, Germany, France, and Netherlands. Peripheral countries include Ireland, Italy, and Spain.

[52] In practice, the overall cost of secured bonds also includes the cost of encumbering assets to back them, leading to a higher cost than the quoted yield.

- There is a wide dispersion of cost of issuance due to bank- and country-specific factors. For unsecured bonds, the spread at issuance ranges between 15 and 90 bps at the first and third quartile, respectively, while secured instruments' spread fluctuates between 105 and 170 bps.

127. Crucially, this approach uses banks' actual funding spreads, which allows accounting for banks' behavioral response to stress. Spreads at issuance represent more closely the actual cost that banks face when they raise wholesale funding than the proxies used by the empirical literature. Common proxies include the 5-year CDS spreads and the secondary market spread for 5-year euro senior unsecured bonds. As Figure 18 illustrates, CDS spreads are not necessarily representative of actual funding costs, as banks tend to refrain from unsecured issue when market spreads widen significantly. Therefore, an analysis of funding costs based on market proxies is likely to generate off-equilibrium path results

128. The modeling strategy is based on estimating bank funding costs by instrument using two econometric approaches:

- A panel based regression using fixed effects. To make sure that the estimation if robust to this choice we also run regressions at the country level using fixed effects.

- A quantile regression approach to assess the impact of underlying drivers at different percentiles of the funding cost distribution.

129. The basic form of the relationship between funding cost and the explanatory variables is as follows:

$$i_t^{i,j} = \alpha + \delta_1^j \cdot i_{t-1}^{i,j} + \delta_2^j \cdot macro_{t-1}^{c,j} + \delta_3^j \cdot fin_{t-1}^{c,j} + \delta_4^j \cdot global_{t-1}^{j} + \varepsilon_t^{i,j}$$

where $i_t^{i,j}$ denotes the funding cost of instrument *j* for bank *i*.[53] To capture broad changes in the state of the economy and shifts to benchmark rates, the set of regressors includes macro variables (growth, inflation, unemployment, recession indicator), financial variables (EURIBOR, swap rates, spreads over swap), and regional/global factors (growth in the EA, ted spread).[54]

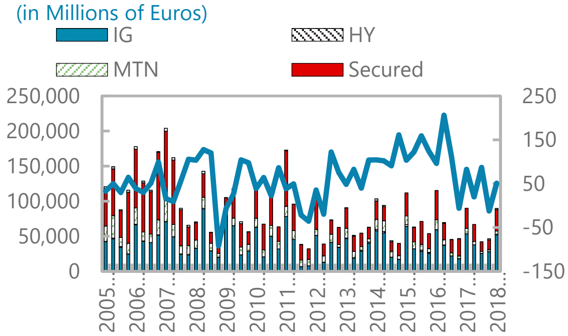
[53] The model is solved using panel fixed effects at the country and euro area level. Dynamic panel data estimators are not warranted as the length of the time series (48 observations) is large and the number of individuals (29 firms) is small. In this particular application, we are more concerned with the quality of the forecast than the quality of the coefficient estimates; simpler estimation techniques like fixed effects are expected to forecast better than Arellano-Bond. Dynamic panel bias can be a concern for small T and Arellano and Bond estimator is suitable for small T and large N.

[54] The base case specification does not include bank specific variables as these are not captured in the scenario, and thus there is no information on their projected paths. Given that the econometric results are used for forecasting purposes rather than for policy analysis (for which the size of the estimated coefficients is the focus of the analysis) the potential bias related to omitted variables is not an issue of concern. The section on "Insights from the Feedback Loop Analysis" provides an estimation of feedback effects between solvency and funding costs endogenizing the path of bank specific characteristics using an iterative approach.

Figure 17. Euro Area: Bank Debt Issuance

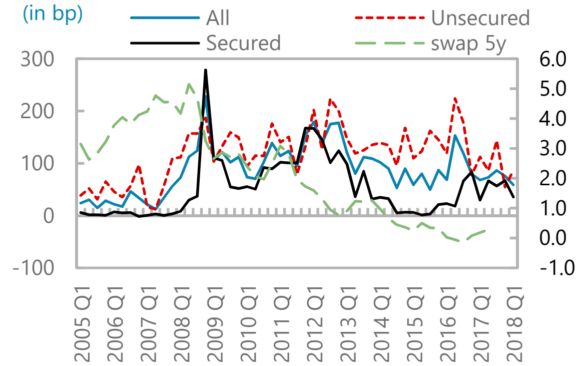
Unsecured issuance accounts for around 60 percent (mainly IG) while the rest is equally split between ABS, MBS, and Covered Bonds.

Debt Issuance by Instrument
(in Millions of Euros)



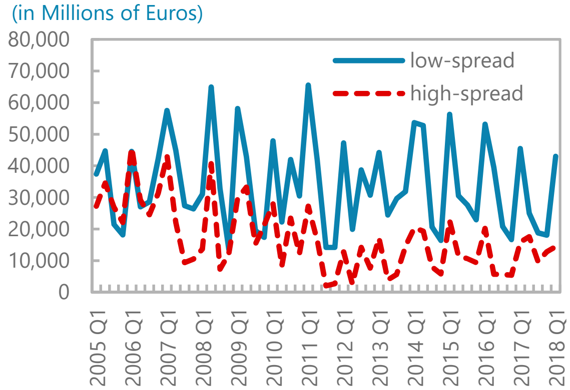
While the spread of secured issuance widened as the financial crisis deepened over concerns on collateral, unsecured issuance was hit by the sovereign debt crisis.

Spread at Issuance Over Swap
(in bp)



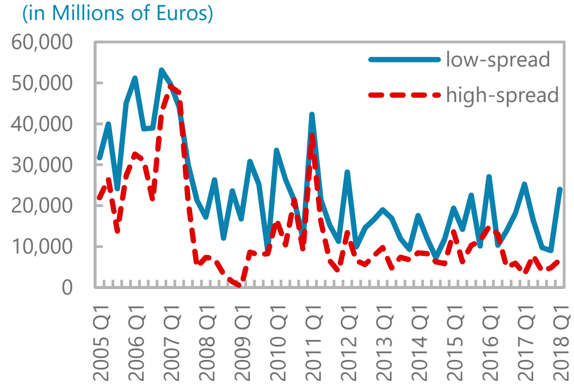
Gross issuance of unsecured bonds fell to near zero during the sovereign debt crisis...

Unsecured Issuance by Region
(in Millions of Euros)



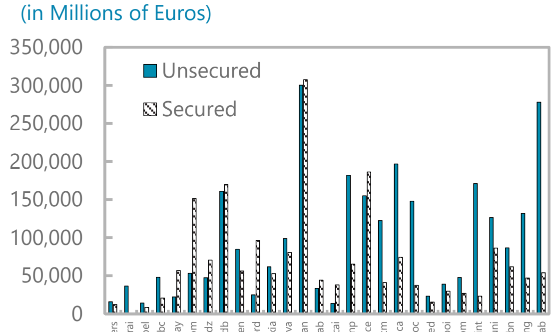
...but was replaced by covered bond issuance.

Secured Issuance by Region
(in Millions of Euros)



There is a wide dispersion in issuance across banks...

Average Issuance by Bank
(in Millions of Euros)



... as well as in cost of issuance reflecting idiosyncratic risk.

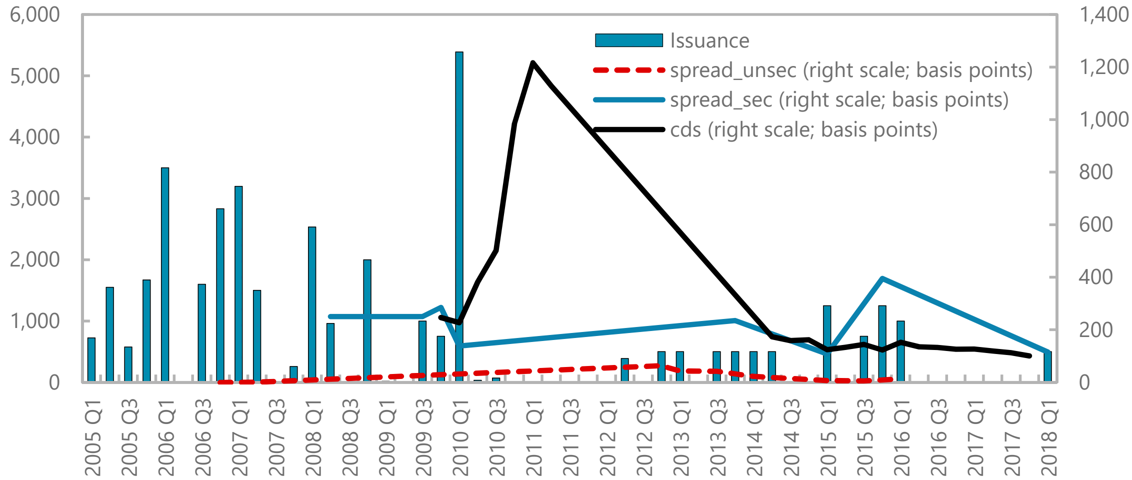
Average Spread by Banks
(in bp)

Source: IMF staff estimates.

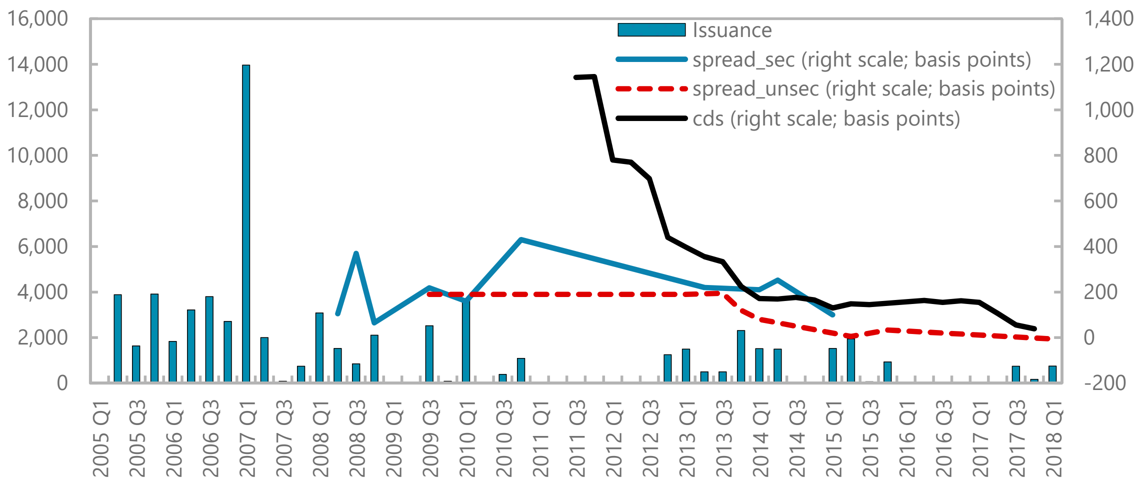
Figure 18. Euro Area: Cost of Debt Issuance for Selected Banks

CDS spreads are not necessarily representative of actual funding costs, as banks under stress tend to stop unsecured issuance or replace it with covered bond issuance when CDS spreads widen significantly.

Allied, Wholesale Funding
(In Million Euros)



Bank of Ireland, Wholesale Funding
(In Million Euros)



Sources: Dealogic, and IMF staff calculations.

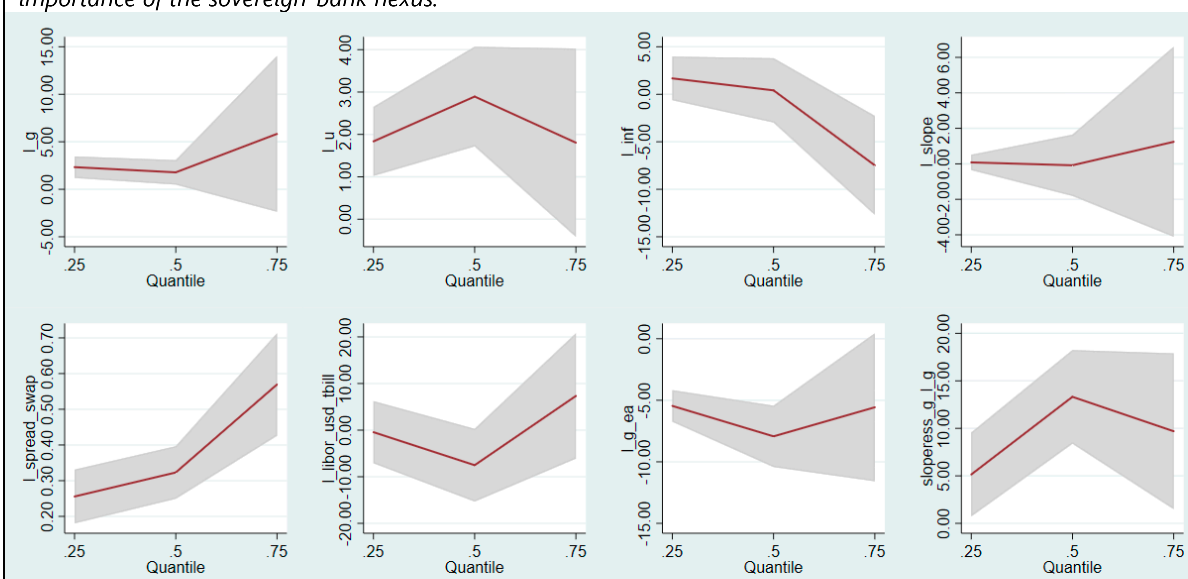
130. Results suggest a high degree of pass-through from changes in policy rates to customer deposit rates. For the pooled regression, the elasticity of deposit rates to changes in the ECB's main refinancing rate reaches 0.2 (Annex Table 6). There is also evidence of some cyclical behavior of rates with an economic expansion in the euro area and tighter money market spreads contributing to higher deposit rates. On the other hand, sovereign stress is not associated with moves in deposit rates. This analysis does not include the effect of the potential downgrade to banks' credit ratings from changes to the potential uplift from government support which was observed during the European sovereign debt crisis.

131. Debt spreads on bank issuance are mainly driven by sovereign spreads, ted spread, and bank solvency. Econometric results shown in Annex Table 7 are consistent with the sovereign-bank nexus whereby higher domestic sovereign stress pushes up the cost of raising market funding by reducing the sovereign rating uplift. A shortage of global liquidity, proxied by a widening of the TED spread, also raises the cost of debt issuance. The elasticity of bank equity to debt spreads is negative and statistically significant.

132. Quantile regression results show that the negative contribution of sovereign stress to the cost of debt issuance rises with sovereign stress. Figure 19 shows the coefficients of the main drivers of wholesale funding costs by quartile. At higher quartiles, the coefficient of sovereign spreads on funding costs is economically and statistically more significant than at lower quartiles pointing at an amplification mechanism from sovereign distress to stress in the banking sector through market issuance.

Figure 19. Euro Area: Determinants of Bank Debt Spreads, Quantile Regression

For higher quartiles, the coefficient of sovereign spreads on funding cost is more significant, pointing at the importance of the sovereign-bank nexus.

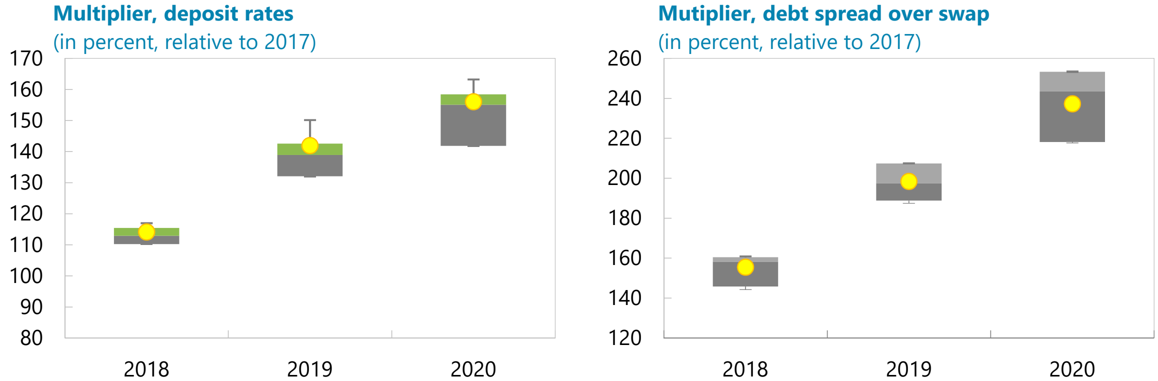


Source: IMF staff calculations. The panel shows the estimated coefficients across quantiles for lagged values of: GDP growth (l_g), unemployment (l_u), inflation (l_inf), the slope of the yield curve (l_slope), the spread of the 10-year sovereign yield over swap rate (l_spread_swap), the 3-month usd libor minus the 3-month US T-bill (l_libor_usd_tbill), GDP growth in the euro area (l_g_ea), and a dummy g | g<0 (stress_g_l_g).

133. The adverse scenario is significantly more severe on the cost of debt issuance than on shifts to deposit rates. Figure 20 shows the box plots that illustrate the distribution of multipliers for projections of deposit rates and debt spreads over the stress test horizon relative to the starting point. While deposit rates rise gradually by 15 percent, 42 percent, and 56 percent over 2018–2020, debt spreads increase by up to 240 percent by 2020. This is consistent with the higher risk sensitivity of wholesale funding relative to core retail deposits.

Figure 20. Euro Area: Distribution of Multipliers Relative to Starting Point

Stressed macrofinancial conditions increase the cost of debt issuance relative to deposit funding.



Note: The charts show the multiplier of deposit rates (LHS) and debt spread over swap (RHS) over the stress test horizon relative to the starting point. Boxplots include the mean (yellow dot), the 25th and 75th percentiles (grey box, with the change of shade indicating the median), and the 15th and 85th percentiles (whiskers).

Pass-through Modeling

134. By contrast with the empirical literature, the pass-through to lending rates was estimated using banks' actual funding rates as well as their asset and liability structure. Loan and deposit pricing relationships are often estimated averaging variables and estimating aggregate time series at the country level. Other approaches include the estimation of net interest income at the individual bank level (both approaches are reflected in STAMP€, 2017). The relationship between bank lending rates and funding costs are typically estimated as a mark-up over a proxy rate rather than using banks' actual funding costs.[55] A notable exception is BIS (2015) where the relationship between lending rate and market rates are based on banks' effective funding costs taking into account banks' liability structure.[56] However, this approach compares funding costs against aggregate lending rates on mortgage and corporate loans rather than on bank's actual lending rates on their lending portfolio.

[55] See Harimohan, McLeay, and Young (2016), Schmitz, Sigmund, and Valderrama (2017), Arnould, Pancaro, and Zochowski (2018, forthcoming).

[56] A key difference is that the authors use the CDS rate over swap rate as a proxy of the cost of debt issuance, rather than using banks' actual spreads over swap rate which is the approach taken in this note.

135. The relationship between lending rates and funding costs is as follows:

$$l_t^i = \alpha + \gamma_1 \cdot l_{t-1}^i + \gamma_2 \cdot state\ \mathrm{var}_{t-1}^c + \gamma_3 \cdot funding_{t-1}^i + \gamma_4 \cdot bank_t^i + \gamma_5 \cdot funding_{t-1}^i \cdot bank_t^i + \varepsilon_t^i$$

where l_t^i denotes the implicit lending rate for bank *I*. The equation includes an autoregressive coefficient and controls for the state of the economy reflected in the scenario. The coefficient γ_3 shows the pass-through of funding costs to lending rates.

136. The empirical strategy includes panel-based regressions as well as quantile regressions. Analogous to the modeling approach used to project funding costs, a panel based regression is performed using fixed effects. Results are shown at the aggregate level for the entire pool of banks as well as broken down at the home country level. A quantile regression approach is used to assess the impact of underlying drivers at different percentiles of the lending rate distribution.

137. There is mixed evidence of pass-through effects across countries. The relationship between funding costs and lending rates is summarized in Annex Table 8. First, the autoregressive coefficient suggests the relevance of banks' back book of loans made in earlier periods. Second, results show that the state of the local economy affects banks' lending rates with stronger GDP growth and wider sovereign yields contributing to higher lending rates. There is mixed evidence on pass-through of bank-specific funding costs to customers. While this effect is significant for countries 1 and 2, there is no evidence on interest pass-through in other countries after controlling for financial conditions.

Impact on Net Interest Margin

138. Using ECB's IRRBB data template, maturity gaps by product, maturity bucket, and currency were constructed. For funding costs, the maturity buckets include instruments without specified maturity, overnight, <1-month, 1–3-month, 3–6-month, 6–12-month, …,1–2-year,…,>20-years. Maturity buckets were constructed separately for deposit and debt securities as deposits tend to reprice at shorter tenors than debt securities. The coverage of securities includes fixed- and floating-rate instruments denominated in euro and non-euro. Maturity gaps are computed according to banks' modelling assumptions and to contractual conditions. Debt instruments at floating rate were repriced at the market-based swap rate. Debt securities issued with remaining contractual maturity within the maturity bucket were re-issued at the projected swap rate and spread over swap, capturing both systematic and idiosyncratic risk.

139. The impact of interest rate shocks on banks' net interest income was calculated using Strategy 2 as:

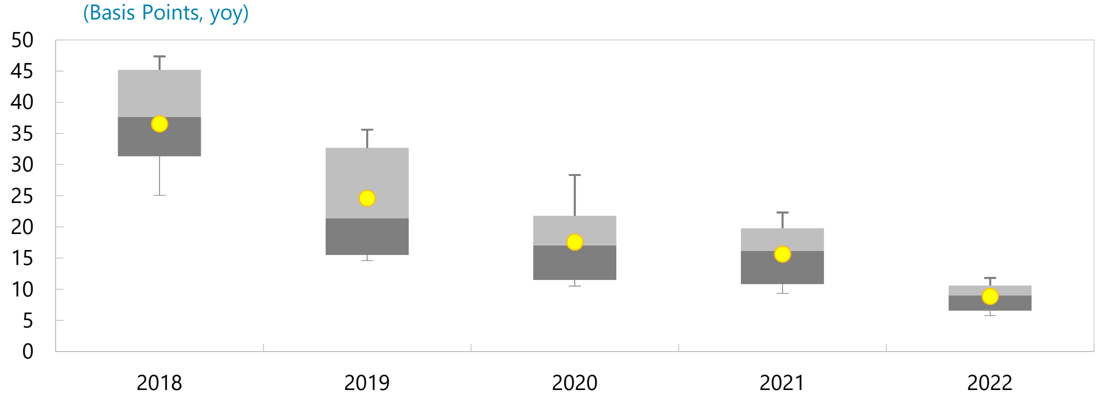
$$NII_{i,t} = \sum_b gap_{i,t}^b \cdot mid_{i,t}^b \cdot \Delta nim_{i,t}^b$$

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*, and $\Delta nim_{i,t}^b$ is the net interest margin shock for bank *i* at time *t*.

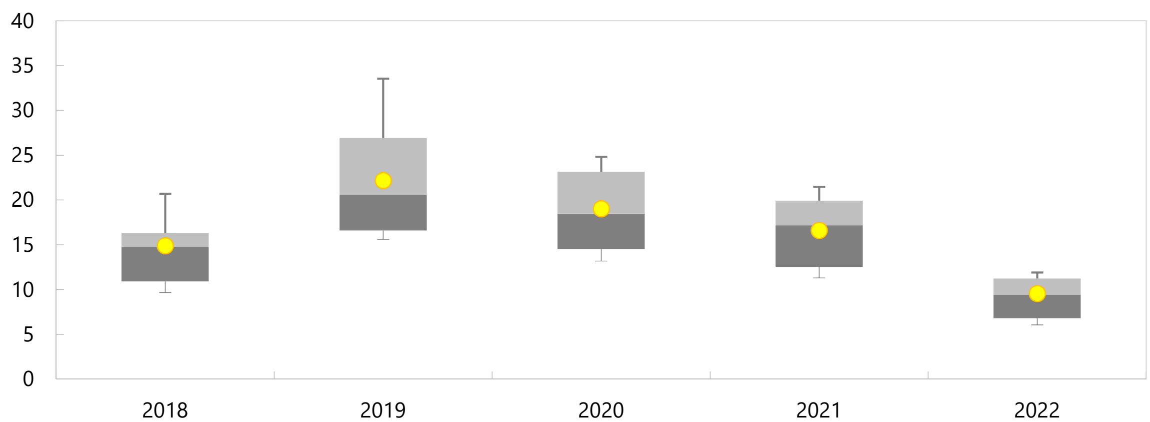
Figure 21. Euro Area: Distribution of Bank Level Rates under the Adverse Scenario

On average, margins contract by over 20 bps in 2017 with banks at the bottom quartile seeing their margins eroded by 35 bps.

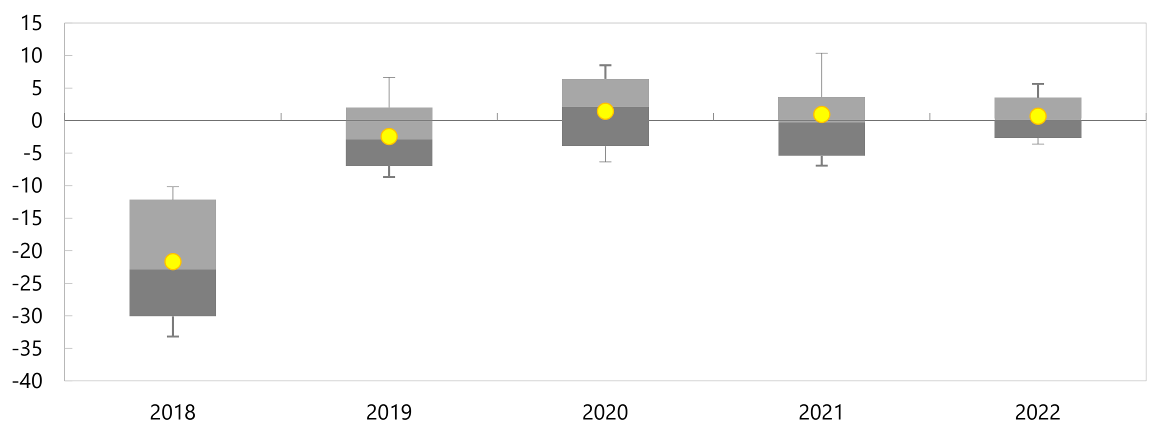
Projected Shocks to Funding Costs
(Basis Points, yoy)



Projected Shocks to Lending Rates
(Basis Points, yoy)



Projected Shocks to NIM
(Basis Points, yoy)



Note: Boxplots include the mean (yellow dot), the 25th and 75th percentiles (grey box, with the change of shade indicating the median), and the 15th and 85th percentiles (whiskers).

140. On average, margins contract by over 20 bps in 2018 with banks at the bottom quartile seeing their margins decrease by 35 bps. Figure 21 shows the year-on-year impact of adverse conditions on, funding costs, lending rates, and net interest margins funding costs, lending rates, and margins. By contrast with the results shown for Strategy 1, accounting for the empirical estimation of pass-through effects alleviates the negative impact of stress on banks' net interest margins.

F. Other Profit and Loss Items

141. To compensate for compressed net interest margins some banks in the euro area have adapted their business models, moving towards more fee and commission-(F&C) generating activities. To offset the expected decline in net interest income related to the current low interest rate environment, some euro area banks have started to gradually shift income generation towards business generating fees and commissions. Net fees and commission income includes income from fiduciary activity, deposit fees, securities transfer orders and issuances, asset management services, and sales of third parties' investment products.

142. At the same time, there are concerns over the financial stability implications from greater reliance on F&C.[57] Some banks have expanded their asset management activities and sales of shares of collective investment funds. However, the competition on markets such as those for investment products, where nonbanks are active too, is strong and growing. Even if banks were able to markedly increase fee and commission income, the higher degree of income diversification might not improve the stability and resilience of banks' overall net income. This would hinge on how resilient F&C income is to adverse developments in financial markets.

143. Banks' reliance on fees and commissions varies across business models. There are substantial differences in the degree to which the 28 banks rely on F&C income. Within the stress testing sample, the share of F&C to total assets of the average bank reached over 50 basis point in 2016. There is a wide dispersion in the distribution with universal banks relying on F&C to a greater extent. The range varies between one- and two-thirds of a percentage point in the first and third quartile of the distribution.

144. The empirical strategy relied on the estimation of a dynamic panel data model over the pool of banks:

$$fc_t^i = \alpha + \mu_1 \cdot fc_{t-1}^i + \mu_2 \cdot macro_t^c + \mu_3 \cdot fin_t^c + \varepsilon_t^i$$

where fc_t^i is the share of fees and commissions to total assets for bank *i* at time *t* and the vector of explanatory variables. The model is estimated using the system Generalized Method of Moments (GMM) estimator developed by Arellano and Bond to address endogeneity and dynamic panel bias.

[57] ECB (2016), "Adapting bank business models: financial stability implications on greater reliance on fee and commission income", Financial Stability Review.

145. On the back of the linkages between F&C income and financial markets, the set of predictors include a wide range of financial conditions.[58] The set of variables comprises the lagged F&C over assets, contemporaneous and lagged GDP growth, the inflation rate, house price growth, stock market returns, the first difference of the short- and the long-term rate, equity volatility, government spread over swap, and TED spread.[59]

146. Results show that the share of fees and commission increases with a flattening of the yield curve and equity volatility. Annex Table 9 shows that the shape of the yield curve definitely affects banks' reliance on fees and commission income. This is reflected in the positive coefficient of the short-term rate difference and the negative coefficient of the long-term rate difference. This result suggests that to compensate for the decline in net interest income associated with the flattening of the yield curve, banks have started to gradually shift income generation towards business generating fees and commissions, instead of interest flows.

147. 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 bank supervisory returns drawing on FINREP data. The main variables included:

- Dividend income;
- Other operating income;
- Non-interest expenses including administrative expenses, depreciation, negative goodwill and other operating expenses;
- Tax expenses over net profits.

148. The stress test analysis does not take into account one-off adjustments. One-off adjustments reported in banks' income statement are considered to be non-recurrent events. Therefore, their P&L impact is zero under both baseline or adverse conditions. The list of one-off events includes profit and loss from non-current assets, discontinued operations, and disposal groups, as well as extraordinary profit.

149. Dividend payout behavior, which is crucial to a bank's ability to recover from shocks, was linked to its profits and bank capital ratio. The dividend payout ratio was subject to the following constraints: (i) A floor set at 30 percent (positive profits); (ii) the capital conservation buffer schedule for CET1; and (iii) statistical analysis on historical dividend

[58] See Kok, C., Mirza, H., and Pancaro, C. (2017), "Macro stress testing euro area banks' fees and commissions", European Central Bank, Working Paper No. 2029, February for a scenario-based analysis of fees and commissions using the 2016 EU-wide stress test scenarios.

[59] The set of predictors is similar to those in ECB (2017), "STAMP€" with greater focus on financial variables.

payments. If profits exceeded 50 percent of income at the cut-off date, the dividend payout ratio was set at 50 percent.[60] If banks were making losses, a zero-dividend payout was assumed.

G. Solvency Results

150. Under the baseline scenario, there is a modest increase in capitalization ratios, reflecting supportive cyclical conditions. Baseline projections imply a weighted-average 40 basis point increase in banks' CET1 ratio at the end of the 3-year horizon as banks continue to build capital through retained earnings and as capital requirements for credit risk decrease (Figure 22). The results differ, however, across business models. Large, but less complex, internationally-active banks benefiting most from improved macroeconomic conditions. These banks experience larger improvements to asset quality which contributes to RWA contraction. In addition, they benefit from an increase in their lending margin in core markets as well from larger expansion in their loan books boosted by credit demand across geographies.

151. Under the adverse scenario, although minimum capital requirements are met in aggregate, a few banks are significantly more vulnerable. Macroeconomic shocks and trading book risk stress are the main determinants of outcomes, but with some degree of variation across banks due to differences in business models, risk exposures, legacy portfolios, and banks' efforts to build up provisions for non-defaulted exposures (Figure 23).[61]

152. Large, but less complex, internationally-active banks are relatively more resilient on average.[62] The comparatively greater impact on G-SIBs partly stems from their large trading books and wholesale funding structures. Domestically-oriented banks are less able to diversify credit risk owing to more limited cross-border activities. Even within the broad business model groupings, bank results differ substantially across G-SIBs and domestically-oriented banks due to differences in their geographic exposures and sensitivity to market shocks. Comparable results are obtained using alternative solvency and profitability metrics (Figure 24).

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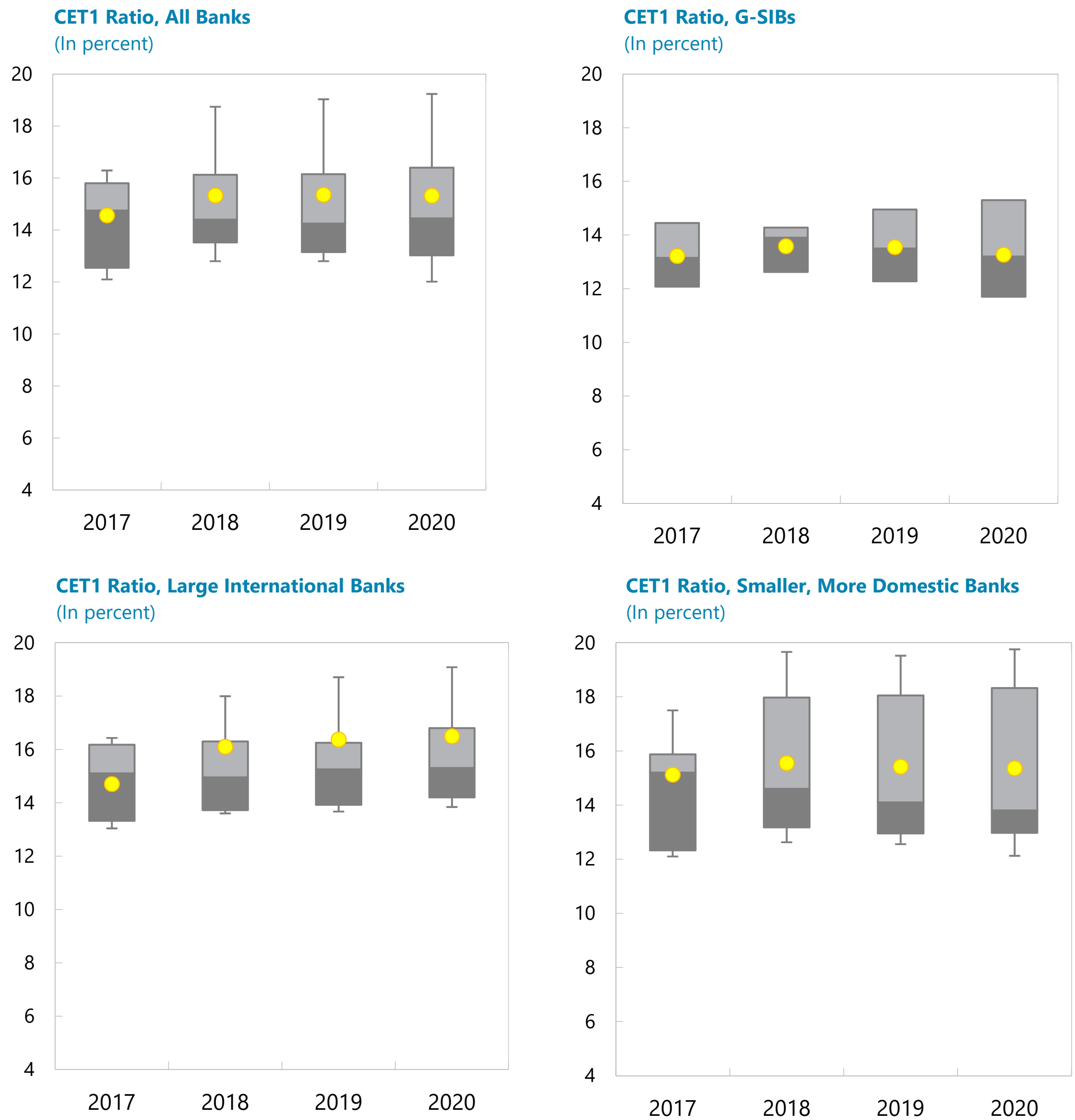
[60] This implies that banks can build capital buffers under the baseline. This is not material under stressed conditions as most banks make losses in the adverse scenario.

[61] The dispersion in bank capital ratios has increased in 2017 relative to 2016 as strong banks have distributed higher dividend payments and expanded their balance sheets while weak banks have de-risked their balance sheet, increased intermediation margins, and stepped-up efforts in fee and commission generated income. The coefficient of variation increases further under stress from 16 percent in 2017 to 23 percent in 2020.

[62] At the lower quartiles, however, weak large internationally active banks do not show higher resilience than their peers.

Figure 22. Euro Area: Solvency Stress Testing Results: Baseline Scenario

Aggregate risk-weighted CET1 capital ratios rise modestly, particularly for the less complex, large internationally-active bank.



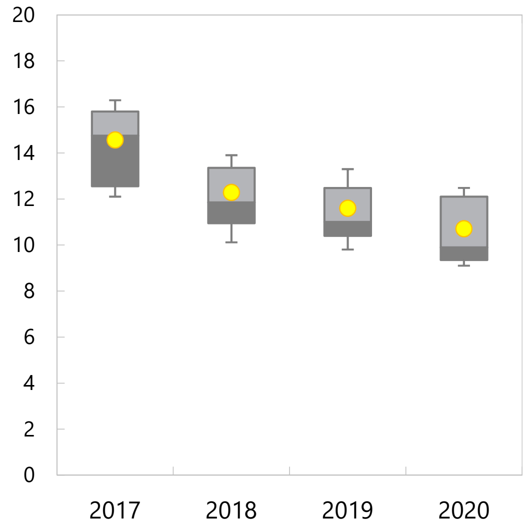
Source: IMF staff estimates based on ECB/SSM supervisory data.

The CET1 capital ratio is defined as common equity Tier 1 capital in percent of risk-weighted assets (RWAs) consistent with CRR and CRD IV. It includes phase-in of capital deductions excluding items subject to national discretion. Boxplots include the mean (yellow dot), the 25th and 75th percentiles (grey box, with the change of shade indicating the median), and the 15th and 85th percentiles (whiskers).

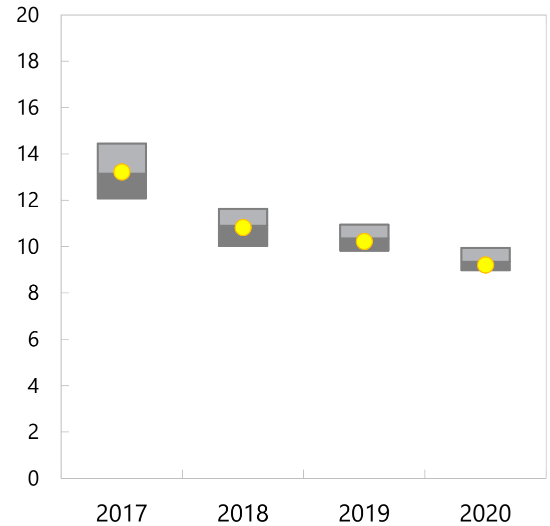
Figure 23. Euro Area: Solvency Stress Testing Results: Adverse Scenario

Aggregate risk-weighted CET1 capital ratios fall by about 390 basis points, with a slightly larger impact on G-SIBs.

CET1 Ratio, All Banks
(In percent)

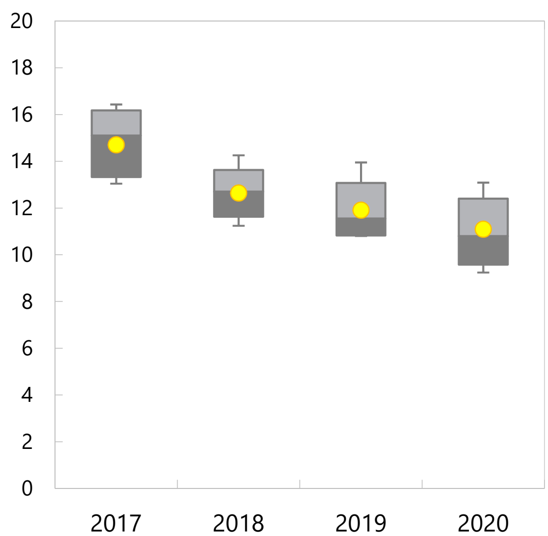


CET1 Ratio, G-SIBs
(In percent)

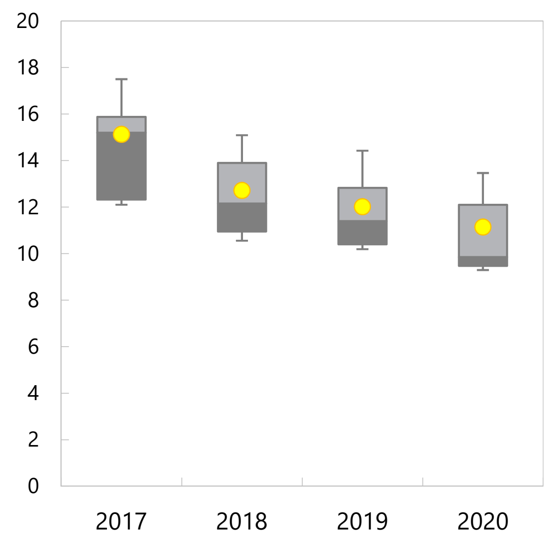


The capital shortfall is smaller for less complex internationally-active banks in contrast to domestically-oriented banks which incur a greater-than-average hit to the capital ratios.

CET1 Ratio, Large International Banks
(In percent)



CET1 Ratio, Smaller, More Domestic Banks
(In percent)

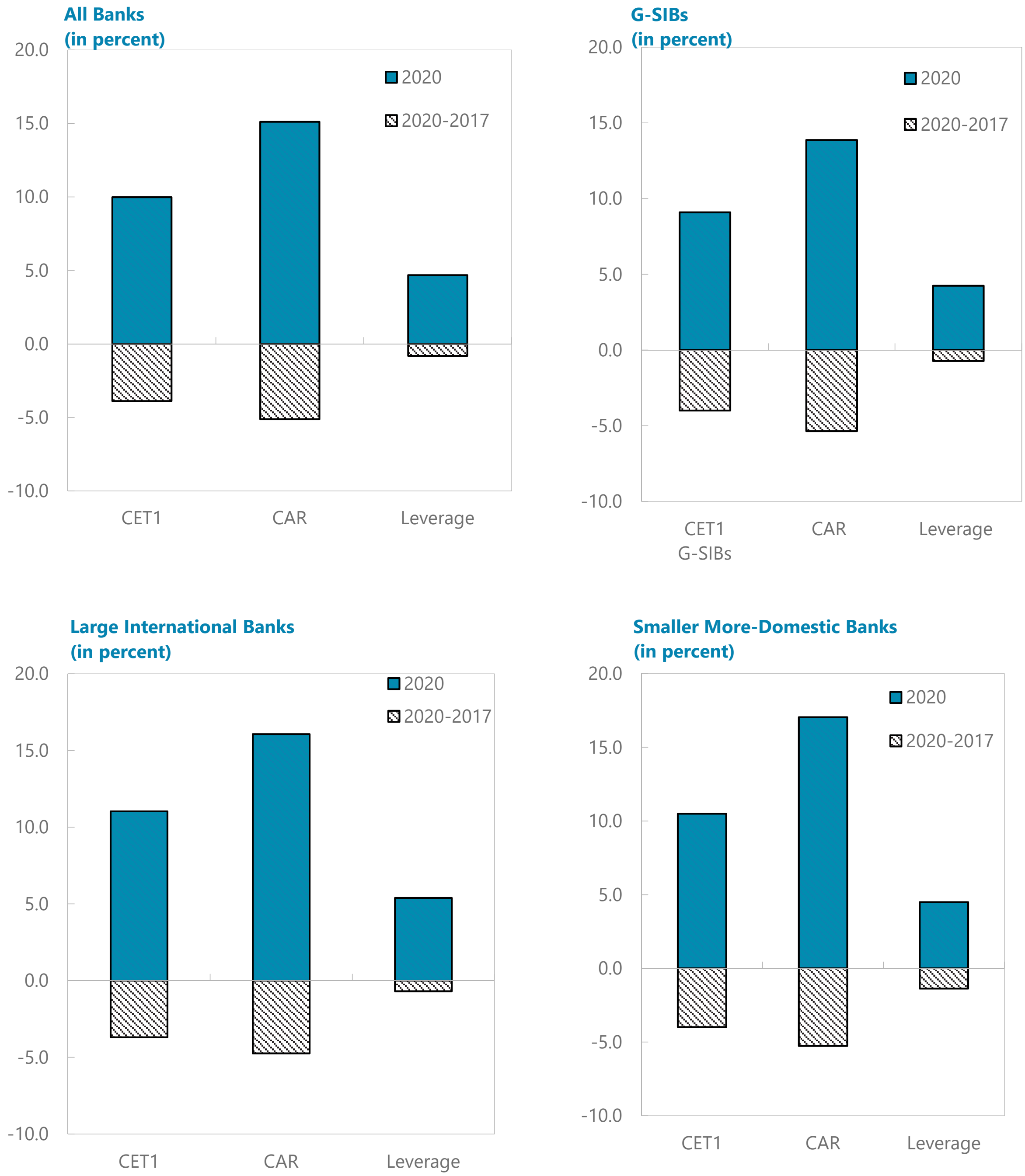


Source: IMF staff estimates based on ECB/SSM supervisory data.

The CET1 capital ratio is defined as common equity Tier 1 capital in percent of risk-weighted assets (RWAs) consistent with CRR and CRD IV. It includes phase-in of capital deductions excluding items subject to national discretion. Boxplots include the mean (yellow dot), the 25th and 75th percentiles (grey box, with the change of shade indicating the median), and the 15th and 85th percentiles (whiskers).

Figure 24. Euro Area: Solvency Stress Testing Results: Alternative Solvency Metrics in the Adverse Scenario

Broadly comparable results are obtained using alternative solvency metrics. 1/



Source: IMF staff estimates based on ECB/SSM supervisory data.

Note: The charts show the weighted average ratios across types of banks. The blue bar is the 2020 ratio. The shaded bar is the capital depletion under stress. The sum of the blue and the shaded bar is the ratio in 2017.

1/ The relatively smaller impact on the leverage ratio is because it is computed using total assets rather than risk-weighted assets (as in the case of the other two solvency ratios).

153. The impact of the adverse scenario on banks' initial capital positions mainly reflects large impairment charges, increased risk-weighted assets, and traded risk stress (Figure 25):

- Weaker global growth, falling real estate prices, and tighter financial conditions increase credit risk and erode collateral values, reducing the aggregate CET1 ratio by 3.0 percentage points relative to end-2016.

- Heightened credit risk (partly driven by PiT shifts to risk parameters), valuation effects in FX exposures, and the projected paths for aggregate lending in the stress contribute to an expansion of RWAs, thereby lowering the CET1 ratio by around 2.1 percentage points across banks.[63]

- Sharp movements in market prices result in substantial losses for banks with large trading books and AFS holdings. These losses are concentrated in 2018 before partially unwinding as asset prices recover. By the end of the stress test horizon, valuation losses decrease the CET1 ratio by 1.0 percentage points on average.

- The aggregate effect of interest rate risk on net income is moderate for most banks, resulting in CET1 ratio which declines by around ½ percentage point. This effect reflects the large stock of customer deposits, which are less sensitive to money market stress; hedging practices to manage duration risk; the repricing structure of debt instruments with longer tenors; and banks' ability to partly pass-on higher funding costs to customers.

- Pre-provision net revenue including aggregate NII, non-interest income, and non-interest expenses, increases the aggregate CET1 ratio by 3.1 percentage points relative to the starting point.[64]

154. The stress test results suggest that balance sheet metrics of strength and market-based indicators are insufficient to predict banks' financial strength under stress. The stress testing exercise yields additional insights into banks' future financial strength under stress conditions which are not captured by current financials.[65] Figure 26 shows the lack of co-movement between banks' balance sheet metrics, including regulatory capital, NIM, NPLs, with capital depletion under stress. While higher initial capital buffers contribute to stronger post-stressed capital ratios, a lack of co-movement prevails for alternative metrics of balance sheet strength. Whereas CDS spreads do not discriminate banks under current benign market conditions, they incorporate some forward-looking information under stress in some cases.

[63] Under the adverse scenario, credit demand declines relative to the baseline, but banks are assumed not to reduce credit supply. While credit growth is subdued under the adverse scenario relative to the baseline, some banks posts positive credit growth in line with the projected economic activity in their core geographies. The euro depreciation in the adverse scenario means that the euro value of foreign-currency assets rises, contributing to the expansion of RWAs.

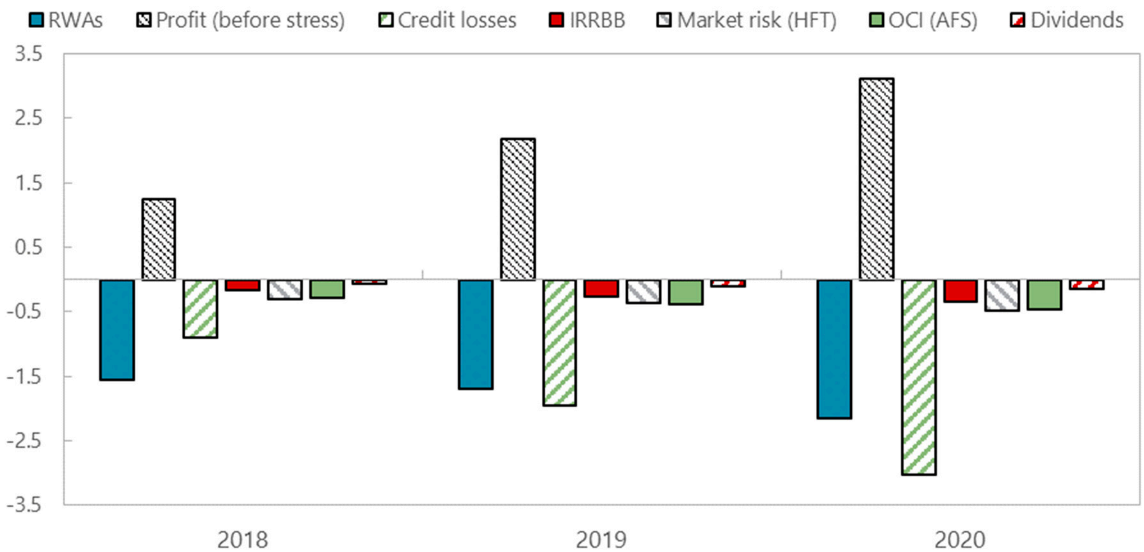
[64] The impact of dividend payments it not material as most banks make losses in the adverse scenario.

[65] This is partly due to the use of granular supervisory data which is not publicly available as well as to the forward-looking nature of the exercise under stress conditions (while financial data is based on baseline conditions).

Figure 25. Euro Area: Solvency Stress Testing Results: Shortfall Contributions in the Adverse Scenario

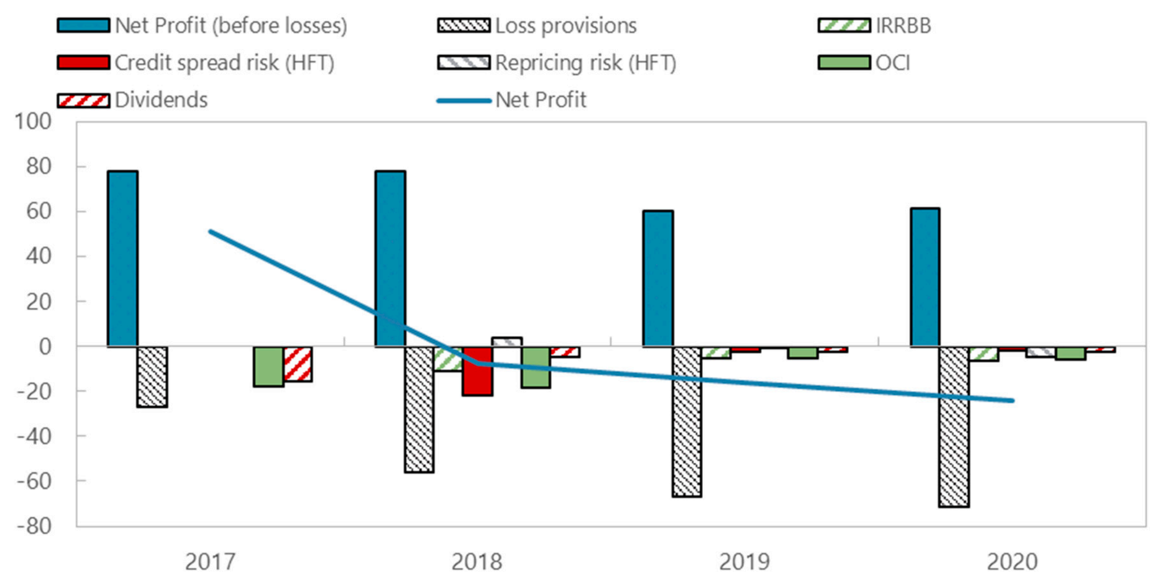
Loan impairment charges, traded risk losses, and rising risk-weighted assets (RWAs) reduce aggregate CET1 ratio by about 3.0 percentage points, 1 percentage point, and 2.1 percentage points, respectively.

Cumulative Impact on CET1 Ratio
(in percent)



On aggregate, banks post negative net profits of €24 billion by 2020 from a pre-stress level of €51 billion in 2017.

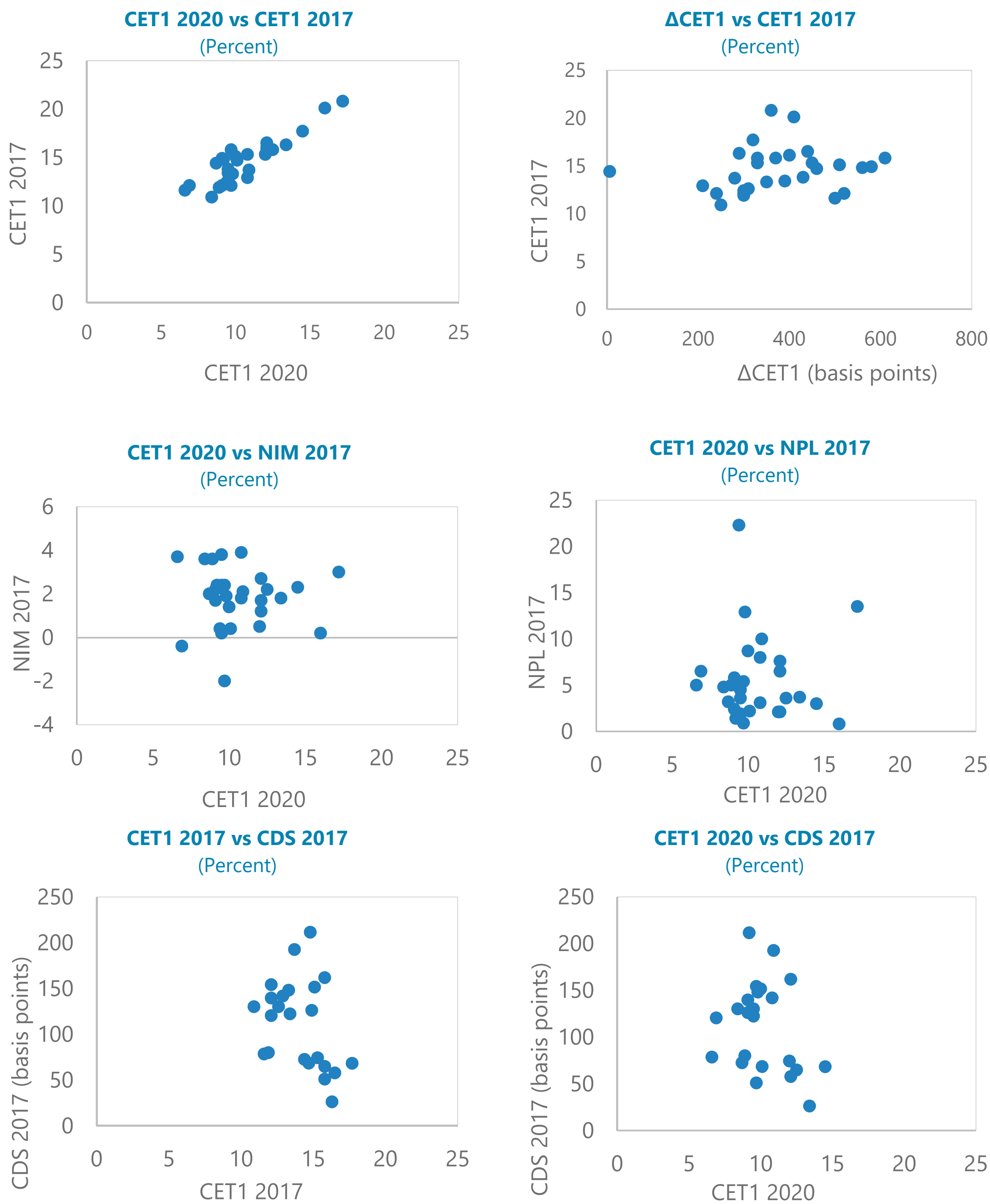
Net Profit
(in billions of euros)



Source: IMF staff estimates based on ECB/SSM supervisory data.

Figure 26. Do Initial Conditions Reflect Stressed Capital?

Initial conditions of balance sheet strength do not reflect capital depletion in a systematic manner.



Source: IMF staff estimates based on banks' Pillar 3 disclosures and Bloomberg data.

H. Sensitivity Tests

Single Factor Tests

155. Scenario-based analysis is accompanied by a range of sensitivity tests to address the diverse risk factors identified above (Figure 27). It is important to underscore that these sensitivity tests are distinct, but complementary to the scenario-based approach. These tests explore (1) the additional losses resulting from replacing selected adverse scenario inputs with hypothetical shocks capturing extreme changes in risk parameters, and (2) banks' sensitivities to a low-for-long interest rate environment over the 3-year horizon:

- Interest rate risk: Replacing the shift to risk-free curves and the model-based funding and lending rate paths under the adverse scenario with a hypothetical 200 basis points parallel upward shift reduces the aggregate CET1 by 200 bps. This test incorporates the impact of hedges to mitigate IRRBB but excludes fair-value hedges on financial assets. G-SIBs are relatively more impacted given the size of their trading portfolio;[66]

- Further decompression of risk premia: A 200 bps widening on own (not all) sovereign spreads over the swap curve lowers the post-stress aggregate CET1 ratio by an additional 30 bps; some less international banks are affected relatively strongly.[67] A widening of spreads on corporate bonds (including bonds issued by financial institutions) similar to that observed during the 2008 leads to a further 175-bps reduction in CET1 capital; the valuation losses more than offset higher earnings.[68] G-SIBs are more severely affected given their larger corporate bond exposures;

- Credit rating downgrade: A one notch-credit downgrade (on standardized exposures) erodes bank capital ratios by 60 bps. Domestically-oriented banks are impacted more severely on the back of their exposure to credit risk corrections and higher reliance on external ratings;

- Tighter LGD floor on mortgage loans: An LGD floor of 30 percent on residential mortgages in their home (headquarter) jurisdiction reduces the aggregate CET1 ratio by around 40 bps. The effect is larger for smaller banks due to their larger share of domestic mortgages;

- Low-for-long: Under the current low interest rate environment, most banks would suffer a hit to their net interest income, resulting in an average CET1 reduction of 85 bps at the end of the three-year horizon.

---

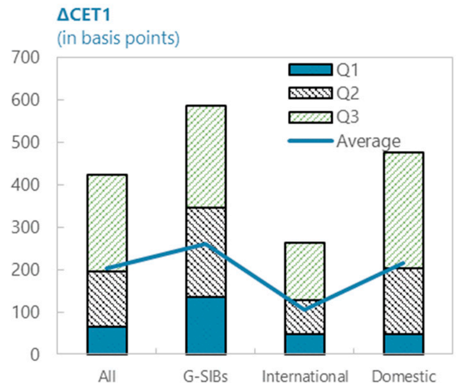
[66] The estimate is conservative because the hedging of trading assets and liquid buffers is neglected.

[67] The stylized 200bps shock is the average widening in sovereign spreads for 5-year Spanish and Italian sovereign bonds over the Bund during the euro area sovereign debt crisis (2010–11).

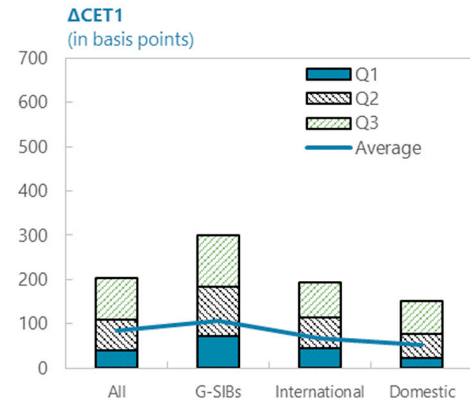
[68] This shock represents around 350 bps widening of spreads over Bund relative to the average 70 bps spread projected under the scenario. The calibration is linked to projections over 5-year Baa-rated European corporate bond spreads for financial and non-financial debt securities.

Figure 27. Euro Area: Solvency Stress Testing: Sensitivity Analysis

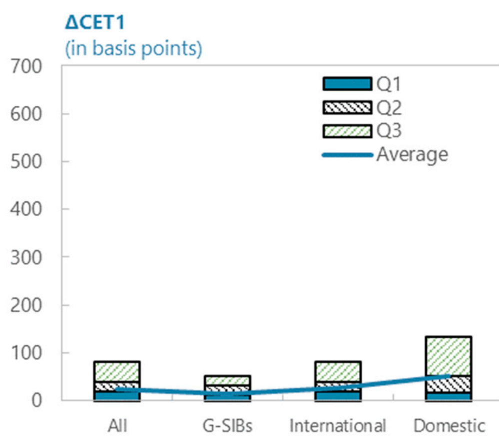
Higher interest rates (200 basis point upward parallel shifts)



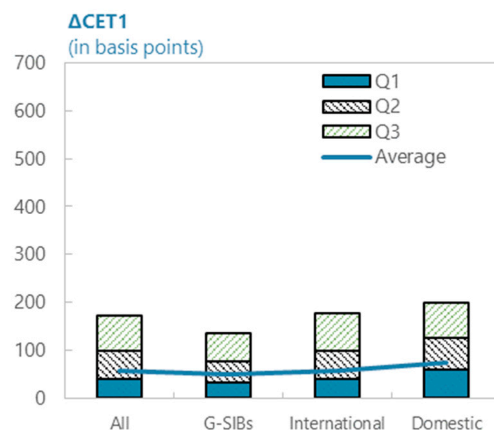
Low-for-long interest rates over 3 years, relative to baseline



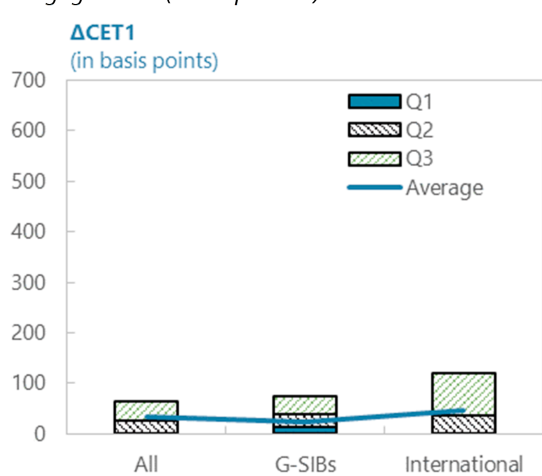
Higher (own) sovereign spreads (200 basis points)



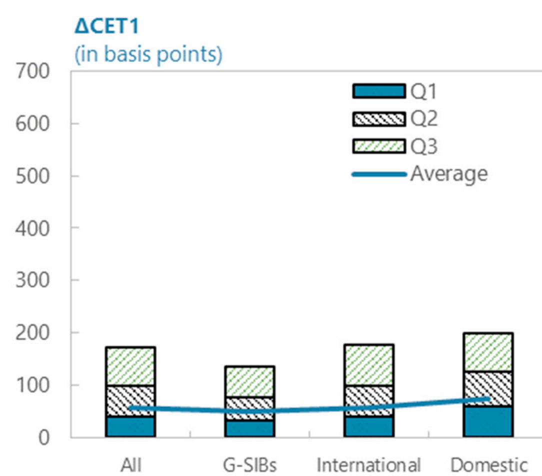
Corporate credit spread shock



30 percent loss given default (LGD) floor on domestic mortgage loans (IRB exposures)



1-notch credit rating downgrade on STA exposures



Source: IMF staff estimates based on ECB/SSM supervisory data.

Note: The charts show capital depletion measured as CET1 at the starting point minus the projected CET1 under the assumed instantaneous shock, except for the 'Low-for-Long' test which shows initial CET1 minus projected CET1 at the end of the 3-year horizon.

Hard-to-value Assets

156. A sensitivity-based reverse stress test on hard-to-value assets was performed. There are concerns that the book valuation of some hard-to-value assets can be kept artificially high, leading to possible excessive risk exposure. At the same time, supervisors have turned a spotlight on banks' riskiest assets and induced banks to reduce their holdings of hard-to-value investments.

157. The calibration of the shock was linked to the opacity of the instrument and the fair value category. Instruments that are more opaque (e.g., complex derivatives) were hit harder than other bespoke trades (e.g. reverse repos). Also, Level 2 assets, which are valued using inputs other than quoted prices due to insufficiently market liquidity or traded over-the-counter were subject to less severe shocks than Level 3 assets which use inputs that are not based on observable market data (referred to as unobservable inputs).[69]

158. The results show that even a modest valuation shock on Level 2 and Level 3 assets would have a significant impact on some G-SIBs capital buffers. A combination of 10 percent valuation shock in Level 3 assets and 5 percent in Level 2 assets could deplete the capital buffers of some large banks over the SREP regulatory minimum (including the phased-in G-SIB capital surcharge, Pillar 2 requirement, and SRC buffer). This is a conservative estimate as stress test impact has not been adjusted for valuation reserves.

LIQUIDITY RISK ANALYSIS AND STRESS TESTS

A. Overview

159. The liquidity risk management and liquidity conditions have significantly improved in recent years. The GFC raised awareness for liquidity risk in the banking system and reduced bank managements' and bank shareholders' liquidity risk tolerance. Regulators and supervisors also became more sensitized to liquidity risks. The introduction of the LCR and the NSFR (likely as of 2019) has improved liquidity regulation and the availability of reporting data across the euro area (EA). The SSM has introduced a comprehensive set of standardized analysis tools, including liquidity stress tests based on supervisory data. At the same time, accommodative euro area monetary policies have led to high central bank excess reserves.

160. To assess current banking system liquidity risks, a comprehensive analysis of large banks' structural liquidity ratios is complemented with a variety of liquidity stress tests. The structural analysis considers the Basel III LCR and the NSFR. While the former measures short-term liquidity risks, the latter ratio gauge more structural longer-term refinancing and funding risks. The FSAP team did not stress structural LCR/NSFR ratios as it is unlikely that during

[69] On aggregate, the calibration specified double degree of severity in the valuation shock for more opaque instruments (e.g., long-term derivatives), and for Level 3 assets (in the fair value hierarchy). Only hard-to-value assets were subject to valuation shocks with no beneficial impact from fair-value adjustments in liabilities.

the times of stress these will be binding (i.e. bank must meet average LCR requirement over the calendar month time horizon, rather than daily) and focused on cash flow based stress tests instead. Cash flow-based liquidity stress tests were conducted using supervisory data on contractual cash flows for different maturity buckets. This approach employs multiple scenarios of increasing severity covering several horizons (for example, 4 weeks, 3 months) with varying assumptions regarding liquidity buffers and shocks to cash inflows and outflows. Also, a "collateral freeze" scenario was simulated, wherein the collateral held at CCPs and available for rehypothecation remains inaccessible for five business days due to a cyber risk event.[70]

161. To deal with parameter uncertainty, the cash flow tests were conducted over a wide range of scenarios featuring different degrees of severity and central bank (CB) support. The calibration of the liquidity stress test drew on the assumptions built into the solvency stress test to ensure consistency among both tests. For example, stressed market values of securities or markets' reaction towards banks' ability to raise funding after drop in capital ratios. The tests also incorporated assumptions about gradual tightening of monetary conditions, such as changes in eligible collateral used to obtain liquidity from the CB, and changes in interest rates.[71]

162. Liquidity risk analysis used multiple data points to highlight structural changes in banks' funding structure. Multiple data points (from Q1 2014 to Q3 2017) from supervisory data templates allowed the FSAP team to deep dive into structural liquidity risks of sample banks, in particular to assess how liquidity risk bearing capacity of banks changed through the four-year time period.

B. Structural Liquidity Risks

Liquidity Coverage Ratio (LCR)

163. Liquidity analysis reveals that all banks in the sample meet the 100 percent minimum LCR requirement. LCR ratios are comfortably above minimum requirements, highlighting large liquidity buffers banks accumulated since the GFC, including long-term funding from the ECB (Figure 28). Shorter maturity transformation by banks also played a role. Across business models, domestically-oriented banks have higher LCRs, partly due to lower reliance on short-term wholesale market funding but higher reliance on long-term CB funding.

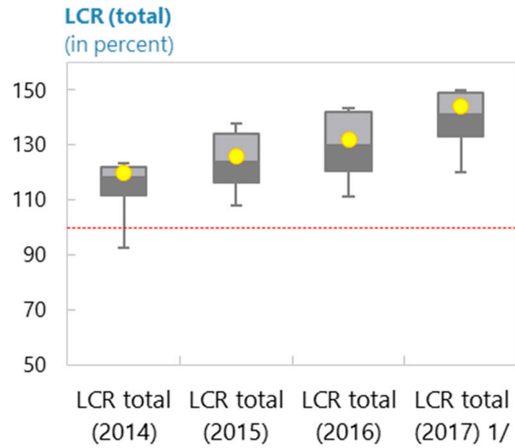
164. Short term overnight funding is a source of liquidity risk during times of market turbulences. Overall overnight funding is close to 22 percent (Figure 28), but some G-SIBs and some large, but less complex, internationally-active banks have even higher share of short-term unsecured funding from financial corporations. This makes those banks more vulnerable to sudden market-wide liquidity dry-outs.

[70] The latter may be a significant source of risk for major European banks given their large notional values in derivatives. Recent reforms may have transformed counterparty credit risk (solvency risk) into liquidity risk. Further enriching liquidity stress testing to account for these developments requires confidential data from ESMA, which was not available during the FSAP mission.

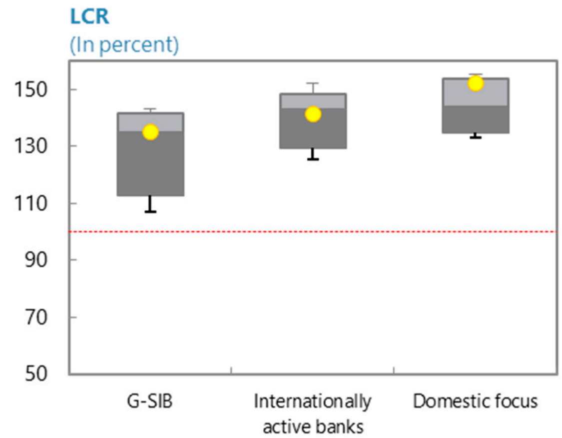
[71] Reliance on central bank financing is one of the indicators of liquidity strain.

Figure 28. Euro Area: Liquidity Coverage Ratio and Structure of Funding by Maturity[1]

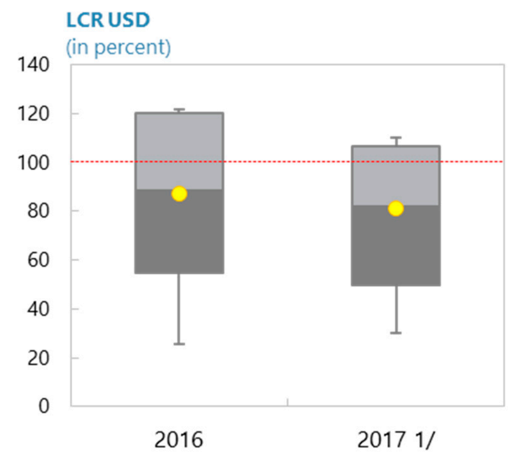
LCR are above 100 percent and reflect large liquidity buffers banks accumulated…



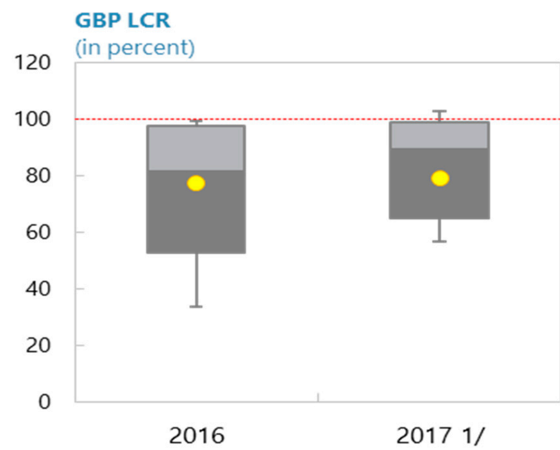
…and smaller domestically-oriented banks have largest total LCR on average



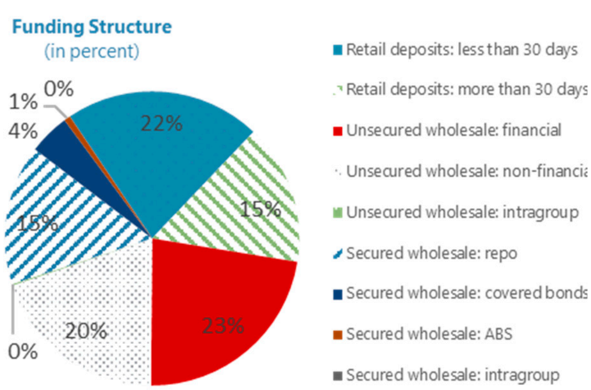
But maintaining USD LCR above 100 percent is a challenge for multiple banks.



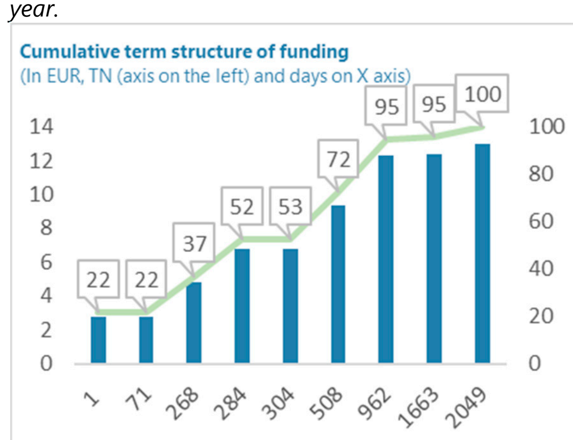
GBP is important for a limited set of banks, and LCR GBP is below 100 percent as well.



Largest share of retail funding is very short term….



…with more than half of funding maturing within one year.



Sources: ECB, and IMF staff calculations.

1/ 2017Q3

165. Retail funding, treated as more stable from the LCRs perspective, in the sample of banks is 37 percent. While retail deposits are the core and stable base of funding for banks, it is typically very short term, especially as customers do not want to lock-in to low or zero interest rates. 74 percent of those retail deposits are insured, bringing the total share of insured deposits to 28 percent of total liabilities. From a funding risk perspective, deposit insurance provides additional stability by lengthening behavioral terms of these deposits, but is an implied contingent liability for the sovereigns or the banking system as a whole, which, in our sample of banks, amounts to €3.6 trillion.

166. Smaller domestically-oriented banks in the sample are very diverse, with some of them having less than 10 percent of retail deposits as a source of funding. At the same time, those banks typically have higher proportion of secured long-term funding (long-term repos with CB, covered bonds, and Asset Backed Securities, ABS). This group of smaller domestically-oriented banks would be vulnerable to liquidity risks if the market liquidity of secured bonds were to freeze.

167. Foreign exchange funding, particularly for the U.S. dollar, remains a source of vulnerability for selected banks. The U.S. dollar and the British pound are the most important foreign currencies that the sample of 29 banks are exposed to. There is no formal requirement to maintain 100 percent LCR for these currencies. In fact, LCRs for these currencies are volatile and fall substantially below 100 percent for many of the banks (Figure 28). Banks appear to rely on amply U.S. dollar liquidity and the backstop of CB swap lines in the case of more turbulent market conditions.

168. The use of collateral swaps does not reveal significant liquidity risk in the sample of banks. Collateral swaps may be used to meet the regulatory liquidity requirements, including the LCR, at the end of reporting periods. For example, such a transaction would allow a bank to borrow liquid assets in exchange for a less liquid assets (from another financial institution such as insurance company that would receive a fee). Almost half of the banks in our sample engage in such transactions, however the amounts were not material relative to total LCR requirements.

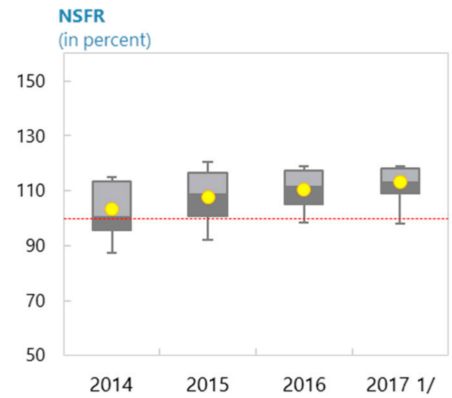
NSFR and Core Funding

169. Banks are well placed for the introduction of 100 percent NSFR requirement (Figure 29). Most of the banks report NSFR ratios above 100 percent, and aggregate stable funding needs are just short of €14 billion (a surplus in banks which report NSFR above 100 percent reaching €950 billion), but this is mainly driven not by the stock of long term market funding (exceeding one year), but by the large amounts of highly liquid short-term assets (sovereign bonds, deposits within central banks) and long-term repos with central banks.[72]

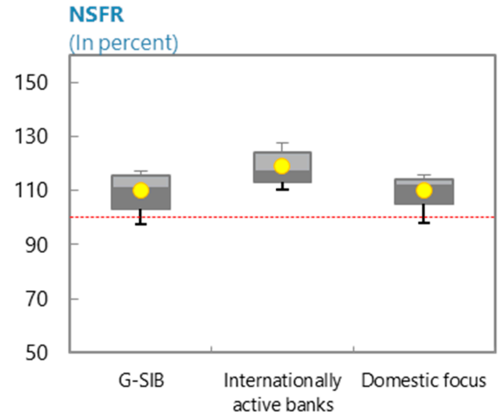
[72] Most of the repos with central banks exceed 1000 days of remaining maturity and account for close to EUR 500 Bn in the sample of 29 banks.

Figure 29. NSFR and Core Funding Ratio

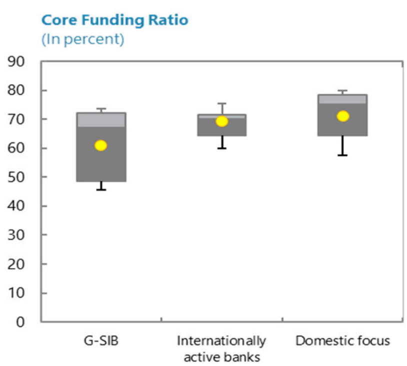
Most of the banks meet NSFR requirement with only a few banks slightly below 100 percent ratio…



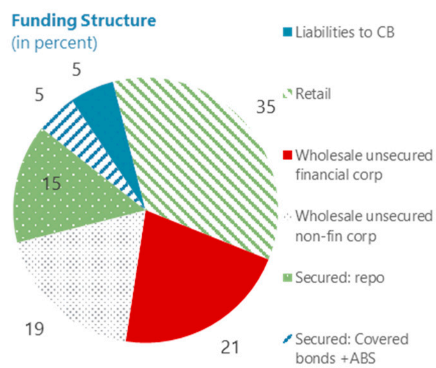
….with all less complex, internationally active banks fully meeting the minimum.



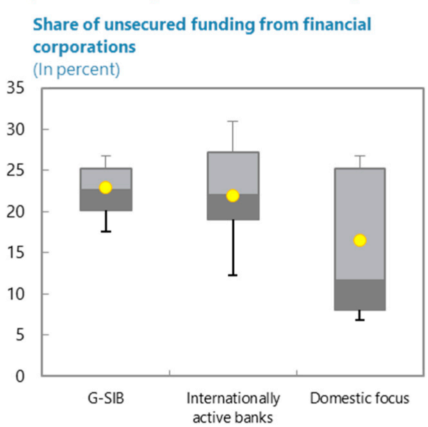
G-Sibs have greater dependence on short-term funding



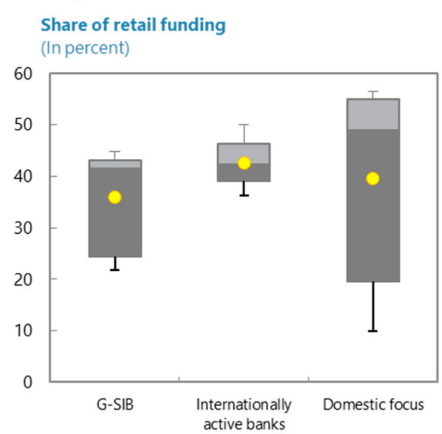
….Unsecured retail and wholesale funding dominates banks' liabilities…



G-Sibs and internationally active banks have higher dependency on funding from financial corporations…



….while smaller domestically oriented banks have very diverse funding models.



Sources: ECB, and IMF staff calculations.

1/ 2017Q3

170. GSIBs rely on short-term wholesale funding to a greater extent than do other banks. The core funding ratio (CFR) measures structure of liabilities in terms of stable relative to total funding.[73] CFRs tend to be high for banks engaged in traditional banking activities (like many of the large, but less complex, internationally-active and relatively smaller domestically-oriented banks in our sample) and low in banks which engage in complex trading and market making activities. G-Sibs which have complex balance sheets have lower CFR compared to their peers. While short-term funding obtained from financial counterparties is typically invested in short-term and liquid assets, funding gaps in terms of maturity mismatches may not be fully covered by available CBC. Recent episodes of banking distress highlighted the loss of commercial funding (retail, wholesale deposits) of more than 40 percent in one year.

Funding Concentration and Dependence on Central Bank Funding

171. Overreliance on one or few funding sources is risky. Diversification and lengthening of funding entails increasing share of longer-term market funding (ABS, long-term covered bonds) with diversified refinancing maturities would be more expensive than short-term wholesale and retail funding, but would greatly reduce wholesale deposit roll-over risks.

172. Funding concentration has increased in the last few years. The domestically-oriented banks display the largest relative dependence on a few funding providers (Figure 30). The share of the ten largest funding providers has gradually risen since 2015, reaching 10 percent on average in 2017Q3. This uptrend is mostly attributed to the increase in CB funding, with domestically-oriented banks in the lead. In contrast, G-SIBs have more diversified funding sources. The prevalence of FX funding concentration, especially U.S. dollar, adds an additional layer of risk.

173. Smaller domestically-oriented banks' dependence on CB funding reflects their business model and challenges in obtaining cheap funding in domestic markets. To some extent large borrowing from CB can also be assumed as a way to build potential precautionary liquidity buffers (for example, possibly motivated by the recent bank resolution cases). Large G-SIBs as well as less complex internationally-active banks have more options to diversify funding as well as obtain cheaper market funding from abroad. Funding from CB also helps banks to maintain higher average interest margin, and last, but not least, risk premiums for long-term debt issuance for banks might differs due to differences in sovereign risk premiums among sample countries; at the same time funding from CB is provided under uniform policy rates while liquidity obtained depends on the quality of collateral.

174. Central bank funding has helped banks meet their regulatory liquidity requirements. While repos with private counterparties are typically short-term, CB funding provides banks with funding which exceeds one year (and typically goes up to five years). This increases LCR and NSFR ratios and allows banks to manage short and long-term liquidity risks. Moreover, ability to encumber assets with the central banks (especially under the full allotment

[73] Defined as: (retail deposits + long-term wholesale funding + equity)/(total liabilities + equity)

auctions) provides banks with ability to obtain cheap funding amid accommodative financial conditions.

175. Tightening of financial conditions would affect sample of banks unevenly, and mainly via two channels:

- Banks with higher share of central bank funding would experience relatively higher increase in funding costs. For domestic banks, replacing the respective amount of long-term CB funding with the 2-year senior unsecured bond would lead, on average, to 10 percent higher interest expenses.[74] G-SIBs and internationally active banks would be much less affected by the changes.

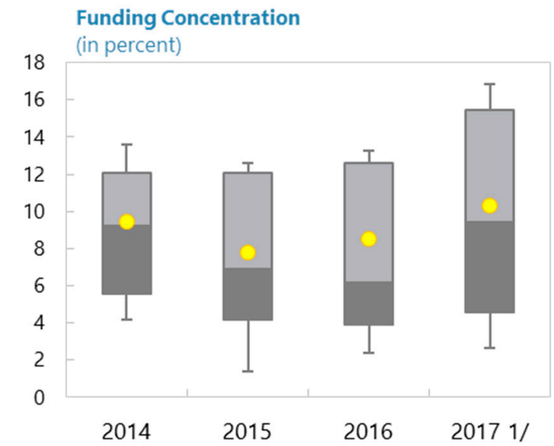
- Long-term funding availability may have an effect on LCR and NSFR ratios, provided that banks would not be able to use less liquid assets (such as credit claims) to obtain market liquidity. On average, the effect in volume would not be large (Box 3). It should be noted however, that change in CB collateral framework and monetary policy operations may also affect market liquidity of the various types of securities, and some wider divergence among sovereign and corporate CDS spreads could be observed, which could exacerbate the direct funding cost effect.

176. For some banks, funding costs will increase. For weak banks, this could lead to a spread shock: the introduction of the BRRD might reinforce the interaction between capitalization and funding costs. An illustrative exercise suggests that the impact on funding costs from a greater reliance on market funding differs: with some smaller, less complex domestic banks affected much more than G-SIBs or internationally active banks (Figure 30). It was assumed, that banks will replace CB funding with market funding (issue 2-year senior unsecured bonds). The interest rate is determined as follows: baseline scenario forecast of 2-year swap rate plus current individual risk premiums for each bank over the respective 2-year swap rate.

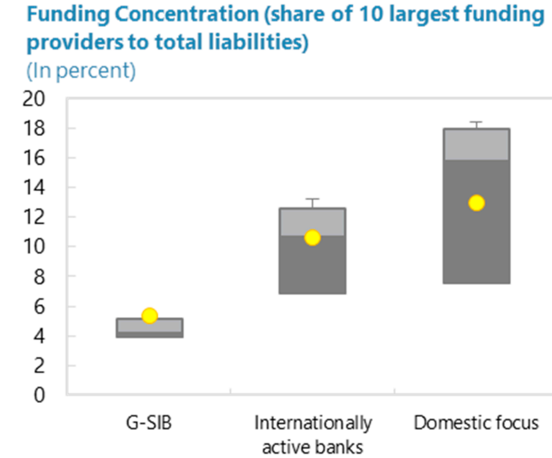
[74] The sensitivity test assumes that risk premiums banks pay for the bond are equal to the current bank specific risk premium over the 2-year swap rate paid for the respective term and instrument.

Figure 30. Funding Concentration and CB Funding[1/]

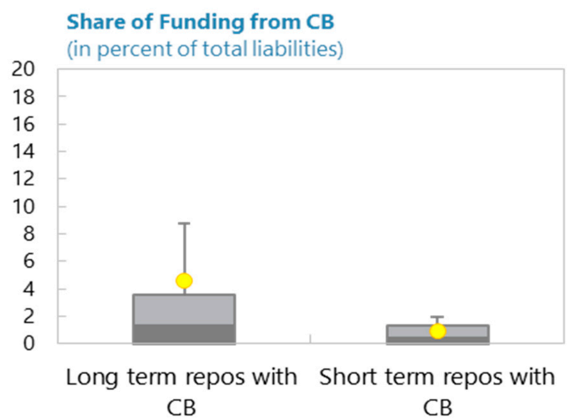
Share of 10 largest funding providers to total liabilities increased…



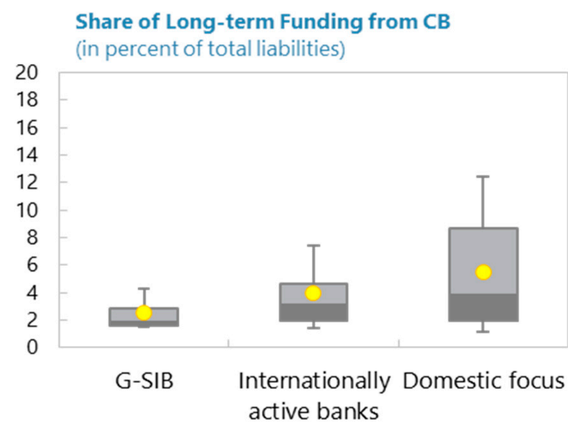
…with smaller, domestic focus banks showing greater dependency on a few funding providers



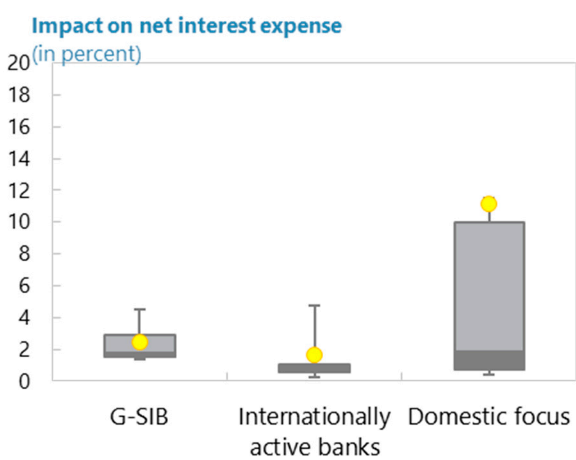
CB funding is mostly long-term…



…with smaller domestic banks benefiting most from it.



Domestic banks would be affected disproportionally more by increase in funding costs if they were to replace CB funding with market one



Sources: ECB, and IMF staff calculations.
1/ 2017Q3

Box 3. Potential Impact of the Eventual Normalization of the of Quantitative Easing (QE) and the Discontinuation of the TLTROs on System-wide Funding Liquidity Risks

A hypothetical normalization of monetary policy would have multiple consequences for the system-wide funding liquidity risk of the EA banks at the system level. The direct and indirect effects on bank funding costs are more difficult to assess and warrant more supervisory attention, as they depend on the future balance-sheet structure of banks (asset quality and capitalization) and on market sentiment.

Some possible consequences can be identified, albeit based on strong assumptions and neglecting many factors, such as the speed of normalization. We apply comparative statics at the system level on the purely heuristic assumption that QE is unwound completely and the TLTROs are discontinued. In practice, this could take many years providing banks with time to adjust. Another strong assumption is that, in the course of the unwind, the same institutions that had sold securities to the EuroSystem under QE, would replenish holdings after QE. They do not buy directly from the EuroSystem, though, but buy the securities that the ultimate debtors of the EuroSystem, such as sovereigns.

The analysis of the impact of monetary policy normalization on the liquidity situation of the banking system needs to consider the effects on both sides of the balance sheet, i.e. assets and liabilities. We divide our analysis in three parts: impact of changes in QE on assets (i.e. counterbalancing capacity of banks) and liabilities (i.e. deposits banks received from nonbank financial institutions), and impact of unwinding of TLTROs.

In December 2017, QE amounted to about €2,300 billion and the outstanding TLTROs to around €750 billion. The QE purchase amounts can be clustered into the following components:

i) The Public-sector purchase program (PSPP) account for the lion's share with about €1,900 billion;
ii) the Covered bonds purchase program (CBPP) of €240 billion;
iii) the Corporate sector purchase program (CSPP) for €131 billion and the
iv) ABS purchase program (ABSPP) for €25 billion.

Table 1. The Direct Impact of the Unwind of QE on Banks' Counterbalancing Capacity (CBC) Under Current Market Prices

Program	Volume (in billion euro)	Share of banks in the sample (in billion euro)	Assumed average haircut in CBC	Impact on banks' CBC
PSPP	1900	285	4%	0.2%
CPBB/CSPP/ABSPP	396	60	7%	0.07%

Sources: http://www.ecb.europa.eu/mopo/implement/omt/html/index.en.html. An ECB analysis (ECB Economic Bulletin, Issue 4/2017, pp. 61) found that euro area banks sold 25 percent of the government securities bought by the EuroSystem. The banks in the sample account for about 60 percent of the EA banking system, so that their share in the QE purchases is about 15 percent. Euro area nonbank financial corporates (insurance companies, investment funds, and pension funds) account for about 30 percent and non-euro area residents the remaining 45 percent. We assume the similar proportions apply to the CBPP, CSPP, and the ABSPP. The average haircuts in the BCC are identical to the haircuts in the liquidity stress test (section C.).

Box 3 (continued)

Unwinding QE would change the composition of balance sheets but also affect the market liquidity of securities and the availability and composition of CBC in some smaller, less complex domestic banks.[1/] In that the ECB decreases its stock of securities and banks run down cash balances to buy more securities, the overall decrease in CBC capacity would be relatively small and depend on two effects: (i) haircut on swapped assets and (ii) market illiquidity of instruments which ECB accepts as a collateral.

From the accounting perspective, asset reallocation reduces the CBC of the system by the average haircut on highly liquid securities. In the case of 29 banks, data available from prudential returns suggests that the haircut is about 3 percent on HQLA (mostly sovereign bonds). Assuming that the banks account for 60 percent of the €360 billion volume proportionate to their share in the EA banking system, the reduction of their liquid CBC (under today's market prices of EA sovereign bonds) would amount to approximately 6 billion euro, or 0.2 percent of the total CBC of the sample.

The haircut effect on less liquid instruments is larger, but the amounts of those securities pledged to the ECB are relatively small. In case of covered bonds (CBPP): the share of the banks in sample is about 60 percent of the €35 billion sold to ECB by EA banks. The average haircuts are about 4 percent, so that the impact of the asset substitution would be negligible (0.04 percent of the CBC). The ABSPP and CSPP of the sample banks amounts to about €23 billion; even though the haircuts are higher (6 to 7 percent), the impact on the CBC is also negligible.

From the market liquidity perspective, absence of ECB as a significant buyer of sovereign and high quality corporate bonds would have an impact on trading volumes and liquidity risk premiums. Based on GFC and sovereign debt crisis episodes, bid-ask spreads as well as banks' ability to liquidate lower quality, less liquid assets may be severely hampered (this assumption was utilized in the cash flow liquidity stress tests under marketable only CBC).

Nonbank financial institutions (NBFIs) accessed QE program via banks. The EuroSystem purchased 16 percent of government securities from investment funds and a further 14 percent from insurance companies and pension funds. It bought the remaining 45 percent from non-EA residents. In general, these counterparties do not have access to the EuroSystem books and hold the cash they receive as deposits with banks, which, in turn, have to hold it as deposit at the EuroSystem.

Scaling down the QE would lead to reduction of NBFIs' deposits at banks. If they shrink their balance sheets in line with their lower holdings of QE related securities, households' deposits in banks increase. Consequently, unwinding QE would not only reduce the CBC of the banks but also largely reduce the €1,400 billion of deposits of NBFIs (and/or the short-term deposits of households) in the sample by a similar amount. In the LCR and in the liquidity stress test these deposits from nonbank financial institutions feature outflow rates under stress of up to 100 percent.

Banks' deposits placed at the ECB would shrink. On the other side of the balance sheet is EA banks' exposure to the ECB (i.e. current account holdings and deposit facility holdings) which adds up to about €2,000 billion (The banks in our sample hold about 62 percent of it). All in all, the net exposure is about €300 billion towards ECB.

1/ Technically it is not an asset swap. Governments would issue bonds to repay the EuroSystem on the maturity of the bonds bought under the PSPP. Banks (and the other institutions which sold government bonds under the PSPP) would buy these newly issued government bonds. The comparative statics assume that banks would run down their excess reserves with the EuroSystem to buy these newly issued government bonds; governments would then transfer the cash to the ECB and the aggregate amount of central bank reserves would drop.

Box 3 (concluded)

The unwind the of the TLTRO would result in a reduction in CB reserves and an increase in less liquid assets, but at correspondingly higher volumes due the haircuts applied, which would largely cancel out; the major effect may be on the cost of funding, especially for weaker banks.[2/] TLTROs amount to roughly €750 billion in the EA; if the banks in the sample participated in proportion to their share of total assets in the EA banking system, their share would be €450 billion. In exchange, the CBC would increase by the encumbered assets. EA banks have posted about €1,700 billion of collateral at the EuroSystem (after haircuts). The EuroSystem operates a collateral pool, but banks are allowed to assume that least liquid assets are encumbered first. These are credit claims, unsecured banks bonds, and ABS/RMBS which in sum amount to about €1,000 billion. This is more than the outstanding TLTROs of €750 billion, such that the liquid collateral can still be reported as unencumbered by banks: government bonds (€340 billion) and covered bonds (€345 billion). The unwind of the TLTROs would lead to a substitution of CB reserves in the CBC with less liquid collateral (i.e. credit claims and ABS/RMBS). However, since the €1,000 billion posted already account for haircuts, the nominal value would be correspondingly higher and the overall impact on aggregate also would be small, except for those banks which have large dependence on EuroSystem funding, such as smaller, less complex domestic banks.

The reversal of the effect of QE on the dispersion of spreads across EA government bonds and other securities and/or a general increase of interest rates would constitute a further effect on the CBC via market liquidity risks of the securities included in it. We estimated the scenario based effects on the liquidity risk of the banks in the sample by incorporating a third approach to the CBC (see section 2.4, "market CBC"). It adds potential interest rate increases and spread dispersion across EA government bonds (i.e. takes into account flight to quality effects but not changes in liquidity risk premia) to the haircuts applied in the other approaches to the CBC. We use the estimated yield effects of the solvency stress test under the adverse scenario and translate them into valuation changes based on the data reported in the asset encumbrance and the counterbalancing concentration templates. These effects are more important for banks that will have to replace larger amounts of cheap EuroSystem funding (e.g. TLTROs) by market funding; for these banks it is important to improve capitalization and asset quality in a timely manner to avoid a spread shock.

However, without access to the Security Holdings Statistics on the bank level, the estimates are very rough and the results should be interpreted as "order of magnitude" effects. Banks's dependence on CB funding is uneven: some smaller, less complex domestic banks received liquidity at the expense of less liquid assets, such as credit claims. Assessing detailed securities holding statistics and trading data would allow to estimate the stressed impact of discontinuation of QE and vTLTRO on market liquidity of CBC securities. Historical trading data suggest that impact may be substantial after markets enter into different liquidity regime.[3/]

Careful planning is important for phase-out of exceptional measures over the medium term as this may have multiple effects on the market liquidity of securities as well as on banks with limited ability to raise market funding. TLTRO has effectively squeezed out some use of term funding markets, thus banks with high dependence on ECB funding may face problems in replacing cheap CB debt with more expensive market funding. Large scale asset purchases also affected market liquidity of securities. As monetary policy normalizes, the ECB may need to intervene in systemically important markets to maintain liquidity and price discovery.

2/ It is uncertain whether the banks would be able to substitute such cheap funding with market-based wholesale funding at reasonable costs.

3/ See Global Financial Stability Review, October 2015, p.p. 49–82; also Han F., Leika M. An Empirical Fire-Sale Model for Stress Testing: Use of Markov Regime-Switching Models (IMF Working paper, forthcoming).

Counterbalancing Capacity and Asset Encumbrance

177. High AE ratios among some of the banks in the sample hinders their ability to further tap unsecured funding markets. In some banks the AE ratio remains high (Figure 31), reflecting dominant business model, funding constraints as well as shift of risks towards unsecured creditors. High encumbrance ratio is common to banks which issue covered bonds to finance their mortgage portfolio, for example, relatively smaller domestically-oriented banks in our sample. Banks with high level of asset encumbrance may not only face higher outflows from short-term market and deposit funding during idiosyncratic and systemic liquidity events, but also be unable to obtain additional liquidity in the markets or central banks (as central banks do typically require collateral for funding operations).[75]

178. Relative asset encumbrance ratio reveals further liquidity risks. Asset encumbrance analysis is based on two ratios: absolute (encumbered assets over total assets) and relative, i.e. encumbered assets over total assets which might be encumbered (i.e. only liquid assets are counted in the denominator). The relative encumbrance ratio is much higher (average in our sample is 65 percent) and reflects available liquidity, i.e. how much assets a bank can quickly encumber in a case of liquidity stress. While average ability to encumber ratio across 29 banks is 35 percent (i.e. 100–65 percent), it does not reflect risks related to individual banks.[76]

179. Contingent liquidity risks may be a source of concern in case of severe market-wide stress. Contingent liquidity risks arise due to additional margin calls because of deterioration of value of collateral (see Box 4). Based on bottom-up sensitivity analysis regularly reported by banks, €738 billion of additional collateral would need to be posted were collateral value to decline by 30 percent. The scenarios are based on gross numbers and do not reflect the value of collateral on the receiving leg (thus might overestimate total effect). In general, this represents a 23 percent increase in aggregate level of encumbrance and some of the 29 banks would face challenges in meeting all margin call requirements.

180. CBC is the first line of defense in case of liquidity shocks, and individual banks are heterogenous in terms of both, amount and quality of CBC. Some wide dispersion is observed among less complex, internationally-active and smaller, domestic oriented banks. This CBC diversity has multiple explanations, notably some relatively smaller domestically-oriented banks have higher share of long-term market based or CB based funding, thus may need lower CBC. Dispersion in CBC quality reflects asset encumbrance with the CB, i.e. banks with higher CB AE ratios tend to have higher quality CBC because the ratio measures quality of remaining unencumbered liquid assets.

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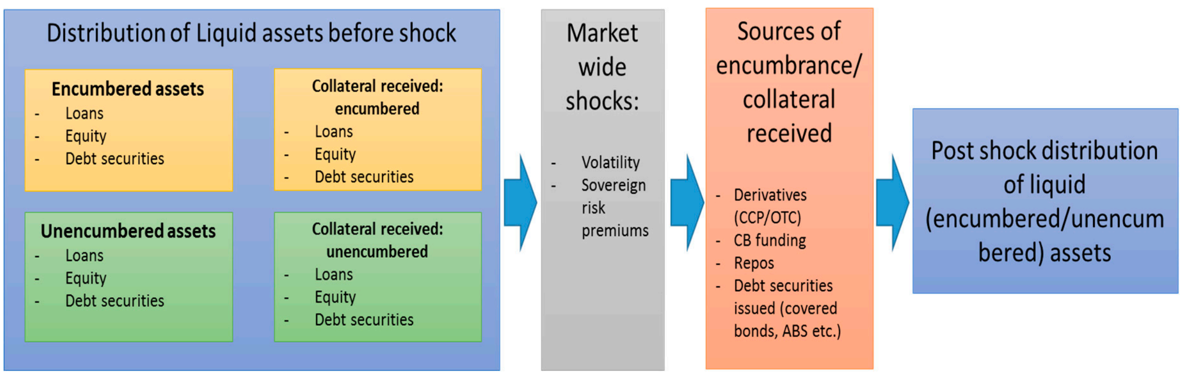
[75] Presence of high level of asset encumbrance shifts risk to unsecured creditors, and thus makes a bank subject to potentially higher wholesale deposit run-off rates. There is a positive feedback loop between level of encumbrance and ability to borrow (and borrow cheaply) in unsecured funding markets: high level of encumbrance makes unsecured debt especially risky, thus investors demand higher risk premiums or unsecured markets could close for a bank altogether.

[76] Moreover, banks with high level of encumbrance, on average perform better in cash flow based liquidity stress tests, because we apply uniform deposit withdrawal ratios across all banks. In practice, these banks should get higher wholesale/uninsured deposit withdrawal rates, while banks with low encumbrance – lower.

Box 4. Contingent Liquidity Risks

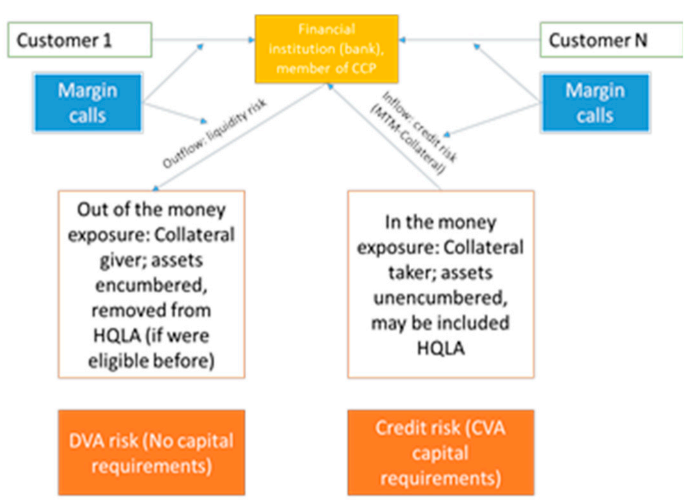
Contingent liquidity risks arise from financial contracts, such as repos (or securities financing transactions (SFT) in broader terms) and derivatives. Compared to behavioral liquidity flows, contingent ones are contractual, however contingent on market events, such as change in value of securities or a derivative being in or out of money. The importance of contingent liquidity risks increased due to migration of OTC SFTs and derivatives into centralized clearinghouses as well as bilateral contract margining requirements. Figure 1 below provides a high-level overview how contingent liquidity risks arise and how they impact liquidity position of a bank. In the nutshell, a market wide shock could lead to a decline in the value of collateral a bank posted on its own behalf. At the same time, a bank may also receive collateral on the opposite transaction, such as reverse repo. Collateral is typically placed and received in high liquid assets, such as cash or sovereign bonds (although there are instances when collateral is posted in less liquid assets, such as equities).

Box Figure 4.1. Contingent Liquidity Risk: Overview



The net effect is the most important in mitigating contingent liquidity risks, i.e. if a bank has balanced own trading position and has no large unidirectional bets in the market, it would post and receive collateral, thus liquidity needs would be netted, especially if contracts are cleared via CCPs (see Figure 2).

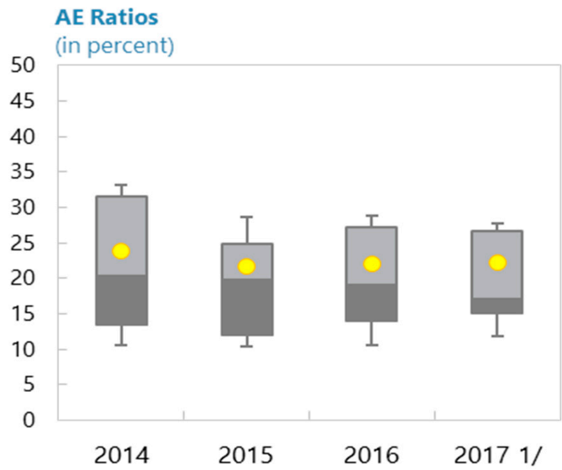
Box Figure 4.2. Role of CCPs in Liquidity Management



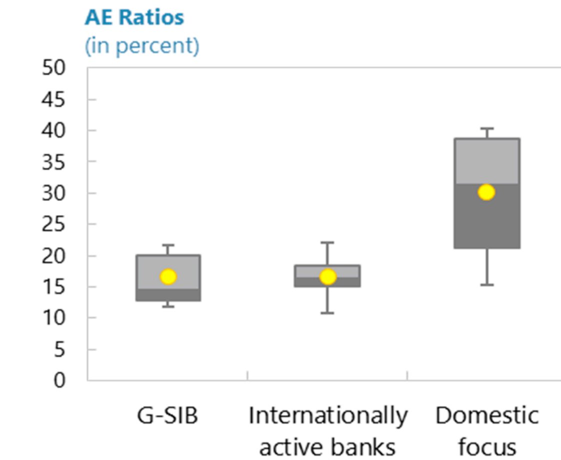
If a bank needs to post more collateral than it receives, its AE ratio goes up, which dries out CBC and may lead to further idiosyncratic shocks, such as inability to rollover unsecured wholesale funding.

Figure 31. CBC and Asset Encumbrance

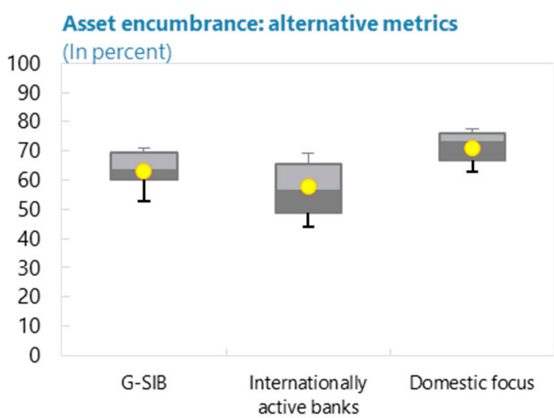
AE ratios remained stable….



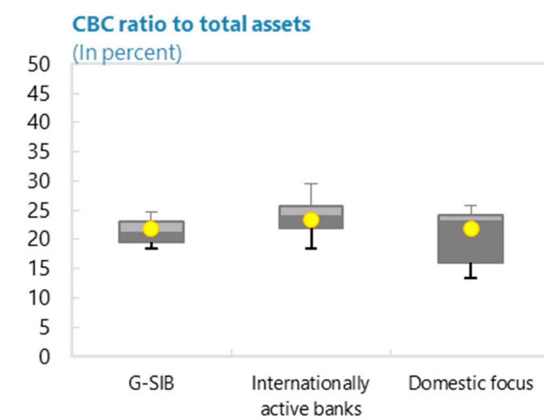
…. with domestic banks much more dependent on secured financing.



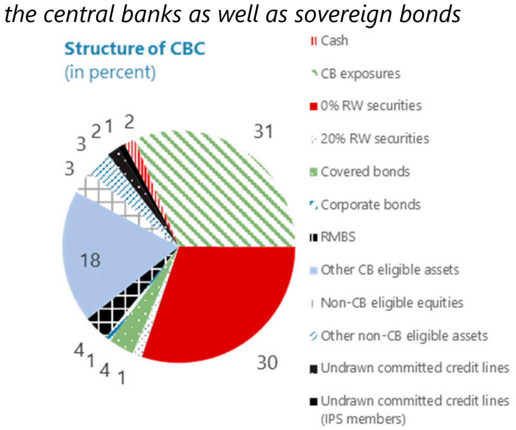
Alternative metrics reveal that some of the banks have fairly limited capacity to use remaining unencumbered assets for further encumbrance



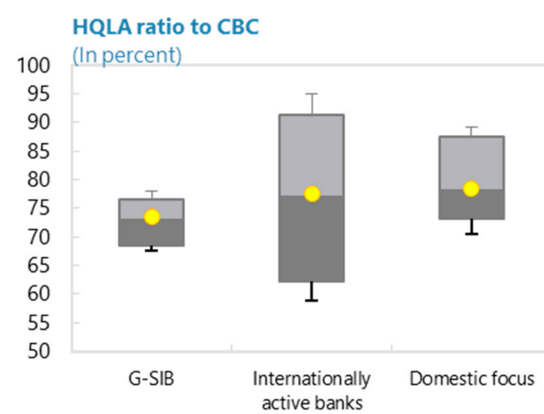
Amount and relative share of CBC compared to TA is fairly high in multiple banks



Majority of assets in CBC are highly liquid: deposits at the central banks as well as sovereign bonds



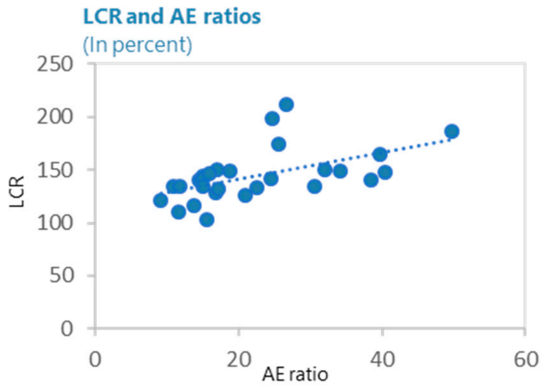
… and this is also reflected in CBC quality ratios.



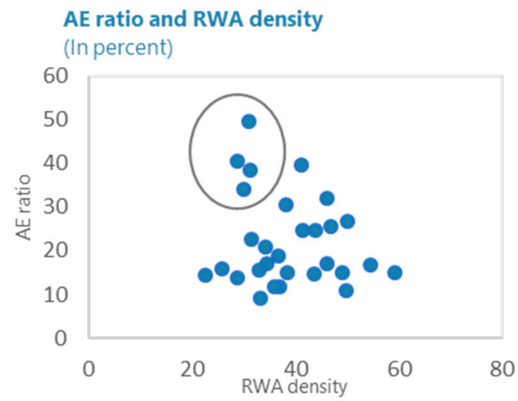
1/ 2017Q3

Figure 31. CBC and Asset Encumbrance (concluded)

Banks with high AE tend to have on average higher LCR....



... but a few banks are subject to risks that subject to shocks to their capital it may be difficult to raise additional funding due to very high AE ratio.



Sources: ECB, and IMF staff calculations.
Note: Data 2017Q3.

181. Banks with low RWA density and high AE may be subject to heightened liquidity risks. Banks which have high share of low risk weighted assets, such as mortgages, and issued asset backed securities or covered bonds, may be subject to heightened liquidity risks if losses in mortgage segment would lead to a sharp drop in CAR at the time of significant refinancing needs, for example, when banks have to redeem own debt securities. Banks with high LCR ratios tend to have higher AE ratios, which shows relative amount of liquidity transformation and support obtained from CB.

C. Cash Flow Liquidity Stress Tests

Introduction and Objectives

182. The cash flow based liquidity stress test (CFLST) analyses the liquidity risk exposure and risk bearing capacity of the sample of 29 banks in the EA. CFLSTs incorporate a set of embedded scenarios that allowed the FSAP team to estimate the order of magnitude of potential liquidity needs of individual banks and the banking system (comprising the sample of 29 banks) under a baseline and multiple stress scenarios. CFLST reveal levels of liquidity risk tolerance, i.e., under which circumstances banks would need additional liquidity support because of the mismatch of cash flows and absence of available CBC for which level of stress banks hold an adequate CBC. In addition, the CFLST contribute to the assessment of common liquidity risk exposures of banks in the banking system, such as reliance on unsecured short- term funding, also holdings of similar less liquid assets in the CBC. The CFSTs does not consider potential redistribution of liquidity within the banking system, i.e. migration of deposits from banks which experience capital shortfall to the banks which have strong capital buffers. This redistribution of flows was observed during the GFC.

Method and Data

183. Cash-flow based liquidity stress tests transform reported cash-flow data into stressed cash-flows and security flow data based on a matrix of scenario dependent stress factors.[77] They focus on two key indicators, namely, liquidity risk exposure and liquidity risk bearing capacity of banks. The first indicator is defined as the difference between cash-inflows and cash-outflows in each time bucket (the net-funding gap, NFG) and the sum of these differences across buckets (i.e. the cumulated net-funding gap, CNFG). The second indicator is the CBC, defined as the sum of cash inflows banks can generate under stress at reasonable prices in the respective bucket after taking into account securities flows. The CCBC is the sum of the counterbalancing capacities across time buckets and the current one. The analysis builds on data collected within the Short-Term Exercise (STE): especially, but not limited to, the Additional Maturity Mismatch Template (Additional Maturity Ladder, C66.00) from 4Q 2014 to 3Q 2017.

184. SSM data quality assurance for the STE is deemed broadly adequate. SSM data quality assurance proceeds in three steps: (i) first the statistics departments of the NCAs run plausibility tests and apply a set of validation rules, (iii) then the SSM statistics department runs validation rules, (iii) then the JSTs use the data in their regular off-site as well as on-site analysis and include any reporting errors and inconsistencies they encounter in their finding and request banks to improve liquidity risk reporting. Nonetheless, the IMF conducted additional data quality checks, comparing the cash flow data with balance sheet data as well as data from additional liquidity monitoring metrics templates.

185. Contractual liquidity risk exposure of banks in the sample is high. Contractual outflows within the first 4 weeks amounts to about 31 percent of total assets (weighted average; excluding open maturity and overnight retail deposits (23 percent of TA) and open maturity and overnight corporate deposits (7.5 percent of TA)) (see Figure 32). The contractual inflows amount to about 21 percent of TA (excluding inflows from central bank deposits (5.9 percent of TA) due to reporting conventions). Thus, the cumulated net funding gap over the first 4 weeks reaches about 10 percent of total asset or €1,700 billion. The main drivers of the net outflows are:

(i) outflows from deposits of financial institutions (-4 percent of TA, net of inflows from financial institutions);
(ii) other deposit outflows (-2.6 percent of TA, net of other deposit inflows);
(iii) repos collateralized with 0percent risk-weight bonds (-1.4 percent of TA, net of similar reverse repos); and
(iv) The composition of repo collateral (ex 0 percent risk-weight bonds) is similar to the composition of collateral for reverse repos within the first four weeks. Gross encumbrance due to repos across all asset categories accounts for about 14 percent of TA; gross reverse repos account for about 10 percent of TA. The composition of repo collateral (ex 0 percent risk-weight bonds) is similar to the composition of collateral for reverse repos within the first four weeks.

[77] For details see Schmieder, C., H. Hesse, B. Neudorfer, C. Puhr, S. W. Schmitz (2012), "Next Generation System-Wide Liquidity Stress Testing" IMF Working Paper No. 12/3 and Schmitz, S. W. (2015), "Macroprudential liquidity stress tests", in: C. Bonner, P. Hilbers, I. van Lelyveldt, (eds.), Liquidity Risk Management and Supervision, Risk Books, London 2015, 237–264.

Figure 32. Heatmap of Contractual Cash Flows

Most of the contractual cash outflows are concentrated within first month, and open maturity deposits dominate....

Cash outflows	Open maturity / Stock in CBC	Overnight	Greater than overnight up to 2 days	Greater than 2 days up to 3 days	Greater than 3 days up to 4 days	Greater than 4 days up to 5 days	Greater than 5 days up to 6 days	Greater than 6 days up to 7 days	Greater than 7 days up to 2 weeks	Greater than 2 weeks up to 3 weeks	Greater than 3 weeks up to 4 weeks	Total
LT unsecured issuances	0.00%	0.04%	0.01%	0.03%	0.01%	0.01%	0.01%	0.00%	0.06%	0.04%	0.05%	0.27%
Secured issuances	0.01%	0.00%	0.01%	0.00%	0.00%	0.01%	0.00%	0.00%	0.00%	0.02%	0.03%	0.08%
ST paper due	0.00%	0.03%	0.05%	0.07%	0.04%	0.03%	0.03%	0.01%	0.08%	0.07%	0.06%	0.48%
Repo's against 0% RW securities	0.09%	0.67%	2.08%	0.93%	0.60%	0.27%	0.25%	0.04%	0.66%	0.25%	0.21%	6.05%
Repo's against 20% RW securities	0.00%	0.06%	0.04%	0.04%	0.02%	0.01%	0.01%	0.00%	0.05%	0.01%	0.00%	0.24%
Repo's against covered bonds	0.00%	0.00%	0.08%	0.03%	0.09%	0.00%	0.00%	0.00%	0.01%	0.00%	0.01%	0.23%
Repo's against corporate bonds	0.00%	0.00%	0.02%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.04%
Repo's against RMBS	0.00%	0.00%	0.02%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.02%
Repo's against other CB eligible assets	0.01%	0.09%	0.15%	0.03%	0.02%	0.01%	0.03%	0.01%	0.06%	0.04%	0.05%	0.50%
Repo's against non-CB elig. equities	0.01%	0.15%	0.08%	0.01%	0.03%	0.05%	0.01%	0.01%	0.01%	0.02%	0.02%	0.40%
Repo's against other non-CB elig. Assets	0.02%	0.16%	0.28%	0.10%	0.05%	0.04%	0.03%	0.00%	0.05%	0.03%	0.04%	0.81%
Retail deposits	22.17%	0.78%	0.18%	0.02%	0.02%	0.02%	0.02%	0.02%	0.13%	0.13%	0.23%	23.73%
Corporate deposits	7.20%	0.30%	0.28%	0.09%	0.10%	0.06%	0.05%	0.02%	0.17%	0.16%	0.17%	8.61%
Central Bank dep. outflows	0.13%	0.07%	0.12%	0.08%	0.04%	0.03%	0.02%	0.01%	0.11%	0.07%	0.04%	0.72%
Other dep. outflows	1.21%	0.04%	0.28%	0.13%	0.03%	0.01%	0.01%	0.00%	0.05%	0.06%	0.04%	1.85%
Fin. inst. (not within IPS) dep. outflows	3.32%	0.65%	0.46%	0.16%	0.08%	0.06%	0.04%	0.03%	0.11%	0.10%	0.09%	5.09%
IPS outflows	0.24%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.25%
FX-swap outflows	0.00%	0.57%	1.31%	0.99%	0.50%	0.37%	0.17%	0.26%	1.13%	1.24%	1.38%	7.93%
Derivative outflows	0.01%	0.17%	0.05%	0.03%	0.05%	0.02%	0.03%	0.01%	0.10%	0.10%	0.07%	0.63%
Other outflows	2.52%	0.36%	0.19%	0.08%	0.03%	0.01%	0.00%	0.00%	0.04%	0.08%	0.04%	3.35%
Total	36.95%	4.13%	5.69%	2.83%	1.71%	1.03%	0.72%	0.45%	2.83%	2.40%	2.53%	61.28%

Most of the cash inflows are concentrated outside of the 30-day horizon, but inflows from deposits at central bank dominate

Cash Inflows	Open maturity / Stock in CBC	Overnight	Greater than overnight up to 2 days	Greater than 2 days up to 3 days	Greater than 3 days up to 4 days	Greater than 4 days up to 5 days	Greater than 5 days up to 6 days	Greater than 6 days up to 7 days	Greater than 7 days up to 2 weeks	Greater than 2 weeks up to 3 weeks	Greater than 3 weeks up to 4 weeks	Total
Rev. repo's against 0% RW securities	0.00%	0.26%	1.70%	0.77%	0.32%	0.13%	0.13%	0.05%	0.55%	0.35%	0.34%	4.61%
Rev. repo's against 20% RW securities	0.00%	0.13%	0.04%	0.01%	0.00%	0.01%	0.00%	0.00%	0.02%	0.02%	0.02%	0.24%
Rev. repo's against covered bonds	0.00%	0.01%	0.11%	0.01%	0.06%	0.00%	0.00%	0.00%	0.02%	0.02%	0.01%	0.24%
Rev. repo's against corporate bonds	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%
Rev. repo's against RMBS	0.00%	0.11%	0.11%	0.03%	0.02%	0.02%	0.03%	0.00%	0.13%	0.05%	0.05%	0.55%
Rev. repo's against other CB eligible assets	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%
Rev. repo's against non-CB elig. equities	0.00%	0.14%	0.08%	0.01%	0.01%	0.01%	0.02%	0.00%	0.01%	0.00%	0.01%	0.28%
Rev. repo's against other non-CB elig. asset	0.00%	0.15%	0.44%	0.09%	0.06%	0.04%	0.03%	0.01%	0.13%	0.08%	0.06%	1.09%
Retail inflows	0.00%	0.23%	0.16%	0.02%	0.02%	0.03%	0.02%	0.01%	0.09%	0.11%	0.13%	0.84%
Corporate inflows	0.00%	0.44%	0.19%	0.09%	0.08%	0.06%	0.08%	0.05%	0.22%	0.30%	0.39%	1.89%
Central Bank inflows	0.00%	4.16%	1.40%	0.09%	0.02%	0.00%	0.00%	0.00%	0.14%	0.01%	0.04%	5.87%
Other entities inflows	0.00%	0.09%	0.17%	0.13%	0.02%	0.02%	0.02%	0.01%	0.04%	0.08%	0.05%	0.62%
Fin. Inst. (not within IPS) Inflows	0.00%	0.47%	0.22%	0.09%	0.04%	0.02%	0.04%	0.01%	0.11%	0.09%	0.12%	1.23%
IPS inflows	0.00%	0.02%	0.00%	0.01%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.03%
FX-swap inflows	0.00%	0.57%	1.31%	0.99%	0.50%	0.37%	0.17%	0.27%	1.14%	1.25%	1.38%	7.95%
Derivative inflows	0.00%	0.19%	0.05%	0.03%	0.09%	0.02%	0.02%	0.01%	0.10%	0.10%	0.08%	0.68%
Other inflows	0.00%	0.25%	0.16%	0.11%	0.10%	0.02%	0.01%	0.00%	0.07%	0.08%	0.05%	0.83%
Total	0.00%	7.21%	6.14%	2.46%	1.34%	0.76%	0.57%	0.42%	2.77%	2.55%	2.74%	26.95%

Sources: ECB, and IMF staff calculations. N.B.: The relatively large Central Bank inflows result from some banks reporting equally high outflows from the CBC under Central Bank excess reserves. This does not affect the cash-flow based liquidity stress tests. The analysis of the contractual liquidity risk exposure above corrected for this effect.

Note: Data 2017Q3

186. Banks in the sample are also susceptible to contingent liquidity risks stemming from changes in net value of repos and derivatives positions. Due to the lack of data, the adverse scenario based impact on the value of collateral posted for derivative transactions could not be estimated, although the value of additional collateral posted/received due to repo and reverse repo transactions (up to three months) was considered in the cash flow liquidity stress tests. The value of collateral was reduced by the haircut obtained from market risk scenario.

Counterbalancing Capacity (CBC)

187. The CBC in the first month fully covers the system-wide cash flow gap. The total sum of assets in the counterbalancing capacity amounts to 20 percent of TA. It is higher than the net funding gap in the unstressed reported data (excl. retail and corporate deposits), which amounts to about 10 percent of TA over the first four weeks. While banks as a group have enough CBC to cover the gap, its distribution is uneven and some banks face shortfalls under stress.

188. Cash and deposits at the CB dominate the composition of the CBC (Table 6). Central bank deposits and 0 percent risk-weight securities account for about two third of the CBC. Credit claims and other non-HQLA are the third largest position with roughly 25 percent of the CBC.

189. Most of the securities included in CBC have low to very low credit risk. Analysis of unencumbered assets by credit quality steps (CQS) reveals that most of the unencumbered assets (i.e. excluding cash, CB reserves, credit claims and other non-marketable securities) fall into the lowest credit risk category (CQS1) thus can be quickly converted into cash and/or used for collateral management purposes. In terms of U.S. dollar liquidity, banks that are active in FX funding market accumulated large amounts of U.S. sovereign debt securities and U.S. government-sponsored enterprise issued papers, which also fall under CQS 1 category.

Table 6. Composition of the CBC, 2017 Q3

(Weighted average across all banks, in percent of TA)

Compared to HQLA	Compared to ST assumptions	Asset category in the CBC	Value in percent of TA
HQLA I	Marketable liquid assets	Cash	0.3
		Central bank deposits	7.3
		0 percent risk-weight securities	5.8
HQLA II		20 percent risk-weight securities	0.2
		Covered bonds	0.8
		Corporate bonds	0.2
		RMBS	0.5
Non-HQLA assets	Non-Marketable liquid assets	Other CB eligible assets (i.e. Credit Claims)	3.4
		Non-CB eligible equity	0.7
		Other non-CB eligible assets	0.8

190. Euro area and U.S. sovereign securities are the most prevalent debt assets included in the CBC. Five countries (Italy, Spain, Germany, United States, and France) cover roughly 65 percent of sovereign exposures in the sample of banks. As most of the banks are exposed to these securities, in the event of a large market shock (such as sovereign crisis in 2012), market liquidity of some of these assets may be severely affected by the typical flight to quality effect with investors selling bonds with lower credit rating but buying higher credit rating securities. At the same time, risk mitigating factor is that average remaining maturity of these sovereign securities is close to two years, hence the impact of changes in interest rates and sovereign risk premiums is relatively lower compared to impact on holdings of long-term debt securities.

Scenarios

191. Parameter uncertainty is an integral component of any liquidity stress test. Regardless of the sophistication of parametrization, liquidity stress situations can be unexpected and last for various time periods (from a few days to the slow drain of liquidity over many months). The best way to address the inherent parameter uncertainty is to run a large set of embedded scenarios of increasing severity.

192. The analysis employs a set of 20 embedded scenarios for a 4-week, 3 months as well as five scenarios for a 5-day time horizon, respectively: a baseline scenario and 4 stress scenarios with increasing severity (mild market stress, medium market stress, severe market stress and a combined severe market-wide and idiosyncratic stress. Each of the stress scenarios is combined with four different approaches to the counterbalancing capacity:

(i) full CBC without haircuts (HCs): fully endogenous liquidity supply by the central bank as long as banks have unencumbered eligible collateral;
(ii) full CBC with bank specific HCs: fully endogenous liquidity supply by the central bank as long as banks have unencumbered eligible collateral;
(iii) marketable CBC: non-marketable components of the counterbalancing capacity (i.e. credit claims and committed lines provided to the banks) are disregarded;
(iv) liquid CBC: bank specific haircuts and bank specific market price effects derived from the solvency stress test for assets that are liquid in private markets.

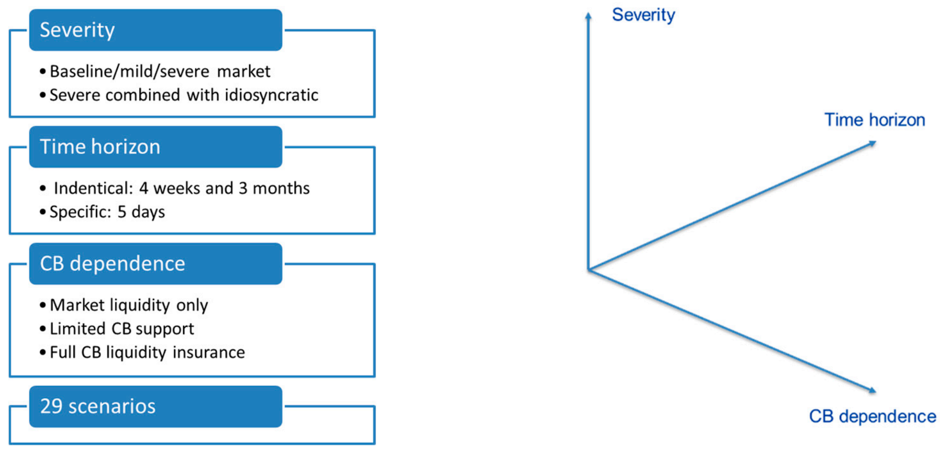
193. Embedded scenarios allow to simulate different degree of banks' dependence on central bank's support under liquidity stress (Figure 33). To ensure consistency with solvency stress tests, the calibration of haircuts under the liquid CBC approach draws on the asset prices (sovereign and corporate bonds) under the adverse scenario of the solvency stress tests.

194. This approach to parameter uncertainty shifts discussions from parameter calibration to liquidity risk tolerance of banks. The ultimate goal of the liquidity tests is to determine a banks' risk tolerance for liquidity risk, that is, determine the maximum degree of risk that the bank is willing to accept under stress conditions. The choice of "threshold" itself is based on multiple parameters, for example, percentage of funding outflow, haircuts on CBC assets. If many banks fail under a very mild outflows or haircuts scenario, this reveals a high liquidity risk tolerance and vice versa. In addition, the broad set of scenarios allows for effective comparisons of liquidity risk exposure and liquidity risk tolerance across banks beyond the simple pass/fail dichotomy.

Figure 33. Stress Test Scenarios

To deal with parameter uncertainty, CFLST was based around multiple scenarios…

Which were grouped according to the three dimensions: severity, time horizon and dependence on CB support



Sources: IMF staff calculations.

195. Five days cyber-risk related scenario assumed unavailability of collateral which is used for rehypothecation. Rehypothecation is a common liquidity management approach, when a financial institution (lender) uses collateral received from another financial institution (a borrower) to cover its own liquidity needs. Unencumbered collateral available for rehypothecation is included into CBC for the life of the loan contract. The scenario assumed severe liquidity event lasting for five working days; with daily simulation of contractual as well behavioral cash flows according to the scenarios. The choice of five days was based on assumption that access to the collateral would be restored at the end of this time horizon. Due to data constraints we were not able to separate bilateral and tri-party repos (the former less susceptible to a cyber risk event as such contracts may be managed bilaterally and not via central clearing counterparty or central depository institution).

196. Scenario calibration builds on event studies of system-wide and idiosyncratic liquidity stress events and is broadly consistent with the literature. For example:

(i) *retail deposit outflows* within one week reached 11 percent in the banking system of for Banesto (ES, 1994) 8 percent, and for IndyMac (USA, June 2008) 7.5 percent. For Washington Mutual (USA, September 2008) retail deposit outflows amounted to 8.5 percent in 10 days and for DSB Bank (NL, 2009) they reached 30 percent in 12 days (Schmieder et al. 2012, Table 3). In their severe scenario (comparable to the Lehman crisis), the outflow rates for retail term deposits amount to 10 percent over the 30-day horizon and for 20 percent for demand deposits;

(ii) *unsecured short-term wholesale funding run-off rates* amounted to 100 percent;

(iii) For secured wholesale funding the outflow rate is 20 percent;

(iv) *The EBA exercise (Severe Market Scenario)* applied run-off rates of 5 percent (retail deposits), 10 percent (NFC deposits), 20 percent (nonbank financial institutions), 100 percent (financial institutions), and 0 percent (government/public entities);

(v) In Halal, Laliotis (2017, Severely adverse scenario) the run-off rates amount to 10 percent for stable deposits, 20 percent non-stable deposits, 100 percent (net unsecured interbank funding), 50 percent (net secured interbank funding), and 100 percent (other wholesale funding, except ABS 50 percent).

197. Run-off rates are higher for unsecured than for secured wholesale funding, as well as for non-insured deposits than for insured ones. Table 7 summarizes the calibration of the inflow and outflow parameters.[78] The inflows parameters are in principle 100 percent of the contractual inflows, except for inflows from loans to retail and for corporate customers (inflows 0 percent). This is in line with the objective of the CFLST to assume that banks will continue business as normal, i.e. analyze the ability of banks to cope with liquidity stress while maintaining their ability to lend to the real economy. In fact, when bank cuts credit lines and/or stops granting loans, it may send the negative signal to the markets about its financial situation, which leads to further outflows from that bank.

198. The haircuts applied for the various components of the counterbalancing capacity capture two different effects: (i) the haircuts applied by the repo counterparty and (ii) the value upon which the haircut is applied (or market price effect). In the "full CBC without haircuts", no haircuts are applied at all. In the "full CBC approach and the "marketable CBC" approach, scenario independent, bank specific ECB haircuts as of December 31, 2017 are applied.[79] Table 8 displays the averages across banks as well as the standard deviations and the range. The first three approaches to the CBC do not consider market price changes of the underlying assets in the CBC. These are added in the fourth approach to the CBC ("liquid CBC"). Moreover, the first three approaches to the CBC assume that banks have unlimited access to central bank funding, as long as they can provide eligible collateral.

[78]Further references can be found: BCBS (2014), "Liquidity stress-testing: a survey of theory, empirics and current industry and supervisory practices," BCBS Working Paper 24. BCBS (2014), "Literature review of factors relating to liquidity stress – extended version" and the literature cited therein. Schmieder et al. (2012). Hałaj, G., D. Laliotis (2017), "A top-down liquidity stress test framework," In: Dees, S., J. Henry, R. Martin (eds.), "Stress-Test Analytics for Macroprudential Purposes in the euro area", ECB, 168–191. Commission Implementing Regulation (EU) 2016/322 of 10 February 2016 amending Implementing Regulation (EU) No 680/2014 laying down implementing technical standards with regard to supervisory reporting of institutions of the liquidity coverage requirement.

[79] The ECB applies the same haircuts for all banks (Guideline (EU) 2016/2299). The actual portfolios in each CBC component differ across banks, especially across maturities. Therefore, the actual haircuts applied to the CBC components differ across banks, too.

Table 7. Scenario Parameters: Run-off Rates for the Major Components of In- and Outflows

Outflows/Inflow	Range of run-off factors (in percent) across mild, medium, severe and severe/idiosyncratic scenarios
Unsecured LT/ST Issuances and financial deposits	30–70
Secured issuances	10–30
Stable retail deposits	2–7
Unstable retail deposits	3–12
Operational corporate deposits (NFCs)	10–25
Non-operational corporate deposits (NFCs) & other deposit outflows	20–50
Repo across all collateral classes*	0
Deposits FI	30–100
FX-Swaps in-/outflows	15–100
Derivative in-/outflows	25–100
Retail / corporate inflows	0
Central bank inflows	100
Other entities inflows	0–30
FI inflows	30–100
Other inflows	100
Committed lines provides by the bank (FI)	25–75
Committed lines provides by the bank (non-FI)	3–10
Margin calls (derivatives)	2–10
Adverse market outflows (derivatives, HLBA)	0–100
Outflows due to rating downgrades	0–100

Note: * Stressed outflow rates for repos are captured by increasing haircuts for the underlying collateral class. Calibration based on: BCBS (2014), „Liquidity stress-testing: a survey of theory, empirics and current industry and supervisory practices“, BCBS Working Paper 24. BCBS (2014), „Literature review of factors relating to liquidity stress – extended version" and the literature cited therein. Schmieder et al. (2012). Hałaj, G., D. Laliotis (2017), "A top-down liquidity stress test framework", In: Dees, S., J. Henry, R. Martin (eds.), "Stress-Test Analytics for Macroprudential Purposes in the euro area", ECB, 168–191. LCR Delegated Act - Commission Implementing Regulation (EU) 2016/322 of 10 February 2016 amending Implementing Regulation (EU) No 680/2014.

Table 8. ECB Haircuts on Components of the CBC
(In percent)

CBC component	Average haircut across Banks	Standard Deviation	Max-Min
Cash	0.0	NA	NA
CB reserves	0.0	NA	NA
0percent RW securities	4.2	3.6	12.1
20percent RW securities	3.3	2.5	9.5
Covered bonds	7.1	3.9	14.5
Corporate bonds (NFC)	7.1	3.9	14.5
Residential Real Estate Mortgage Backed Securities	5.6	4.7	15.5
Other central bank eligible assets (credit claims)	26.1	13.0	47.5
Equities	25.0–75.0	NA	NA
Other non-central bank eligible assets	75.0	NA	NA
Undrawn committed lines provided to the bank	50.0	NA	NA

Note: The ECB applies the same haircuts for all banks (Guideline (EU) 2016/2299). The actual portfolios in each CBC component differ across banks, especially across maturities. Therefore, the actual haircuts applied to the CBC components differ across banks, too.

199. The CBC composition as well as haircuts applied to various components of the CBC significantly differs across banks. CFLST usually apply the same haircuts for all banks regardless of the (usually unobserved) composition of the portfolio in each component of the CBC. As shown in Table 8, both the standard deviation and the difference between the maximum and the minimum haircuts in each component are economically significant. Based thereon, the CFLST framework was refined relative to past applications and applied bank specific haircuts in the analysis.[80] We assume that the haircuts applied to the collateral which is already deposited with the EuroSystem is equal to the haircuts for remaining unencumbered assets. The caveat of this approach is that haircuts are applied based on the value of collateral which is already encumbered, hence may not fully reflect haircuts for the assets which are available for encumbrance.

200. The assumption is broadly in line with the data reported in the unencumbered collateral data from the CBC concentration reports. Haircuts banks report already include haircuts which can be applied by ECB and or are subject to LCR reporting haircuts, but based on unencumbered assets (i.e. forward looking). Figure 34 provides summary of haircuts on unencumbered assets. The reported average haircuts for sovereign bonds are in the range of 10 percent, which is slightly more conservative than average ECB haircuts. However,

[80] Ideally, the EA FSAP CFLST would have got access to the Securities Holding Statistics (SHS) of the EuroSystem to apply haircuts and market price scenarios to each security. However, this was not possible.

unencumbered assets template is consolidated, and includes securities located in many jurisdictions and currencies (thus, some of them are not eligible within the ECB collateral framework). Moreover, haircuts depend on many factors, such as bond itself (sovereign), remaining maturity of bond as well as currency and rating. Other securities, like ABS, or debt securities issued by corporations have very similar haircuts. Finally, equity instruments have haircut close to 100 percent, which assumes that they are almost illiquid within CBC.

201. For the impact of market prices on CBC, haircuts on unencumbered sovereign debt as well as corporate securities were calculated under the adverse scenario of the solvency stress test. Adverse scenario produced two components: changes in risk free-rates (yields of German sovereign bonds) and risk premiums over the reference rate of the German sovereign bonds. The risk-free rates changed in line with the adverse scenario (Figure 34). Information on the composition of each bank's CBC was derived from the CBC concentration template, and the data then merged with EBA transparency exercise data (maturity of exposures).

202. Banks can also obtain liquidity in the markets using repos subject to market haircuts. Banks are subject to market haircuts when they need to obtain funding under market terms, for example, by entering into repo transactions. The FSAP team used market data to compare various haircuts (Figure 34). FSAP team estimates of haircuts were broadly in line with market haircuts on respective securities.

203. The approach to haircuts on CBC was designed as follows:

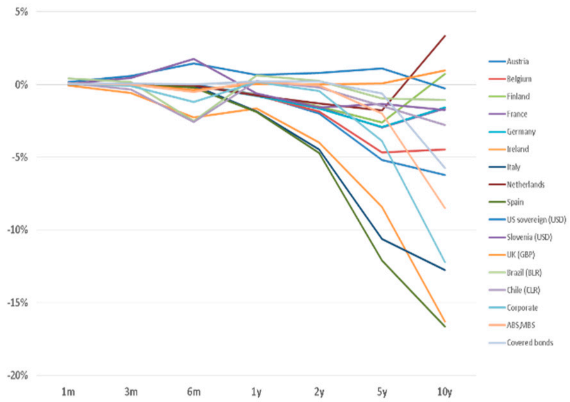
- Full CBC approach without haircuts approach: no haircuts are applied; full CBC as reported by banks is included;
- Full CBC approach with haircuts approach: bank specific haircuts are applied; full CBC as reported by banks is included;
- In the "marketable CBC" approach, bank specific haircuts are applied, but haircuts for "Other central bank eligible assets" and for "Undrawn committed lines" provided by other banks are set to 100 percent to differentiate between banks that rely more heavily on these two non-marketable CBC components;
- In the "liquid CBC" approach, the same approach as under the "marketable CBC," but in addition the haircuts applied by the ECB are applied on top of market price changes derived from the solvency scenario.

Figure 34. FSAP Team, Comparable Banks and Market Haircuts on CBC

Changes in market prices of sovereign debt securities owned by banks were based on the Adverse scenario used in Solvency stress test

Changes in market value of sovereign bonds

(In percent)



*Average haircuts for tri-party repos reflect liquidity value banks are getting by entering market transactions (in contrast to repos with CB)**

Haircuts by the type of collateral

(In percent)

Type of collateral	Repo haircuts (duration of repo)			
	1 m	3 m	1 y	> 1 y
government securities	1.6	1.9	2.1	2.4
public agencies / sub-national governments	2.0	2.3	2.6	2.9
supranational agencies	1.8	2.2	2.4	2.7
corporate bonds (financial)	4.3	5.1	5.6	6.4
covered bonds	2.6	3.1	3.4	3.9
RMBS/CMBS	3.8	4.6	5.0	5.7
Other asset backed	3.4	4.0	4.4	5.0
CDO, CLN, CLO	3.6	4.3	4.8	5.4
convertible bonds	6.0	7.1	7.8	8.9
equity	4.8	5.7	6.2	7.1
other	3.4	4.1	4.5	5.1

*By the type of sovereign, FSAP team estimates are close to the haircuts applied by markets***

Haircuts by sovereign

(In percent)

Sovereign	LCH Clearnet margin collateral haircuts (by term of security)					
	4-10 bus. day <= 1yr	> 1yr <= 3yrs	> 3yrs <=7 yrs	> 7yrs <= 11yrs	> 11yrs <= 30yrs	> 30yrs
Austria	5.5	6.3	8.0	8.3	11.5	13.6
Belgium	6.1	7.0	8.8	10.0	13.3	17.1
Finland	5.5	6.3	7.3	8.0	11.5	NA
France	5.8	6.3	7.3	8.1	11.8	13.9
Germany	5.5	6.1	7.3	8.0	12.3	12.8
Italy	8.0	10.5	14.1	15.9	19.8	21.6

Banks report haircuts on CBC items they hold applying LCR as well as own haircuts. Data 2017Q3.

Haircuts by CBC categories

(billions of euros and percent)

Type of security	Total amount (billions of euro)	CB eligible amount (billions of euro)	Haircuts (in percent)
Securities issued by general governments	706	634	10
Securities issued by corporations	101	85	16
Asset-backed securities	32	25	22
Equity instruments	8	0.4	96

Sources: ECB, and IMF staff calculations.

* Source: International Capital Market Association. European Repo Market Survey. October 2017.

*** Source: LCH Clearnet.*

Results of the Cash Flow-based Liquidity Stress Tests

Time Horizon: 4 Weeks

204. The interaction between scenarios and their parametrization is presented in a transparent fashion. The impact of a step-wise increase of severity along the three dimensions in Figure 38 is reported in the results matrix (Tables 9–11 below). The values in the cells are measures of systemic stress, e.g., the banking system's cumulated counterbalancing capacity at the end of the specific scenario horizon. Along the x-axis the severity of the scenarios increase, e.g. from the baseline scenario to a full-blown combined idiosyncratic and a severe market stress. Along the y-axis the reaction of the central bank can be scaled from an accommodative central bank reaction (all central bank eligible assets are considered in the counterbalancing capacity without any haircuts) to strict adherence to the pre-crisis implementation framework of monetary policy with fixed allotment (only assets which are liquid in private markets are considered in the counterbalancing capacity with stressed haircuts).

205. The liquidity shocks simulated in the 20 scenarios for the 4-week time horizon generated large effects but most banks were able to cope without exhausting buffers. The liquidity risk exposure of the sample is relatively high, as even the mild market scenario leads to a reduction of the aggregate CBC of 5 percent of total assets (Table 9). Under the most severe scenario, the impact of the shock amounts to 16 percent of total assets or 80 percent of the initial CBC. All banks have a positive CCBC throughout the stress horizon under the full CBC approaches without haircuts (HC) (Table 10), except in the severe Idiosyncratic scenario in which one bank features a negative CCBC after stress. Disregarding non-marketable components of the CBC leads to a maximum of 5 banks with negative CCBC (Table 6) with an average shortfall of 4 percent of total assets of these banks (Table 11). Under the "Liquid CBC" the severity of stress reaches 16 percent of total assets; 6 banks feature a negative CCBC after stress with a shortfall of 3 percent of their total assets. From a system-wide perspective, the aggregate shortfall of 0.6 percent of the total assets of the entire sample is small.

Table 9. Average Scenario Impact in Percent of TA in the 4-Week Time Horizon Under Various Scenarios

Approach to CBC	Baseline	Mild Market	Medium Market	Severe Market	Severe M/ Idiosyncratic
Full CBC w/o HCs	0	-5	-8	-12	-14
Full CBC w HCs	1	-4	-7	-11	-13
Marketable CBC	1	-7	-10	-14	-16
Liquid CBC	1	-7	-10	-14	-16

Table 10. Number of Banks with Neg. CCBC in the 4-Week Time Horizon Under Various Scenarios

Approach to CBC	Baseline	Mild Market	Medium Market	Severe Market	Severe M/ Idiosyncratic
Full CBC w/o HCs	0	0	0	0	0
Full CBC w HCs	0	0	0	0	1
Marketable CBC	0	0	0	4	5
Liquid CBC	0	0	0	4	6

Table 11. Average CCBC (in percent of TA) of Banks Neg. CCBC in the 4-Week Time Horizon Under Various Scenarios

Approach to CBC	Baseline	Mild Market	Medium Market	Severe Market	Severe M/ Idiosyncratic
Full CBC w/o HCs	0	0	0	0	0
Full CBC w HCs	0	0	0	0	-3
Marketable CBC	0	0	0	-2	-4
Liquid CBC	0	0	0	-2	-3

206. The major drivers of liquidity stress are net unsecured deposits of financial institutions and net repos. Retail, corporate, and other deposit outflows as well as the impact of scenario based haircuts on the CBC are substantial only in the most adverse case. Under the baseline scenario, funding liquidity would be affected mainly via changes in market haircuts on these assets; without changes in haircuts and eligibility of assets as collateral, the total effect on CBC is negligible (Figure 35). The total contribution to decline in CBC if only a marketable collateral is used is €136 billion, or 8 percent of initial CBC. In the most severe case, total decline in CBC, after market price haircuts, bank specific haircuts and assuming liquid collateral only, is close to 20 percent of the initial CBC. To cover the outflows, banks would use cash as well as deposits at the CB. Repos and reverse repos also form a sizable portion of inflows and largely compensate for the outflows from repos.

207. G-SIBSs and domestic banks are the most vulnerable to liquidity shocks. G-SIBs are more dependent on short-term wholesale funding from financial corporates, thus experience higher funding outflows in the tests. Some of the less complex, domestically oriented banks tend to have lower CBC buffers, thus are hit more by the change in assumptions about CBC liquidity.

Time Horizon: 3 Months

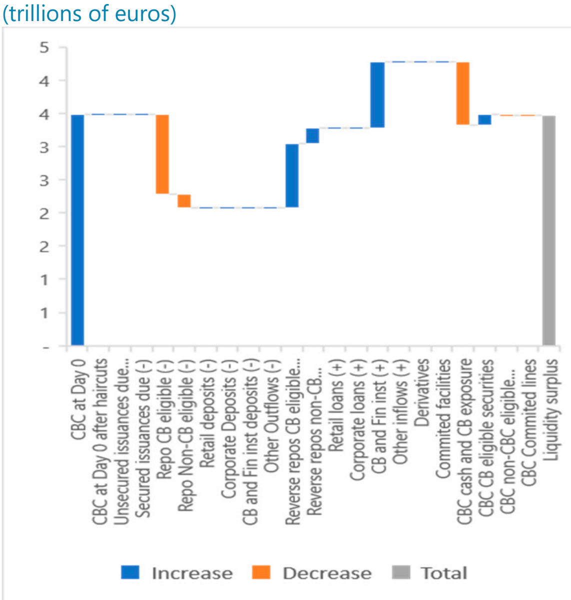
208. The sample is in aggregate resilient to the shocks over the longer, 3-month horizon but some weaker banks come "close to the edge" even under scenarios of medium severity. Under the most severe scenario, the impact of the scenario amounts to 18 percent of total assets or 90percent of the initial CBC (Table 12). All banks have a positive CCBC throughout the stress horizon under the full CBC approach without HCs in all but the most severe scenario, in which five banks (Table 13) display a neg. CCBC of 1percent of their total assets (Table 14). Disregarding non-marketable components of the CBC leads to a maximum of 11 banks with negative CCBC with an average shortfall of 3percent of their total assets. From a system-wide perspective, the aggregate shortfall of 1.3 percent of the total assets of the entire sample is modest.

Figure 35. Stress Test Results: 4 Weeks Scenarios

Baseline scenario: all banks have sufficient liquidity buffers

Contributions to changes in CBC: 4 weeks baseline scenario, full CBC

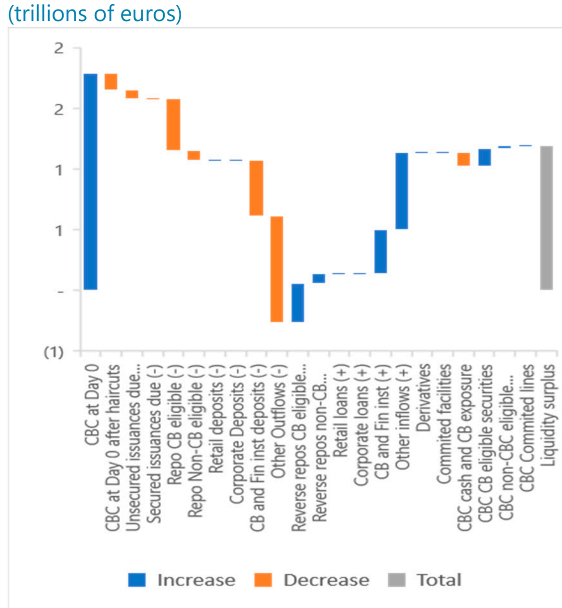
(trillions of euros)



Haircuts do not have major impact on ST results….

Contributions to changes in CBC: 4 weeks severe/idiosyncratic scenario, market CBC

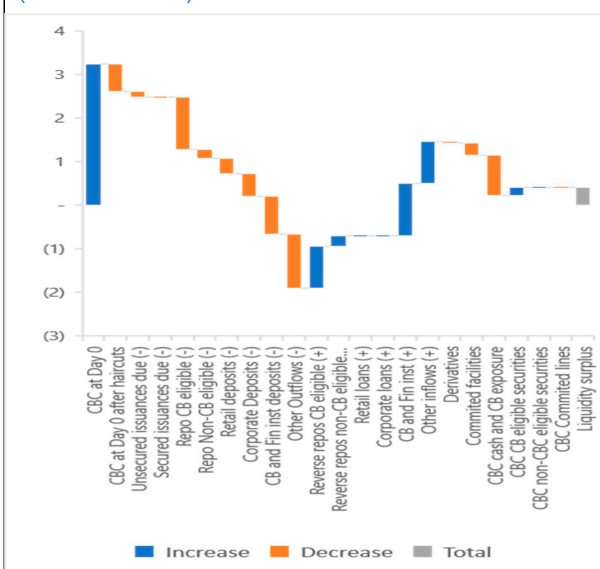
(trillions of euros)



…even in the most severe case.

Contributions to changes in CBC: 4 weeks severe/idiosyncratic scenario, liquid CBC

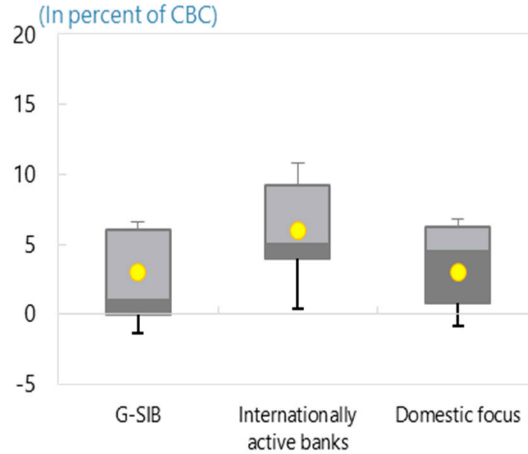
(trillions of euros)



ST results show resilience of the sample of banks and only in the most severe scenario several banks have negative CBC

ST results (severe scenario): liquidity surplus to total assets

(In percent of CBC)



Source: IMF staff calculations.

Table 12. Average Scenario Impact in Percent of TA in the 3-Month Time Horizon Under Various Scenarios

Approach to CBC	Baseline	Mild Market	Medium Market	Severe Market	Severe M/ Idiosyncratic
Full CBC w/o HCs	-1	-6	-10	-14	-16
Full CBC w HCs	0	-6	-9	-14	-16
Marketable CBC	0	-8	-12	-16	-18
Liquid CBC	0	-8	-12	-16	-18

Table 13. Number of Banks with Neg. CCBC in the 3-Month Time Horizon Under Various Scenarios

Approach to CBC	Baseline	Mild Market	Medium Market	Severe Market	Severe M/ Idiosyncratic
Full CBC w/o HCs	0	0	0	0	5
Full CBC w HCs	0	0	0	2	5
Marketable CBC	0	0	1	4	11
Liquid CBC	0	0	2	7	11

Table 14. Average CCBC (in percent of TA) of Banks Neg. CCBC in the 3-Month Time Horizon Under Various Scenarios

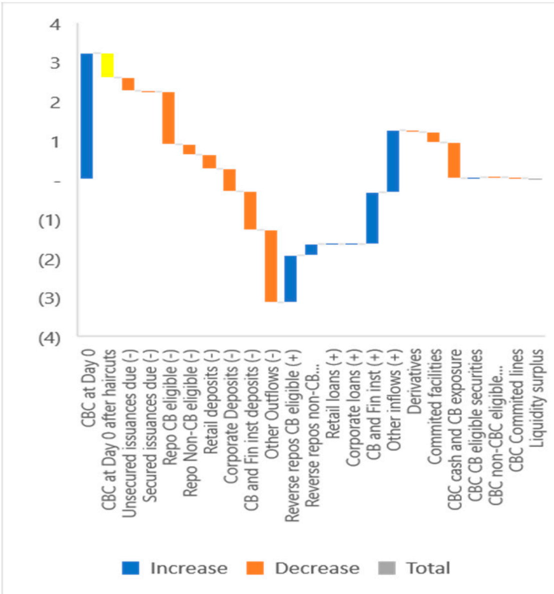
Approach to CBC	Baseline	Mild Market	Medium Market	Severe Market	Severe M/ Idiosyncratic
Full CBC w/o HCs	0	0	0	0	-1
Full CBC w HCs	0	0	0	-1	-2
Marketable CBC	0	0	-1	-4	-3
Liquid CBC	0	0	-1	-2	-3

209. Cash flow patterns under the 3-month scenario are similar to the 4-weeks scenario, as many of the short-term cash flows mature within the first few weeks. The overall liquidity surplus declines significantly, as aggregate CBC drops from €3.2 trillion to just €45 billion. This is almost ten times lower than surplus under the same four weeks scenario (remaining aggregate CBC drops to €408 billion). The key contributing factors are other inflows and outflows, slightly higher proportion of repos and reverse repos maturing (Figure 36). As a result, a few more banks, especially internationally-active ones, feature a negative CBC under the severe/idiosyncratic, liquid CBC three-month scenario compared with the same four weeks scenario.

Figure 36. Stress Test Results: 3-Month Scenarios

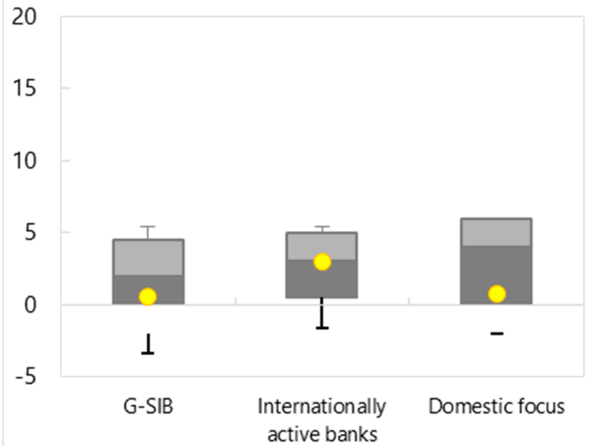
CBC is almost depleted within 3-month horizon…

Contributions to changes in CBC: 3 month severe/idiosyncratic scenario, liquid CBC
(trillions of euros)



…yet majority of banks still able to maintain liquidity surplus above zero; however, a few less complex, internationally active banks would see their CBC negative.

ST results (severe scenario): liquidity surplus to total assets
(In percent of CBC)



Source: IMF staff calculations

Time Horizon: 5 Days

210. G-SIBSs which are active in repos and derivatives markets are more dependent on rehypothecation for their own liquidity management purposes. Share of collateral received and available for rehypothecation could be a significant part of CBC in some G-SIBSs and internationally active banks (Figure 37). At the same time, only part of the collateral is typically used for rehypothecation, and smaller, less complex domestic banks rarely engage in such transactions. FSAP team analyzed rehypothecation data for several periods, and the patterns did not change much. Rehypothecation was an important contributor to amplification of systemic risk during the GFC.[81] The cyber-risk event scenario assumed that banks would not be able to access collateral located in CCPs, Central Securities Depositories (CSDs) etc. This may happen, if, for example, a cyber-attack on market infrastructure of these service providers prevents banks from accessing collateral. To test for the impact of such an attack, we combined cyber risk event with two CFLST scenarios: baseline, i.e. no further outflows and shocks in financial markets, and severe scenario (liquid CBC only). At the same time, collateral used for bilateral repo and derivatives transactions (i.e. OTC and not cleared through CCP) may not be affected.

211. Under the five-day collateral freeze scenario, no bank's liquidity buffers were depleted in the baseline scenario, but a few banks failed under the adverse scenario.

[81] See Financial Stability Board: Transforming Shadow Banking into Resilient Market-based Finance, January 2017.

Collateral unavailability in the severe scenario within the first three days does not lead to negative CBC in any of the banks, at the same time a few banks did not meet the test over the remaining two days. Total impact on CBC from this event is 9 percent decline (Figure 37), however the distribution is very uneven (i.e. G-SIBs and internationally-active banks are affected more). The difference between five days cyber risk related and four weeks severe, liquid CBC liquidity stress scenarios is that a few banks would fail the test much sooner than under four weeks scenario (i.e. no one bank fails within the first week in four weeks scenario). This outcome reflects sufficient counterbalancing capacity and the fact that only a limited number of banks (mostly G-SIBs) have elevated levels of re-pledged (rehypothecated) collateral which can aggravate liquidity shortages under more extreme market conditions.

212. At the same time the test has limitations, as it does not assume further cascading liquidity effects on positions of other market participants, i.e. what would happen if G-SIB will be illiquid and not be able to provide services to its counterparts. Hence, liquidity risks resulting from rehypothecation of collateral needs to be further analyzed and monitored, possibly by using granular institution-level data about contingent liquidity flows due to derivatives and securities financing transactions.

213. The general resilience of the system to liquidity shocks has substantially increased in recent years amid generally accommodative financing environment. Extraordinary EuroSystem operations have changed the composition of banks liabilities and the structure of their CBC. At the same time, banks differ notably in terms of funding structures, asset encumbrance, and the amount and composition of CBC.

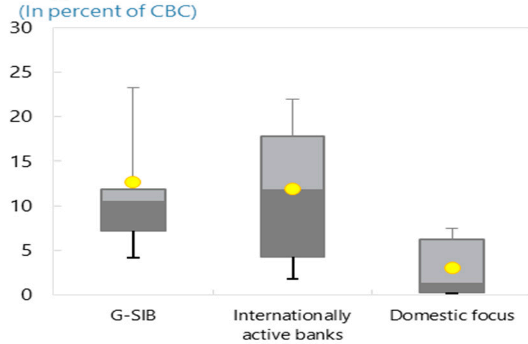
214. The analysis reveals the heterogeneity of the banks in the sample. Figure 38 shows that the distribution of the CCBC after stress shifts towards the left with increasing scenario severity. Most of the banks remain liquid even in the most severe scenario (combined severe market and idiosyncratic scenario over 3 months with "marketable CBC"). The banks that feature a negative CCBC after stress are very heterogeneous with respect to the causes of their liquidity problems: some have low initial CBCs, other feature relatively large shares of credit claims in their initial CBC; some have high outflows due to committed lines to customers, other due to outflows from deposits of financial institutions or other deposits.

215. Financial tightening would affect banks' funding and liquidity conditions unevenly. Banks which are more dependent on central bank refinancing operations, such as long-term refinancing operations, and those which used lower quality collateral to obtain liquidity are most at risk of facing higher funding costs once they have to revert to more market funding.

Figure 37. Stress Test Results: 5-Day Scenario

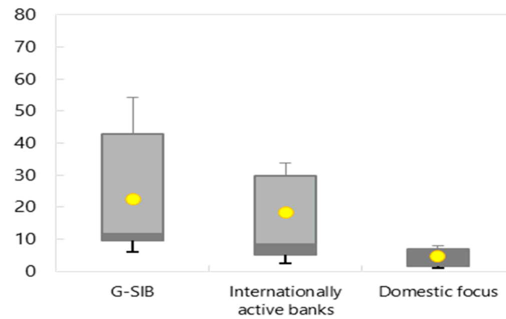
Baseline scenario: all banks have sufficient liquidity buffers

Share of collateral received and available for rehypothecation
(In percent of CBC)



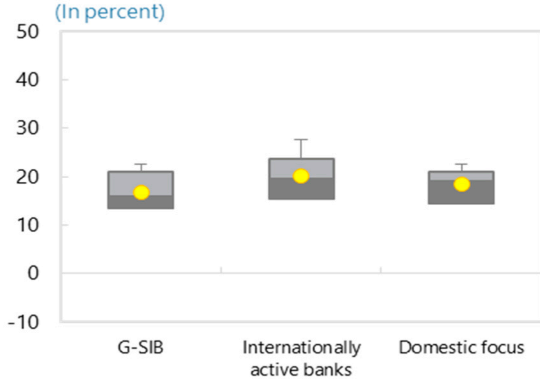
Haircuts do not have major impact on ST results….

Share of collateral received and used for rehypothecation
(In percent of CBC)



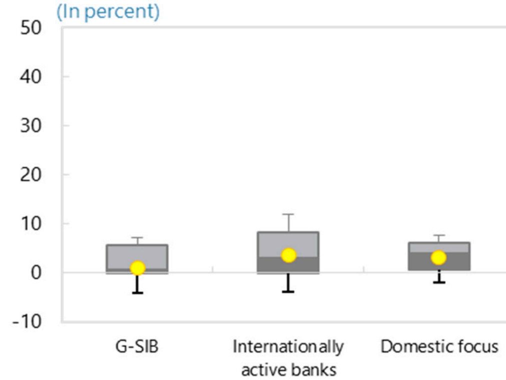
…even.

5 day ST results (baseline)
(In percent)



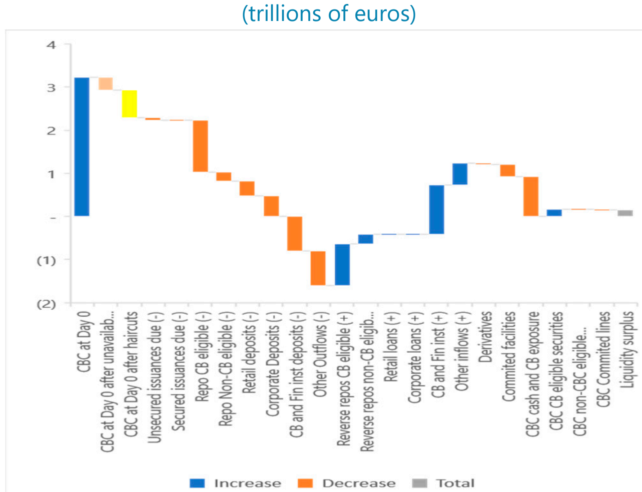
ST results show resilience of the sample of banks and only in the most severe scenario several banks have negative CBC

5 day ST results (severe scenario)
(In percent)



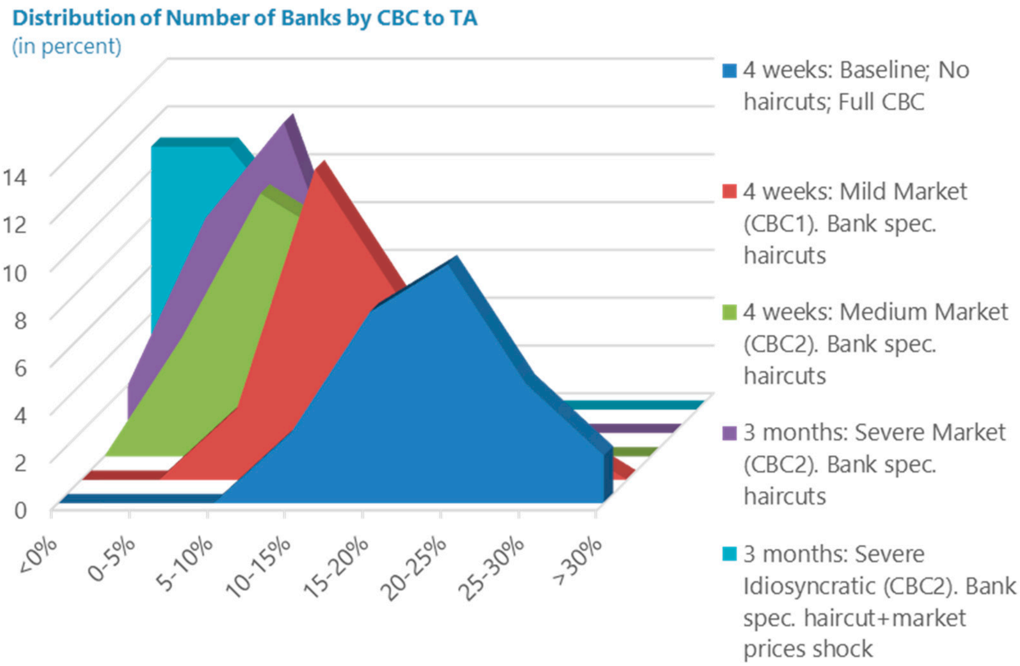
Collateral freeze scenarios assumed additional decline in initial CBC, but it was much lower than market based and CB haircuts on CBC assets.

Contributions to changes in CBC: 5 days severe/idiosyncratic scenario, liquid CBC
(trillions of euros)



Source: IMF staff calculations.

Figure 38. Distribution of Number of Banks by CBC After Scenarios



216. Some banks will need to proactively strengthen their balance sheets to ensure reasonable funding costs as their reliance on private markets increases. In particular, banks that rely heavily on short-term funding from financial institutions and also provide substantial committed facilities should lengthen funding tenors and increase liquidity buffers. Moreover, there appear to be some banks that combine relatively low capitalization with low liquidity, and thus may be especially vulnerable to a combination of shocks. Supervisory should focus their attention on the banks that feature a negative CCBC after stress. Banks may need to increase their CBC, lengthen and stagger the tenors of deposits from financial institutions, and improve the risk-sensitivity of pricing of committed lines to customers.

217. The banking system needs to prepare for an eventual tightening of financial conditions. While overall funding liquidity effects of the unwind of the QE and LTRO tend to be limited (yet unevenly distributed) under the current structure of banks' balance sheets, changes in monetary conditions and increase in policy rates needs to be compensated to maintain profitability. The effect of increase in funding cost can be minimized via multiple options, such as pass-through of increase in costs to interest rates on new loans, increase in fees and commissions, last, but not least, with longer maturity transformation in banks' balance sheets, i.e. substitution of short-term investments into sovereign and similar low yield securities with longer term assets. Longer maturity transformation would require increase in long-term stable funding, which should not be an issue for banks which cleaned up their balance sheets, adopted cost-efficient efficient business models and can issue equity in the markets.

EXPLORATORY STUDY: SOLVENCY-LIQUIDITY INTEGRATION

A. Motivation

218. This section attempts to quantify the amplification and feedback mechanisms from the interaction between solvency, liquidity and funding costs. Results of solvency and liquidity stress tests alone do not allow for the endogenous incorporation of effects of changes in CET1 ratios on funding costs over the stress test horizon, i.e. how markets price the change to the risk profile of banks under stress. Moreover, the structure of banks liabilities changes as bank tries to adopt to the most stable yet cheapest funding structure subject to own balance sheet (such as AE ratio) and regulatory constraints (such as LCR, NSFR ratios). A bank's funding costs depend on the structure of its liabilities, benchmark rates linked to the macroeconomic and monetary policy developments as well as on banks' commercial margins over reference rates. This margin depends on the level of market rates (e.g., due to the zero lower bound) as well as on the banks' business model. More importantly, it also carries an idiosyncratic component linked to the bank's risk of insolvency. For example, bank idiosyncratic risk is included in the 2018 EBA's methodological approach to funding cost insofar as it floors the margin on new liabilities to the expected change in the spread of debt instruments in the event of a credit rating downgrade.

219. The FSAP analysis (Module 1) attempts to endogenize the mark-up over benchmark (idiosyncratic risk) using a quantile-based approach. Rather than conditioning bank funding costs on a pre-determined credit rating event, the FSAP approach projects funding costs as a function of banks' projected capital buffers under stress. This methodology is more closely related to credit rating agencies' approach to assess the forward-looking component of a bank credit risk outlook (e.g., Moody's).[82] However, while Moody's credit rating is informed by the end-point results of the stress test, the FSAP approach takes into account the feedback loop between capital and funding costs throughout the stress test horizon.

220. The FSAP analysis (Module 2) estimates the amplification channel from stressed bank equity valuations using a Merton-based approach. The solvency stress test focuses on regulatory capital ratios. The risk of insolvency can be amplified by an equity tank which might trigger a run on the bank and precipitate its collapse. Merton-based models provide one way to estimate probabilities of default for publicly traded banks under stress. We use an off-the-shelf commercial model of default based on the Merton approach to calculate the implied bank rating under stress.

221. The FSAP analysis (Module 3) aims at estimating the size of the backbook effect and its impact on the CET1 ratio. The empirical literature finds a statistically and economically

[82] Moody's (2016), "Stress Testing Banks: A Globally Comparable Approach."

significant interaction between capitalization (CT1/CET1 ratios) and funding costs.[83] It studies the main drivers of the impact of higher funding costs on the CET1 ratio: the funding structure, the maturity structure of assets and liabilities, the pass-through rate of higher average funding costs on new loans to households and corporates and the risk density. The results of the exercise should inform the better incorporation of second round effects in macroprudential stress tests and in DSGE models. The model yields insights for policy decisions by comparing the costs of sustained periods of elevated funding costs for banks with the costs of bank recapitalizations for the real economy.

222. In sum, the exploratory analysis of the solvency-liquidity nexus is based on a threefold approach:

- *Funding cost feedback loop*: The quantification of the feedback loop between funding costs and capital ratios under the adverse scenario;
- *Credit rating analysis*: The projection of a bank's implied credit rating or the associated CDS spread, using a Merton-based approach based on the solvency stress test inputs;
- *Backbook effect*: The estimation of the required pass-through rates on flow of matured loans (assuming constant balance sheet) to absorb higher funding costs.

B. Module 1: Insights from the Feedback Loop Analysis

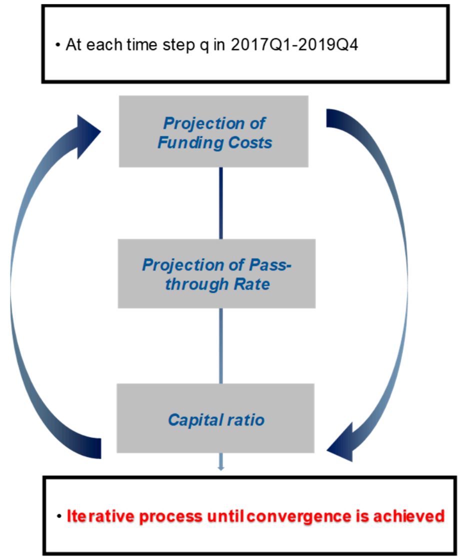
223. The projection of bank funding costs followed an iterative process at each time step between 2018Q1 and 2020Q4:[84]

- ***Initial Projection of Effective Funding Costs (Stage 1)*:** An effective cost measure is projected at the bank level by mapping the structure of bank liabilities with the interest rate path for each funding instrument (i.e. central bank deposits, government deposits, customer deposits, deposits from financial institutions, debt securities at floating rate, and debit securities at fixed rate). The interest path is projected using a modeling strategy based on a quantile regression approach linked to the scenario. By contrast to the modeling strategy explained in the Solvency Section, the interest paid on each liability is conditional on bank's initial capital ratio.
- ***Initial Projection of Effective Interest Income (Stage 2)*:** Net interest income is projected using an econometric-based pass-through coefficient at the bank level. The effective interest received depends on the composition of the loan book, the market reference rate, and the bank commercial margin linked to the scenario. By contrast to the pass-through modeling

[83] See Schmitz et al. (2017) and the literature cited therein.

[84] Modeling of simplified and less granular feedback cost loops were included in the 2018 Belgium FSAP, the 2017 Japan FSAP and the 2017 New Zealand FSAP.

specified in the Solvency Section, the lending rate is dependent on bank's initial capital position.



- ***Initial Projection of Bank Capital (Stage 3)*****:** The macroeconomic and financial scenario combined with banks' initial conditions (which affect net interest income projections) translate into losses, revenues, costs, and balance sheet items which inform the projection of the initial path for bank CET1 capital.

- ***Iterative Process (Stage 4):*** At each time step, defined quarterly over 2018Q1 through 2020Q4, the projection of bank CET1 capital serves to inform the revised effective funding costs and effective interest income. Interestingly, the path of funding costs affects net interest income directly, through interest expenses, and indirectly, through the pass-through rate channel.[85] The revised net interest income is combined with the path for other projections (i.e., credit risk, market risk, P&L items, balance sheet, required capital) to project bank capital at time *t+1*.[86] The process is repeated until convergence in funding costs (and hence net income) is achieved.

224. Effective bank deposit rates are projected controlling for bank specific variables using the following specification:

$$i_t^{i,j} = \alpha + \delta_1^j \cdot X_{t-1}^{c,j} + \delta_2^j \cdot bank_{t-1}^{i,j} + \varepsilon_t^{i,j}$$

where $i_t^{i,j}$ denotes the funding cost of instrument *j* for bank *i*, $X_{t-1}^{c,j}$ is a set of controls linked to the macroeconomic and financial scenario in country *c*, and $bank_{t-1}^{i,j}$ are lagged bank specific variables (see Section E for further details). The most significant bank variable that affects deposit rates is CET1.

225. Results show that deposit rates are sensitive to changes in bank solvency (Annex Table 10). A 100-bps increase in regulatory Tier 1 capital is linked to a 20 bps decrease in the effective rate on customer deposit. This effect is remarkable as customer deposits are typically less credit sensitive than wholesale deposits (from other financial institutions). The relationship is convex as shown by the positive coefficient of the squared term.[87]

[85] This is because the modeling strategy conditions the pass-through rate on the funding cost path.

[86] Credit risk and market risk is contingent on benchmark paths generated in the scenario.

[87] A similar result is obtained by Arnould, Pancaro, and Zochowski (2018), using deposit rates on new business from IMIR and secondary yields on senior bonds.

226. Effective lending rates are projected according to the following modeling strategy:

$$l_t^i = \alpha + \gamma_1 \cdot l_{t-1}^i + \gamma_2 \cdot Y_{t-1}^c + \gamma_3 \cdot bank_{t-1}^i + \gamma_4 \cdot funding_{t-1}^i + \gamma_5 \cdot funding_{t-1}^i \cdot bank_{t-1}^i + \varepsilon_t^i$$

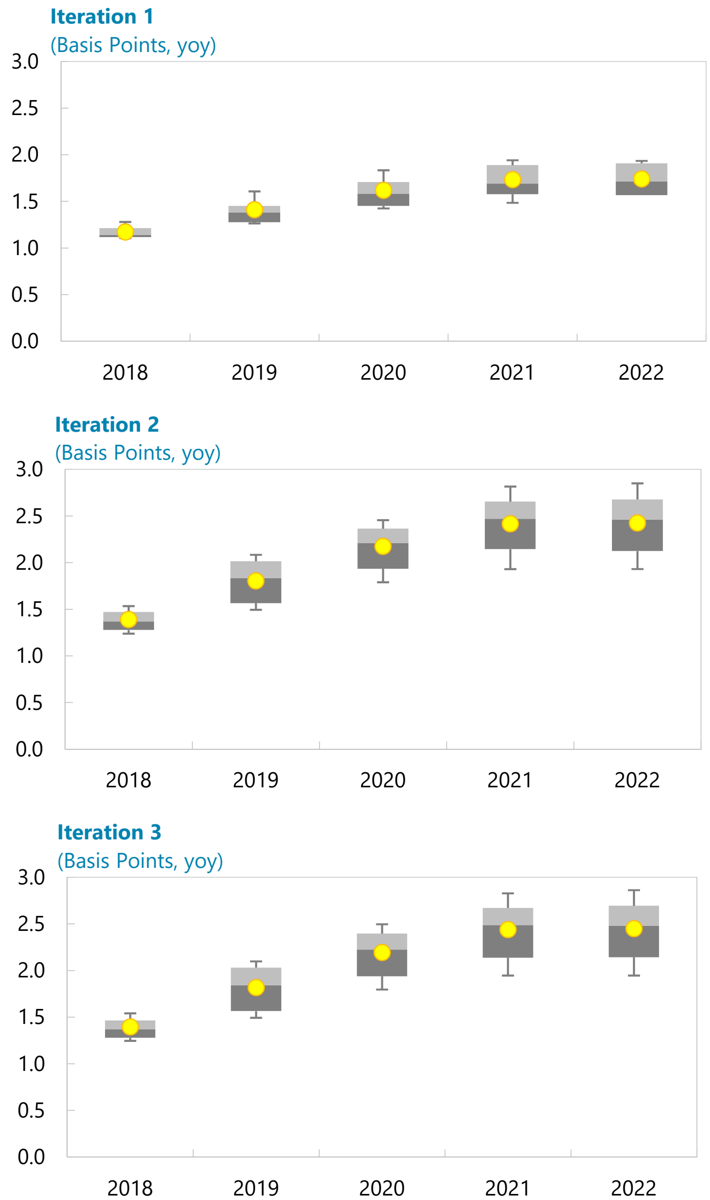
where l_t^i denotes the implicit lending rate for bank *I* (see Section E for further details). The equation includes an autoregressive coefficient l_{t-1}^i, a set of control variables Y_{t-1}^c linked to the scenario, and bank specific variables $bank_{t-1}^i$. The coefficient γ_4 shows the pass-through of funding costs to lending rates. The equation tests whether the pass-through rate is a function of bank specific characteristics as shown by coefficient γ_5.

227. Econometric results suggest that funding costs are passed through more quickly to lending rates when capital buffers are lower. The relationship between funding costs and lending rates is summarized in Annex Table 11. The table shows some interesting results about banks' lending pricing behavior. In contrast with the results shown in the Solvency section, the pass-through rate is economically with an estimated coefficient of 0.65 and statistically significant at the 99 percent confidence level once bank-specific variables are included. The results suggest that banks with a weaker capital position tend to increase the pass-through rate more completely. This is motivated by the need to have sound internal transfer pricing schemes and loan pricing strategies which encourage higher pass-through rates when capital ratios are lower. This is also consistent with the assumption that weak banks attempt to replenish capital buffers through retained earnings.

228. Convergence is achieved after three iterations. The process nests a distribution of funding costs over the stress testing horizon. This distribution is evaluated relative to the starting position (the effective implied rate). The multiplier is the ratio of stressed funding cost under the adverse scenario to the starting position for each asset class. The resulting multiples for the first three iterations on deposit rates are shown in Figure 39. In stage one, the median multiplier across banks is 1.14 in 2018, 1.38 in 2019, and 1.58 in 2020. In stage 2, the median multiplier reaches 1.37 in 2018, 1.83 in 2019, and 2.21 in 2020. In stage 3, the multiplier is 1.37 in 2018, 1.84 in 2019, and 2.22 in 2020, and remain stable in successive iterations.

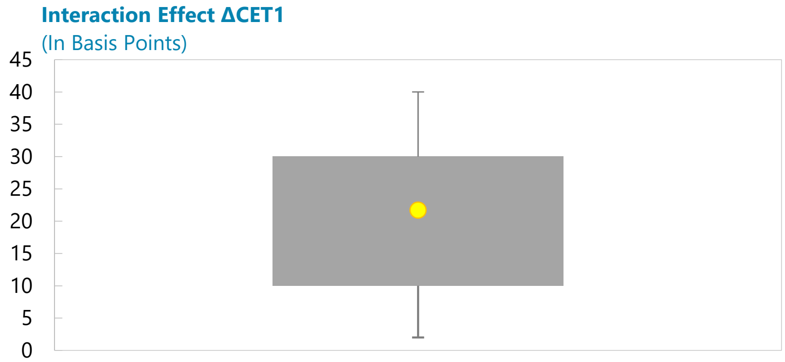
229. Accounting for feedback loops in funding costs adds an average 30 bps to capital depletion. Figure 40 shows the distribution on bank capital impact from the feedback look channel in net interest income. While the impact is moderate for the average bank, weaker banks are particularly hit, adding an amplification channel which triggers an adverse feedback loop. At the 90th percentile the impact increases to 50 bps.

Figure 39. Euro Area: Solvency-Funding Cost Feedback Loop



Note: The panel shows the ratio of stressed funding costs relative to the starting point under the adverse scenario. A fixed point between projected CET1 ratios and projected funding costs is achieved after three iterations.
Boxplots include the mean (yellow dot), the 25th and 75th percentiles (grey box, with the change of shade indicating the median), and the 15th and 85th percentiles (whiskers).

Figure 40. Euro Area: Impact of Solvency-Funding Cost Feedback Loop



Note: The chart shows the distribution of the additional impact on CET1 ratio from endogenizing bank funding costs as a function of stressed capital ratios. Boxplots include the mean (yellow dot), the 25th and 75th percentiles (grey box, with the change of shade indicating the median), and the 15th and 85th percentiles (whiskers).

C. Module 2: Insights from the Merton-based Analysis

230. **Credit ratings provide an indication of funding costs and funding availability which are complementary relative to regulatory capital ratios.** Credit ratings use a forward-looking assessment of a bank's financial strength under expected conditions. To assess financial stability, it is important to understand the potential effects of a sudden economic deterioration or unexpected developments on credit rating migration. This is precisely the question addressed in the analysis. We quantify by how much the credit rating of the bank will change under the stressed operating environment evaluated in the solvency stress test.

231. **The analysis was based on the Bloomberg's DRSK module based on a Merton-like approach.**[88] This function calculates the implied default probability, implied rating, and implied CDS based on current bank data. We override the input variables with the paths projected in the solvency stress test to generate the implied shifts to credit ratings.

232. **The key inputs of the model were drawn from the worst period in the FSAP solvency stress test.**[89] The Merton-based model uses eight key input variables. These inputs are derived from the market data or the bank's financials. The market category includes three inputs: the share price, market capitalization, and share price volatility. Within the financials category are effective short-term debt, effective long-term debt, loan loss reserves, nonperforming loans, and net income.

233. **The individual bank market variables are projected in line with the scenario.** A simple model was used to estimate the beta of individual bank share prices in combination with the path of the equity share price for major indices in the euro area calibrated in the scenario.

[88] This function uses a mainstream commercial Merton-based model with shares some commonality with the in-house model used in the Technical Note on Interconnectedness.

[89] This analysis is in line with the micro-interaction analysis conducted in BIS (2015) "Making supervisory stress tests more macroprudential: Considering liquidity and solvency interactions and systemic risk", Working Paper 29, November.

The correction in equity prices is accompanied by a sudden drop in market cap and an increase in volatility.

234. The financial variables were extracted from the solvency results. Although the Merton model is based on the distance to default leverage parameter which incorporates the ratio of firm value to debt, which an adjustment for market volatility and expected return on assets (extracted from equity prices), information from other financial variables can significantly improve model performance. Loan loss reserves were calculated using a stressed coverage ratio on defaulted exposures, nonperforming loans were projected for IRB and STA exposures, and net income was estimated from P&L projections. Financials are projected as of end-2020.

> The DRSK model is a balance sheet focused measure of credit risk based on the structure model proposed by Merton. In this model, a bank is viewed as solvent if the value of the assets is larger than the value of its liabilities. The key insight of the Merton framework is that the equity of the firm can be viewed as a call option on the total assets of the firm where the strike price is equal to its liabilities. While trading liabilities (repo, short sales, and derivatives) are important measures of credit risk alongside short-term debt, customer deposits tend to be stable over time, and receive a 50 percent haircut. The value of the bank assets is inferred from the equity value using a Black Scholes option pricing approach.

235. Results suggest significant non-linear amplification effects from the combination of a deterioration in banks' financials, liquidity stress, and a market price correction. On average, the implied PD of listed banks increases by [80] bps from the deteriorating economic conditions assumed under the adverse scenario. An additional liquidity shock whereby long-dated debt dries up and banks are forced to increase their reliance on short-term maturities by 20 percent leads to a further [40] bps increase in banks' PDs. The share price decline envisaged in the scenario (with major indices declining by 20 percent) has an additional impact of [60] bps increase in default risk. Using the Bloomberg Credit Risk Scale, the default probability impact is mapped to a credit risk measure. On average, the combination of solvency shocks, liquidity risk, and equity correction lowers banks' credit rating by [four] notch-downgrade in Bloomberg's credit risk bank mapping.

D. Module 3: Insights from Backbook Effect Analysis

236. The test applies a stylized path of rate shocks that generates banks' funding cost projections. In the first year of stress, the average funding costs of banks increase by 10 bps, in the second year by 30 bps, and in the third year by 60 bps. Based on the STE cash flow data, the rate shocks are applied to the amount of liabilities that reprice within one to three years, yielding funding cost projections for Y1, Y2, and Y3, and similarly for the repricing of new short-term liabilities in Y2 and Y3.

237. Banks are allowed to pass-through rising funding costs to new loans in selected product markets. Based on the STE cash-flow data, the volume of assets that the bank can reprice in Y1, Y2, and Y3 is calculated. Pass-through is allowed in product segments where banks are likely to have some pricing power; i.e. retail loans and loans to non-financial corporations. Banks can only reprice new loans as in variable rate contracts the spread above the benchmark rate is contractually fixed. The STE data allows taking into account the repricing of new short-term loans in Y1 in Y2 and Y3 and similarly the repricing of new short-term loans in Y2 in Y3.

238. Banks generate new loans at a rate over the minimum hurdle rate (MHR). Banks increase their credit loan spreads when their own funding costs increase to avoid that a loan is economic value added negative from issuance onward. They due to by increasing the loans minimum hurdle rate (MHR). Loans that can only be generated at rates below the MHR are not issued. The MHR ensures that capital and liquidity are distributed across the bank in an efficient manner. The MHR includes the funding and capital costs of the loan, the risk costs, and the operational costs attributed to the loan. To model the MHR impact of the funding cost effect, a pass-through rate of 100 percent of the weighted average funding costs on the repriceable loans is assumed. In the stylized example, this amounts to MHR increases of 10, 30, and 60 bps in years 1–3.

239. The exercise also addresses the question: by how much would the pass-through rate have to increase, such that the frontbook effect offsets the backbook effect? The increase in interest income due to the repricing of new loans is the frontbook effect. To calculate the backbook effect, the increasing interest income from the higher loan spreads is subtracted from the increasing funding costs in billion EUR cumulated over Y1 to Y3.

240. The MHR approach could be applied to calculate the impact of a recapitalization on loan spreads. The impact of the MHR on the weighted average cost of capital (WACC) could be computed under two scenarios: one with swift recapitalization and one with bank undercapitalization, where the increase in WACC is due to an increase of the CET1 ratio and its impact on the internal hurdle rate for asset generation r_L, where RoE_t is the bank's target return on equity, *tax* the tax rate (we assume 25 percent for corporate profits in EA), and r_D the interest rate on debt to be replaced by equity):

$$\Delta WACC=\Delta r_L =\Delta CET1\times[(RoE_t-(1-tax)\times r_D)/((1-tax))]$$

241. At this stage, the model is highly stylized and needs to be further refined in the future to produce reliable output for supervisors. It abstracts from various interactions, such as the impact of higher loan spreads on loan demand. The impact of lower loan demand on the bank's CET1 ratio, and in turn on bank funding costs. Thus, the model is not included in the solvency stress test results. Instead, it is employed to study the determinants of the differences of the backbook effect across banks in the sample.

242. Risk weights density and the asset liability mismatch explain a large part of variation of the impact of the backbook effect on banks' CET1 ratio. We define risk density (RD) as RWA/EAD (in percent) and the asset liability mismatch as the weighted average maturity of liabilities divided by the weighted average maturity of the repriceable loans (in percent). The value of the inputs is extracted from the solvency results.

Table 15. Contribution of Risk Density and Asset Liability Mismatch on the Backbook Effect

	ΔCET1
RD	*-1.49551****
	(-4.32515)
ALM	*0.012794****
	(6.422979)
C	*0.83231****
	(6.455153)
Adjusted R-squared	0.608477
S.E. of regression	0.146822
Sum squared resid	0.538914
Log likelihood	15.57536
Akaike info criterion	-0.89824
F-statistic	21.98069
Durbin-Watson stat	1.570205
Prob(F-statistic)	0.000003

Note: This table shows the econometric results for the contribution of bank risk density (RD) and asset liability mismatch (ALM) on the backbook effect, measured as the impact of funding cost increases on CET1 ratio (ΔCET1).

243. Disregarding the backbook effect in solvency stress testing systematically and significantly underestimates the shock impact. The average backbook effects amounts to about two-third of the entire funding cost effect. In order to reduce the backbook effect to 0, the pass-through rate would have to be unrealistically high (above 500 percent). The impact of a moderate average increase in funding costs on the CET1 ratio is economically significant with an average of 88 bps after three years.

244. The impact of the feedback-effect of funding costs on the CET1 ratio is heterogeneous across banks in the sample. It is higher for banks with (i) a higher asset liability mismatch, (ii) a higher share of unsecured wholesale funding, (iii) a lower risk density, (iv) a lower volume of repriceable loans, and (v) with less pricing power in loan markets (a lower pass-through rate of higher funding costs on loans).

OVERALL ASSESSMENT

245. Overall the resilience of large euro area banks has improved, but important vulnerabilities remain. Capital buffers are in aggregate sizeable relative to immediate threats, but some banks are especially vulnerable to credit risk and others to market risks, including from risk premia decompression, basis risk, and valuation shocks. While IMF results are not directly comparable to the 2018 EU-wide stress test results due to differences in scenario and methodology, comparable results are obtained using alternative solvency metrics. IMF sensitivity-based reverse stress test results suggest that, a moderate valuation shock on hard-to-value assets, might deplete capital buffers of some large complex banks. At a structural level, low profitability is found in many banks across all business models, despite improving conjunctural conditions.

246. The range of results highlights the diversity of the euro area banking sector. The large, but less complex, internationally-active banks are more robust to stress scenarios and the single factor shocks, pointing to the potential risk-sharing benefits conferred from cross-border banking. Because G-SIBs' business models generally emphasize trading and capital markets-related activities, they are disproportionately affected by market dislocation under severe market conditions. In contrast, domestically-oriented banks are relatively more vulnerable to deteriorations in macroeconomic conditions.

247. To the extent that the failure of a significant subsidiary and investment firms could cause major disruption of the euro area financial system, ECB's macroprudential stress testing framework could be expanded to include them.[90] The stress test exercise is conducted at the level of the banking group using consolidated data. This approach assumes a free flow of capital and liquidity within each banking group. Stress tests thus do not take into account the challenges from intra-group support measures between: regulated entities, regulated and unregulated entities, cross-border, cross-sectoral, "upstream" support (from a subsidiary to its parent) or "downstream" (from the parent to its subsidiary). While the parent of a significant subsidiary in the euro area may provide 'downstream' support, measures can vary between jurisdictions due to differing regulatory, legal or tax regimes. The prospective move to place significant investment firms under SSM supervision will both necessitate and facilitate this extension.

Box 5. Possible Supervisory Implications of the Stress Testing Exercise

The FSAP stress tests contributes to identifying priority areas of supervision:

- Supervisory attention could prioritize credit risk in high-risk portfolios. Prudential provisioning practices in some banks might need to be stepped up to build additional buffers.
- Valuation effects from a sudden correction in asset prices, basis widening, and shocks to hard-to-value assets should be high priority.
- Attention should be given to business risk from lower-than-expected business volumes, migration of client positions, compressed margins, and dynamic hedging.
- Supervisors could focus their attention on banks that feature a negative post-stress CBC. Banks may need to increase their CBC, lengthen and stagger the tenors of deposits from financial institutions, or improve the price risk-sensitivity of committed lines to customers.
- Some banks might need to proactively strengthen their balance sheets (by increasing their capital base) to ensure reasonable funding costs as their reliance on private funding increases. Banks that combine relatively low capitalization with low liquidity are especially vulnerable to a combination of shocks.

[90] This requires access to sufficiently granular supervisory data at the subsidiary level.

Annex I. Solvency Stress Tests—Selected Regression Results

Annex Table 1. Euro Area: Determinants of Credit Risk in Low-Spread Country C1

Dependent Variable = EDF corp (C1)						
	Full Sample 2005Q1–2016Q4			In-sample period to test performance 2005Q1–2014Q4		
	(1)	(2)	(3)	(4)	(5)	(6)
L.g	-0.135***	-0.118**	-0.133***	-0.101***	-0.078	-0.097*
	(0.043)	(0.046)	(0.043)	(0.032)	(0.059)	(0.050)
L2.g		-0.010	-0.006		0.003	-0.026
		(0.046)	(0.081)		(0.039)	(0.086)
L3.g			-0.008			-0.042
			(0.044)			(0.037)
L.slope	0.367***	0.775***	0.975***	0.366***	0.925***	1.089***
	(0.083)	(0.220)	(0.233)	(0.081)	(0.215)	(0.237)
L2.slope		-0.384	-0.845		-0.536**	-0.666
		(0.275)	(0.498)		(0.236)	(0.550)
L3.slope			0.292			-0.013
			(0.414)			(0.450)
L.spread_swap	-0.001	-0.002	0.000	-0.001	-0.001	0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)
L2.spread_swap		0.000	-0.002		-0.001	-0.003
		(0.002)	(0.002)		(0.002)	(0.002)
L3.spread_swap			0.003**			0.002
			(0.002)			(0.002)
L.libor_usd_tbill	0.513***	0.435*	0.420	0.523***	0.392	0.317
	(0.156)	(0.240)	(0.301)	(0.155)	(0.251)	(0.295)
L2.libor_usd_tbill		0.102	0.053		0.108	0.077
		(0.201)	(0.236)		(0.230)	(0.244)
L3.libor_usd_tbill			0.264**			0.239*
			(0.125)			(0.116)
L.g_ea	0.029	0.069	0.178*	0.004	0.059	0.149
	(0.047)	(0.052)	(0.100)	(0.045)	(0.041)	(0.091)
L2.g_ea		-0.020	-0.108		-0.054	-0.082
		(0.067)	(0.117)		(0.069)	(0.128)
L3.g_ea			0.059			0.076
			(0.103)			(0.107)
L.g | g<0	0.112*	0.172**	0.158	0.101	0.170*	0.237*
	(0.060)	(0.075)	(0.114)	(0.060)	(0.083)	(0.134)
Constant	-4.415***	-4.463***	-4.678***	-4.451***	-4.470***	-4.536***
	(0.203)	(0.222)	(0.234)	(0.197)	(0.227)	(0.245)
Observations	47	46	45	39	38	37

Dependent variable = EDF for the corporate portfolio of low-spread euro area country C1. Regressors include: g (GDP growth), slope (10-year sovereign bond minus 3-month T-bill rate), spread_swap (10-year bond yield minus 10-year swap rate), libor_usd_tbill (3-month usd libor minus 3-month US T-bill), g_ea (GDP growth in the euro area), and g | g<0 (GDP growth negative). Lagged variables are denoted by L (t-1), L2 (t-2), and L3 (t-3). Estimation using Newey-West HAC-robust standard errors. *** p<0.01, ** p<0.05, * p<0.1

Annex Table 2. Euro Area: Determinants of Credit Risk in High-Spread Countries C2 and C3

	Variable = EDF corp (C2)		Variable = EDF corp (C3)	
	(1)	(2)	(3)	(4)
	Full Sample 2005Q1–2016Q4	In-sample period to test performance 2005Q1–2014Q4	Full Sample 2005Q1–2016Q4	In-sample period to test performance 2005Q1–2014Q4
L.g	0.203	-0.129	0.371	0.301
	(0.166)	(0.086)	(0.145)	(0.151)
L.slope	0.469**	0.225*	0.038	0.282***
	(0.188)	(0.127)	(0.114)	(0.090)
L.spread_swap	0.005***	0.004***	0.003***	0.002***
	(0.001)	(0.001)	(0.001)	(0.001)
L.libor_usd_tbill	0.049	0.241**	0.618***	0.635***
	(0.153)	(0.109)	(0.069)	(0.076)
L.g_ea	-0.313***	-0.139*	-0.406***	-0.375***
	(0.088)	(0.079)	(0.093)	(0.088)
L.g | g<0	0.345***	0.380***	-0.089	-0.044
	(0.115)	(0.086)	(0.083)	(0.091)
Constant	-5.575***	-4.992***	-4.481***	-5.196***
	(0.509)	(0.260)	(0.348)	(0.288)
Observations	47	39	47	39

Dependent variable = EDF for the corporate portfolio of two high-spread euro area countries C2 and C3. Regressors include: g (GDP growth), slope (10-year minus 2-year sovereign bond yield), spread_swap (10-year yield minus 10-year swap rate), libor_usd_tbill (3-month usd libor minus 3-month US T-bill rate), g_ea (GDP growth in the euro area), and g | g<0 (GDP growth negative). Lagged variables are+ denoted by L (t-1), Estimation using Newey-West HAC-robust standard errors. *** p<0.01, ** p<0.05, * p<0.1

Annex Table 3. Determinants of Credit Risk in Large Emerging Market Country C4

	Dependent Variable = EDF corp (C4)							
	Full Sample 2005Q1–2016Q4				In-sample period 2005Q1–2014Q4			
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
L.g	-0.014	0.012	0.002	-0.032	-0.021	0.006	0.003	-0.045
	(0.021)	(0.019)	(0.018)	(0.029)	(0.016)	(0.028)	(0.024)	(0.054)
L2.g		-0.065***	-0.049**	-0.017		-0.059**	-0.060**	-0.056
		(0.016)	(0.020)	(0.045)		(0.023)	(0.025)	(0.030)
L3.g			-0.047**	-0.052***			-0.041	-0.055
			(0.017)	(0.015)			(0.026)	(0.073)
L4.g				-0.026				-0.047
				(0.032)				(0.063)
L.lt	0.035	0.428**	0.137	-0.005	-0.001	0.241	0.101	0.041
	(0.151)	(0.195)	(0.171)	(0.274)	(0.154)	(0.312)	(0.209)	(0.686)
L2.lt		-0.304**	0.308*	0.438*		-0.247	0.235	0.597
		(0.141)	(0.177)	(0.231)		(0.201)	(0.188)	(0.266)
L3.lt			-0.363**	-0.291			-0.406**	-1.251
			(0.171)	(0.311)			(0.173)	(0.740)
L4.lt				-0.117				1.199
				(0.314)				(1.547)
L.fx	0.006**	0.004*	0.003	-0.002	0.008***	0.006*	0.000	-0.001
	(0.003)	(0.002)	(0.002)	(0.004)	(0.003)	(0.003)	(0.004)	(0.007)
L2.fx		0.003	-0.001	0.001		0.004	0.002	0.000
		(0.003)	(0.002)	(0.003)		(0.003)	(0.005)	(0.011)
L.libor_usd_tbill	0.089	-0.026	0.039	0.045	0.170	0.026	0.062	-0.004
	(0.063)	(0.050)	(0.065)	(0.047)	(0.112)	(0.087)	(0.103)	(0.131)
L2.libor_usd_tbill		0.056	0.098	0.158		0.081	0.061	0.493
		(0.076)	(0.077)	(0.129)		(0.074)	(0.103)	(0.270)
L3.libor_usd_tbill			0.161**	0.164**			0.268**	0.224
			(0.065)	(0.059)			(0.092)	(0.159)
L.g_em	-0.105	-1.699**	-0.510	-0.375	-0.146	-1.191	-0.801	-0.523
	(0.326)	(0.708)	(0.549)	(0.812)	(0.361)	(0.859)	(0.569)	(1.756)
L2.g_em		1.593**	-0.289	-0.196		1.082	0.338	-0.015
		(0.679)	(0.829)	(0.807)		(0.814)	(0.915)	(1.037)
L.g | g<15th perc	0.044	0.097***	0.077**	0.039	-0.460***	-0.028	0.258	0.117
	(0.029)	(0.033)	(0.030)	(0.042)	(0.134)	(0.204)	(0.176)	(0.179)
Constant	-3.459***	-3.543***	-3.267***	-2.901**	-3.667***	-4.037***	-3.798***	0.909
	(0.703)	(0.725)	(0.751)	(1.236)	(0.735)	(0.753)	(0.707)	(5.947)
Observations	47	46	45	44	39	38	37	36

Dependent variable = EDF for the corporate portfolio of non-euro area emerging market country C4. Regressors include: g (GDP growth), lt (10-year sovereign bond yield), fx (year-on-year nominal depreciation relative to the USD), libor_usd_tbill (3-month usd libor over 3-month US T-bill rate), g_em (GDP growth in emerging markets), and g | g<15th perc (GDP growth below the 15th percentile). Lagged variables are denoted by L (t-1), L2 (t-2), L3 (t-3), and L4 (t-4). Estimation using Newey-West HAC-robust standard errors. *** p<0.01, ** p<0.05, * p<0.1

Annex Table 4. Euro Area: Determinants of Deposit Rates in Low-Spread Country C1

	corporate_new business		households_new business	
	(1)	(2)	(3)	(4)
L.new business	-0.321	-0.009	-0.375	0.020
	(0.600)	(0.453)	(0.295)	(0.179)
L.g	0.058***	0.020	0.011	0.039
	(0.014)	(0.021)	(0.010)	(0.031)
L.inf	-0.037	0.099**	-0.015	0.118**
	(0.048)	(0.046)	(0.035)	(0.043)
L2.inf		-0.091*		-0.074**
		(0.049)		(0.033)
L.credit	-0.096*	-0.055	0.001	-0.044
	(0.050)	(0.053)	(0.025)	(0.031)
L.ecb_pol	0.486	0.503***	0.883***	0.615***
	(0.290)	(0.121)	(0.172)	(0.094)
L2.ecb_pol		-0.719***		-0.277**
		(0.138)		(0.125)
L.libor_euro	0.711*	0.745*	0.341**	0.305**
	(0.414)	(0.379)	(0.155)	(0.118)
L2.libor_euro		0.149		0.009
		(0.210)		(0.137)
L.swap	-0.215	0.403	0.009	0.018
	(0.172)	(0.262)	(0.046)	(0.134)
L2.swap		-0.529		0.047
		(0.377)		(0.165)
L.spread_swap	-0.005*	0.003	-0.003**	-0.002
	(0.003)	(0.002)	(0.001)	(0.002)
L2.spread_swap		-0.004		0.002
		(0.004)		(0.002)
L.libor_usd	0.175***	-0.140	-0.087**	-0.268**
	(0.040)	(0.190)	(0.040)	(0.098)
L2.libor_usd		0.324		0.299**
		(0.231)		(0.131)
Constant	0.133	0.295	0.617***	0.347**
	(0.240)	(0.282)	(0.208)	(0.138)
Observations	47	46	47	46
Adj R2	0.979	0.990	0.987	0.989

Dependent variable = deposit rate on new business from corporations (columns 1 and 2), and households (columns 3 and 4) in low-spread euro area country C1. Regressors include: l.new business (lagged deposit rate), g (GDP growth), inf (inflation rate), credit (private sector credit growth), ecb_pol (ECB main refinancing rate), libor_euro (3-month euro libor rate), swap (10-year swap rate), spread_swap (10-year sovereign bond yield over swap rate), and libor_usd (3-month euro libor rate). Lagged variables are denoted by L (t-1) and L2 (t-2). The sample covers 2005Q1 through 2016Q4. Estimation using Newey-West HAC-robust standard errors. *** p<0.01, ** p<0.05, * p<0.1

Annex Table 5. Euro Area: Determinants of Lending Rates in High-Spread Country C2

Corporate Loans		Consumer Loans		Mortgage Loans	
L.len_corp	0.296	L.len_con	0.549***	L.len_mor	0.217
	(0.200)		(0.090)		(0.139)
L.edf_corp	-0.276***	L.edf_con	-0.005	L.edf_re	-0.075**
	(0.072)		(0.089)		(0.035)
L.u	0.161***	L.u	-0.008	L.u	0.112***
	(0.048)		(0.081)		(0.035)
L.inf	0.129***	L.inf	0.007	L.inf	0.099***
	(0.029)		(0.077)		(0.028)
L.credit	-0.028**	L.credit	-0.078	L.credit	-0.014
	(0.012)		(0.054)		(0.015)
L.ecb_pol	0.485***	L.ecb_pol	-0.581	L.housing	-0.004
	(0.171)		(0.388)		(0.015)
L.libor_euro	0.107	L.libor_euro	0.514**	L.ecb_pol	0.442
	(0.152)		(0.222)		(0.265)
L.swap	-0.076	L.swap	0.243*	L.libor_euro	0.259*
	(0.055)		(0.139)		(0.145)
L.spread_swap	-0.001	L.spread_swap	0.000	L.swap	-0.014
	(0.001)		(0.001)		(0.079)
L.libor_usd	0.392***	L.libor_usd	0.447*	L.spread_swap	-0.001
	(0.110)		(0.239)		(0.001)
Constant	-1.345***	Constant	2.827	L.libor_usd	0.221***
	(0.478)		(1.943)		(0.073)
				L2.libor_usd	
				Constant	-0.659
					(0.498)
Observations	47	Observations	47	Observations	47
Adj R2	0.964	adjR2	0.805	adjR2	0.978

Dependent variable = lending rate on new business: len_corp: loans to corporations (column 1), len_con: consumer loans (column 2), and len_mor: loans to households for house purchase (column 3) in a high-spread country. Regressors include: L.len_corp (lagged len_corp), L.len_con (lagged len_con), L.len_mor (lagged len_mor), edf_corp (Moody's 1-year edf on the corporate group), edf_con (Moody's 1-year edf on the consumer nondurables group), edf_re (Moody's 1-year edf on the construction and real estate development group), u (unemployment rate), inf (inflation rate), credit (private sector credit growth), housing (growth in residential real estate prices), ecb_pol (ECB main refinancing rate), libor_euro (3-month euro libor rate), swap (10-year swap rate), spread_swap (10-year sovereign bond yield over swap rate), and libor_usd (3-month euro libor rate). Lagged variables are denoted by L (t-1). The sample covers 2005Q1 through 2016Q4. Estimation using Newey-West HAC-robust standard errors. *** p<0.01, ** p<0.05, * p<0.1.

Annex Table 6. Euro Area: Determinants of Bank Retail Deposit Rates

										All countries	
VARIABLES	C1	C2	C3	C4	C5	C6	C7	C8	C9	Spec 1	Spec 2
L.int_dep	0.61***	0.72***	1.01***	0.54***	-0.06	0.92***	0.88***	0.89***	0.71***	0.77***	0.77***
	(0.097)	(0.067)	(0.049)	(0.067)	(0.161)	(0.028)	(0.076)	(0.048)	(0.072)	(0.021)	(0.021)
L.g	-0.091	0.024	0.109*	0.028	0.044	-0.080	-0.004	-0.030	0.048	0.009	-0.001
	(0.080)	(0.019)	(0.061)	(0.054)	(0.206)	(0.066)	(0.004)	(0.043)	(0.162)	(0.008)	(0.009)
L.u	0.082	-0.054*	-0.059	0.029	-0.632	0.028	-0.019	-0.022	-0.073	-0.009	-0.008
	(0.193)	(0.029)	(0.064)	(0.028)	(0.810)	(0.116)	(0.019)	(0.019)	(0.113)	(0.009)	(0.009)
L.inf	0.110	0.001	-0.030	0.112*	0.125	0.032	-0.027	-0.027	0.083	0.027	0.024
	(0.128)	(0.011)	(0.089)	(0.057)	(0.143)	(0.050)	(0.026)	(0.029)	(0.103)	(0.016)	(0.016)
L.libor_euro	0.071	-0.061	-0.294	0.562***	-0.450	0.044	0.013	-0.037	0.184	-0.075	0.025
	(0.283)	(0.049)	(0.218)	(0.183)	(0.761)	(0.117)	(0.107)	(0.064)	(0.339)	(0.047)	(0.056)
L.ecb_pol	0.447	0.275***	0.293	-0.267	0.408	0.084	0.143	0.183**	-0.096	0.253***	0.180***
	(0.286)	(0.045)	(0.220)	(0.208)	(0.423)	(0.122)	(0.122)	(0.070)	(0.370)	(0.058)	(0.060)
L.spread_swap	0.003	-0.000	-0.002	-0.002	1.158	0.000	0.001**	0.001**	-0.005*	0.000	0.000
	(0.002)	(0.000)	(0.002)	(0.001)	(0.739)	(0.001)	(0.000)	(0.000)	(0.003)	(0.000)	(0.000)
L.libor_usd_tbill	-0.281	-0.041	-0.032	-0.049	0.146	-0.392***	-0.192**	-0.153***	-0.220		-0.180***
	(0.199)	(0.035)	(0.184)	(0.145)	(0.846)	(0.085)	(0.075)	(0.048)	(0.278)		(0.054)
L.g_ea	0.052	-0.003	-0.056	0.069	-0.271	0.060	0.050**	0.081**	0.066		0.026*
	(0.074)	(0.018)	(0.072)	(0.077)	(0.368)	(0.039)	(0.019)	(0.032)	(0.137)		(0.015)
L.g | g<0	-0.077	-0.028	-0.020	-0.219**	-0.411	0.014	0.012	-0.003	-0.195	0.014	-0.007
	(0.114)	(0.021)	(0.054)	(0.103)	(3.432)	(0.069)	(0.019)	(0.028)	(0.128)	(0.018)	(0.020)
Constant	-0.319	0.547**	0.165	0.035	0.781	-0.118	0.229	0.114	0.677	0.288***	0.303***
	(1.250)	(0.236)	(0.398)	(0.609)	(1.670)	(1.202)	(0.215)	(0.203)	(0.778)	(0.105)	(0.104)
Observations	76	44	129	194	47	220	81	118	111	1,020	1,020
Adj R2	0.902	0.997	0.927	0.835	0.553	0.917	0.976	0.977	0.751	0.815	0.819
Number of cnid	2	2	6	5	1	5	2	3	3	29	29

Dependent variable = customer deposit rate (bank specific). Regressors include: L.int_dep (lagged int_dep), g (GDP growth), u (unemployment rate), inf (inflation rate), libor_euro (3-month euro libor rate), ecb_pol (ECB main refinancing rate), spread_swap (10-year sovereign bond yield over swap rate), libor_usd_tbill (3-month usd libor over 3-month US T-bill rate), g_ea (GDP growth in the euro area), and g | g<0 (GDP growth negative). Lagged variables are denoted by L (t-1). The sample covers 2005Q1 through 2016Q4. Estimation using panel data with fixed effects at the country level (columns 1-9), and at the euro area level (columns 10 and 11). *** p<0.01, ** p<0.05, * p<0.1.

Annex Table 7. Euro Area: Determinants of Bank Bond Spreads at Issuance

										All countries	
VARIABLES	C1	C2	C3	C4	C5	C6	C7	C8	C9	Spec 1	Spec 2
L.g	1.533	6.661	3.895	-2.495	-0.064	-5.184	1.940	25.415	-30.026***	0.925	1.732
	(19.142)	(15.194)	(6.940)	(9.455)	(0.093)	(13.311)	(2.178)	(19.275)	(8.764)	(1.199)	(1.188)
L.u	63.016	-18.201	-10.483***	4.997	0.006	34.276***	23.601**	10.482	-16.005**	1.096	1.792*
	(59.416)	(22.383)	(3.410)	(4.314)	(0.365)	(12.767)	(11.051)	(11.876)	(6.292)	(1.027)	(1.017)
L.inf	26.681	9.866	-2.297	-0.397	0.076	9.745	29.602**	4.194	-1.378	-1.419	-1.619
	(32.609)	(8.968)	(8.431)	(8.715)	(0.063)	(8.516)	(12.214)	(11.391)	(5.094)	(1.876)	(1.847)
L.slope	-7.344	-18.461	2.624	23.171	-0.015	1.153	-14.689	4.072	-5.823	0.004	0.274
	(33.072)	(18.550)	(13.380)	(18.576)	(0.011)	(11.789)	(31.496)	(27.959)	(11.042)	(1.139)	(1.122)
L.spread_swap	0.371	0.263	0.043	0.185	0.662**	0.125	-0.130	0.532**	0.233	0.463***	0.406***
	(0.539)	(0.267)	(0.182)	(0.170)	(0.308)	(0.152)	(0.320)	(0.247)	(0.185)	(0.044)	(0.044)
L.libor_usd_tbill	3.686	-33.557	-0.512	22.835	0.268	37.678**	-20.401	48.775**	-2.314	10.376**	-5.071
	(49.549)	(29.612)	(14.204)	(16.795)	(0.320)	(14.951)	(22.685)	(21.005)	(16.423)	(4.311)	(5.174)
L.g_ea	-22.576	-11.513	-2.425	15.585	0.011	3.182	-25.310***	-14.549	20.693***	-3.941**	-2.320
	(19.443)	(11.228)	(9.158)	(11.090)	(0.153)	(8.595)	(7.725)	(14.514)	(7.754)	(1.758)	(1.757)
L.g | g<0	16.786	10.915	-10.837**	-8.124	-0.709	-3.338	-1.035	-9.127	17.682**	2.839	6.636**
	(25.746)	(16.431)	(5.446)	(17.694)	(1.575)	(12.357)	(5.299)	(12.244)	(7.673)	(2.476)	(2.721)
L.equity											-1.000***
											(0.164)
L.equity_vol											0.001
											(0.005)
Constant	-249.500	254.873	139.502***	-46.184	0.566	-264.269**	-72.019	-60.779	212.771***	72.787***	79.966***
	(385.179)	(202.451)	(22.780)	(84.106)	(0.629)	(130.951)	(123.398)	(168.397)	(58.969)	(11.348)	(11.287)
Observations	54	58	261	184	47	232	59	125	127	1,147	1,147
Adj R2	0.185	0.132	0.114	0.416	0.847	0.123	0.667	0.428	0.190	0.199	0.225
Number of cnid	2	2	6	5	1	5	2	3	3	29	29

Dependent variable = average spread of new debt issuance to benchmark (bank specific). Regressors include: g (GDP growth), u (unemployment rate), inf (inflation rate), slope (10-year minus 3-month T-bill), spread_swap (10-year sovereign bond yield over swap rate), libor_usd_tbill (3-month usd libor over 3-month US T-bill rate), g_ea (GDP growth in the euro area), g | g<0 (GDP growth negative), equity (price growth of major equity index), and equity_vol (realized equity volatility). Lagged variables are denoted by L (t-1). The sample covers 2005Q1 through 2016Q4. Estimation using panel data with fixed effects at the country level (columns 1-9), and at the euro area level (columns 10 and 11). *** p<0.01, ** p<0.05, * p<0.1.

Annex Table 8. Euro Area: Determinants of Bank Lending Rates

VARIABLES	(1) C1	(2) C2	(3) C3	(4) C4	(5) C5	(6) C6	(7) C7	(8) C8	(9) C9	(10) All Countries
L.int_loans	0.414***	0.842***	0.621***	0.204***	0.152	0.700***	0.773***	0.551***	0.994***	0.688***
	(0.145)	(0.055)	(0.048)	(0.069)	(0.142)	(0.051)	(0.063)	(0.091)	(0.031)	(0.021)
L.g	0.063	0.027	-0.145	-0.084	-0.011	-0.231**	-0.003	-0.081	0.023**	0.023
	(0.148)	(0.024)	(0.205)	(0.077)	(0.067)	(0.099)	(0.004)	(0.127)	(0.011)	(0.022)
L.inf	-0.061	-0.019	-0.003	0.015	0.085**	-0.013	0.046*	0.064	0.030***	-0.027
	(0.172)	(0.013)	(0.320)	(0.062)	(0.037)	(0.062)	(0.025)	(0.079)	(0.007)	(0.038)
L.lt	0.296	0.070***	0.745***	0.185	0.420***	0.274***	0.166***	0.139	0.024***	0.292***
	(0.288)	(0.023)	(0.237)	(0.134)	(0.132)	(0.078)	(0.044)	(0.100)	(0.008)	(0.052)
L.funding cost	0.770*	0.104***	0.150	-0.050	-0.033	0.033	-0.062	0.271	-0.006	0.059
	(0.456)	(0.032)	(0.143)	(0.135)	(0.074)	(0.071)	(0.094)	(0.168)	(0.004)	(0.051)
L.spread_swap	-0.002	0.000	0.001	-0.002**	0.393***	-0.000	-0.002***	-0.003***	-0.001***	-0.002***
	(0.003)	(0.000)	(0.007)	(0.001)	(0.116)	(0.001)	(0.000)	(0.001)	(0.000)	(0.001)
L.libor_usd_tbill	-0.186	-0.003	-0.582	0.765***	-0.038	-0.229***	-0.023	-0.104	-0.082***	-0.076
	(0.251)	(0.036)	(0.391)	(0.143)	(0.224)	(0.085)	(0.057)	(0.130)	(0.017)	(0.100)
L.g_ea	0.149	0.021	0.470**	0.008	-0.230**	0.163***	0.047***	0.155	0.002	0.113***
	(0.124)	(0.016)	(0.232)	(0.088)	(0.090)	(0.058)	(0.016)	(0.098)	(0.009)	(0.034)
L.g | g<0	-0.099	0.016	-0.088	0.048	-0.220	0.129	0.026*	-0.047	0.038***	-0.075
	(0.188)	(0.024)	(0.223)	(0.095)	(1.103)	(0.088)	(0.014)	(0.074)	(0.009)	(0.048)
Constant	0.931*	0.131	0.037	2.918***	2.094***	0.751***	0.676***	0.781***	-0.068	0.433***
	(0.469)	(0.134)	(0.567)	(0.467)	(0.481)	(0.172)	(0.167)	(0.283)	(0.103)	(0.145)
Observations	89	84	282	194	47	220	89	118	96	1,219
Adj R2	0.845	0.984	0.615	0.535	0.929	0.804	0.981	0.849	0.988	0.623
Number of cnid	2	2	6	5	1	5	2	3	3	29

Dependent variable = lending rate (bank specific). Regressors include: L.int_loans (lagged implicit lending rates on loans), g (GDP growth), inf (inflation rate), lt (10-year sovereign bond yield), funding cost (interest expense over interest-bearing liabilities), spread_swap (10-year sovereign yield over swap rate), libor_usd_tbill (3-month usd libor over 3-month US T-bill rate), g_ea (GDP growth in the euro area), and g | g<0 (GDP growth negative). Lagged variables are denoted by L (t-1). The sample covers 2005Q1 through 2016Q4. Estimation using panel data with fixed effects at the country level (columns 1-9), and at the euro area level (column 10). *** p<0.01, ** p<0.05, * p<0.1.

Annex Table 9. Euro Area: Determinants of Bank Fees and Commissions

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
VARIABLES	C1	C2	C3	C4	C5	C6	C7	C8	C9	Spec 1	Spec 2
L.fc	0.694***	0.570***	0.654***	0.546***	0.041	-0.026	0.164***	0.255***	0.827***	0.583***	0.672***
	(0.071)	(0.105)	(0.048)	(0.035)	(0.181)	(0.072)	(0.042)	(0.081)	(0.054)	(0.105)	(0.048)
L.g_ea	-0.037*	0.004	0.007*	-0.010	-0.006	-0.033	-0.029*	0.019	0.005		0.012**
	(0.020)	(0.015)	(0.004)	(0.008)	(0.053)	(0.057)	(0.016)	(0.025)	(0.005)		(0.005)
equity	-0.001	-0.001	0.001**	0.001**	0.073	-0.002	-0.001	0.003**	0.000	0.000	0.001
	(0.001)	(0.002)	(0.000)	(0.001)	(0.097)	(0.004)	(0.001)	(0.001)	(0.000)	(0.001)	(0.001)
L.equity	0.001	0.001	-0.001	-0.000	-0.058	-0.003	0.002*	-0.000	-0.000	0.001*	-0.000
	(0.001)	(0.001)	(0.000)	(0.001)	(0.087)	(0.004)	(0.001)	(0.002)	(0.000)	(0.001)	(0.001)
ch_st	-0.030	0.026	0.025	-0.024	-0.029	-0.131	0.326***	0.154	0.029	0.040*	0.057**
	(0.107)	(0.075)	(0.024)	(0.025)	(0.070)	(0.225)	(0.099)	(0.151)	(0.028)	(0.024)	(0.025)
L.ch_st	0.040	0.054	-0.030*	-0.001	0.033	-0.072	-0.030	-0.125	-0.031	-0.010	-0.033
	(0.076)	(0.064)	(0.018)	(0.028)	(0.064)	(0.160)	(0.080)	(0.139)	(0.022)	(0.023)	(0.025)
ch_lt	0.363**	-0.220***	0.011	0.067	0.102	-0.313	0.013	-0.091	0.055**	0.005	-0.067**
	(0.140)	(0.075)	(0.029)	(0.049)	(0.064)	(0.302)	(0.024)	(0.101)	(0.026)	(0.031)	(0.032)
L.ch_lt	-0.060	-0.053	0.031	0.026	0.064	0.037	0.032*	-0.074	0.022	0.034	0.040
	(0.133)	(0.070)	(0.029)	(0.042)	(0.064)	(0.295)	(0.018)	(0.095)	(0.023)	(0.031)	(0.030)
g	0.028	-0.020	-0.003	0.000	0.009	0.064	-0.001	-0.035	-0.001	-0.007*	-0.006
	(0.025)	(0.028)	(0.004)	(0.016)	(0.028)	(0.098)	(0.002)	(0.027)	(0.006)	(0.004)	(0.004)
L.g	0.008	0.001	0.001	0.005	-0.012	0.052	0.000	0.021	0.000	-0.000	-0.004
	(0.022)	(0.029)	(0.004)	(0.017)	(0.029)	(0.095)	(0.002)	(0.038)	(0.006)	(0.004)	(0.004)
housing	0.001	-0.004	-0.001	0.000	0.011	0.031	-0.004	-0.041	-0.003	0.002	-0.001
	(0.006)	(0.011)	(0.002)	(0.004)	(0.021)	(0.036)	(0.004)	(0.032)	(0.003)	(0.003)	(0.003)
L.housing	-0.014**	0.012	0.006***	0.003	0.011	-0.034	0.007	0.058*	-0.000	0.004	0.001
	(0.006)	(0.012)	(0.002)	(0.004)	(0.053)	(0.036)	(0.005)	(0.029)	(0.002)	(0.003)	(0.003)
inf	-0.071**	-0.012	-0.009	-0.005	-0.003	0.000	0.049	-0.046	-0.005	0.013	0.021**
	(0.034)	(0.019)	(0.009)	(0.009)	(0.009)	(0.091)	(0.034)	(0.038)	(0.007)	(0.009)	(0.009)
L.inf	0.025	-0.011	0.005	0.017**	-0.002	0.027	-0.015	0.035	-0.008	-0.003	-0.011
	(0.037)	(0.024)	(0.009)	(0.009)	(0.008)	(0.077)	(0.029)	(0.034)	(0.007)	(0.009)	(0.009)
L.equity_vol	-0.007	-0.007	0.005	0.000	0.012	-0.015	0.011**	-0.005	-0.002		0.007**
	(0.005)	(0.009)	(0.004)	(0.005)	(0.008)	(0.044)	(0.006)	(0.010)	(0.002)		(0.003)
L.libor_usd_tbill	0.066	0.011	0.001	0.012	0.080	-0.170*	-0.019	-0.044	0.024**		-0.022
	(0.041)	(0.041)	(0.009)	(0.019)	(0.061)	(0.099)	(0.049)	(0.048)	(0.010)		(0.016)
L.spread_swap	0.000	-0.000	-0.000	0.000	0.007	-0.002*	-0.000	-0.000	-0.000		-0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.023)	(0.001)	(0.000)	(0.000)	(0.000)		(0.000)
Constant	0.456***	0.185***	0.092***	0.286***	0.438	0.722***	0.320***	0.752***	0.068***	0.575***	0.595***
	(0.097)	(0.063)	(0.020)	(0.028)	(0.299)	(0.104)	(0.040)	(0.097)	(0.020)	(0.010)	(0.013)
Observations	90	92	276	192	46	216	83	123	120	1,248	1,248
Adj R2	0.774	0.697	0.609	0.817	0.470	0.111	0.803	0.556	0.824	0.532	0.693
Number of cnid	2	2	6	5	1	5	2	3	3	29	29

Dependent variable: = fc (fees and commissions to total assets). Regressors L.fc (lagged dependent variable), g_ea (GDP growth in the euro area), equity (price growth of major equity index), ch_st (yoy change in 3-month libor rate), ch_lt (yoy change in 10-year sovereign bond yield), g (GDP growth), housing (growth in residential real estate price growth), inf (inflation rate), equity_vol (realized equity volatility), libor_usd_tbill (3-month usd libor over 3-month US T-bill rate), and spread_swap (10-year sovereign yield over swap rate). The sample covers 2005Q1 through 2016Q4. Panel data estimation with Generalized Method of Moments (GMM) estimator developed by Arellano and Bond at the country level (columns 1-9) and at the euro area level (columns 10-11). *** p<0.01, **p<0.05, *p<0.1.

Annex Table 10. Euro Area: Effect of Bank Solvency on Bank Retail Deposit Rates

										All countries	
VARIABLES	C1	C2	C3	C4	C5	C6	C7	C8	C9	Spec 1	Spec 2
L.g	-0.108	0.121***	0.063	0.028	0.125	0.192	-0.017***	-0.163*	0.148	-0.005	0.001
	(0.099)	(0.038)	(0.136)	(0.066)	(0.212)	(0.163)	(0.006)	(0.088)	(0.226)	(0.014)	(0.013)
L.u	-0.033	0.027	0.413***	0.063*	-0.179	0.906***	-0.253***	0.042	-0.408**	0.021	0.028**
	(0.236)	(0.062)	(0.133)	(0.034)	(0.917)	(0.283)	(0.053)	(0.040)	(0.159)	(0.014)	(0.014)
L.inf	-0.108	0.025	0.045	0.228***	0.001	-0.005	0.075**	-0.196***	0.361**	0.029	0.030
	(0.154)	(0.024)	(0.194)	(0.068)	(0.143)	(0.123)	(0.032)	(0.056)	(0.140)	(0.025)	(0.025)
L.libor_euro	0.696*	0.209**	0.499	0.076	-0.957	0.394	1.030***	0.434***	1.909***	0.011	-0.009
	(0.349)	(0.102)	(0.481)	(0.118)	(0.793)	(0.298)	(0.181)	(0.130)	(0.624)	(0.043)	(0.041)
L.ecb_pol	0.461	0.361***	0.196	0.714***	-0.826	0.767**	-0.072	0.746***	-1.267*	0.867***	0.821***
	(0.352)	(0.105)	(0.489)	(0.160)	(0.910)	(0.305)	(0.171)	(0.108)	(0.640)	(0.055)	(0.060)
L.spread_swap	0.005**	0.001	-0.003	-0.003***	1.498**	0.001	0.002***	0.000	-0.004	-0.000	0.000
	(0.003)	(0.001)	(0.004)	(0.001)	(0.699)	(0.002)	(0.000)	(0.001)	(0.004)	(0.000)	(0.000)
L.libor usd_tbill	-0.698***	0.116	0.401	0.354*	-0.569	-0.263	-0.614***	-0.114	-1.516***	-0.149**	-0.094
	(0.249)	(0.073)	(0.415)	(0.196)	(0.725)	(0.215)	(0.089)	(0.086)	(0.381)	(0.071)	(0.070)
L.g_ea	-0.052	-0.157***	-0.182	-0.119	0.048	-0.044	0.112***	0.159**	-0.158	-0.041*	-0.054**
	(0.086)	(0.025)	(0.155)	(0.099)	(0.342)	(0.096)	(0.032)	(0.068)	(0.179)	(0.023)	(0.022)
L.g | g<0	-0.082	-0.132***	0.010	-0.087	0.258	-0.296*	0.038*	-0.016	-0.063	-0.046	-0.021
	(0.141)	(0.043)	(0.119)	(0.128)	(3.342)	(0.171)	(0.021)	(0.056)	(0.193)	(0.031)	(0.030)
L.tier1											-0.190**
											(0.083)
L.tier1_sq											0.006*
											(0.003)
Constant	1.579	0.419	-0.931	0.347	-0.239	-7.908***	2.165***	-0.186	4.370***	0.967***	2.260***
	(1.505)	(0.534)	(0.875)	(0.755)	(1.395)	(2.955)	(0.338)	(0.431)	(1.184)	(0.157)	(0.522)
Observations	77	46	133	196	47	221	83	119	113	1,035	988
Adj R2	0.848	0.982	0.676	0.755	0.561	0.476	0.951	0.901	0.534	0.571	0.607
Number of cnid	2	2	6	5	1	5	2	3	3	29	29

Dependent variable = customer deposit rate (bank specific). Regressors include: g (GDP growth), u (unemployment rate), inf (inflation rate), libor_euro (3-month euro libor rate), ecb_pol (ECB main refinancing rate), spread_swap (10-year sovereign bond yield over swap rate), libor_usd_tbill (3-month usd libor over 3-month US T-bill rate), g_ea (GDP growth in the euro area), g | g<0 (GDP growth negative), and tier 1 (tier 1 ratio). Lagged variables are denoted by L (t-1). The sample covers 2005Q1 through 2016Q4. Estimation using panel data with fixed effects at the country level (columns 1-9), and at the euro area level (columns 10 and 11). *** p<0.01, ** p<0.05, * p<0.1.

Annex Table 11. Euro Area: Effect of Bank Solvency on Pass-Through of Funding Costs to Lending Rates

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	All countries	
	c1_s1	c2_s1	c3_s1	c4_s1	c5_s1	c6_s1	c7_s1	c8_s1	c9_s1	Spec 1	Spec 2
L.int_loans	0.552***	0.941***	0.621***	0.203***	0.143	0.705***	0.756***	0.639***	0.989***	0.688***	0.655***
	(0.121)	(0.049)	(0.048)	(0.068)	(0.139)	(0.050)	(0.058)	(0.073)	(0.031)	(0.021)	(0.022)
L.g	0.036	0.005	-0.128	-0.093	-0.018	-0.244**	-0.003	-0.154	0.022**	0.023	0.024
	(0.148)	(0.024)	(0.205)	(0.072)	(0.064)	(0.094)	(0.004)	(0.120)	(0.011)	(0.022)	(0.023)
L.inf	-0.088	-0.022*	0.039	0.014	0.087**	-0.014	0.035**	0.054	0.029***	-0.024	-0.017
	(0.173)	(0.013)	(0.317)	(0.061)	(0.036)	(0.062)	(0.017)	(0.079)	(0.007)	(0.038)	(0.040)
L.lt	0.604***	0.070***	0.774***	0.161	0.398***	0.292***	0.151***	0.205**	0.024***	0.314***	0.137*
	(0.225)	(0.024)	(0.235)	(0.117)	(0.121)	(0.067)	(0.038)	(0.092)	(0.008)	(0.048)	(0.071)
L.funding cost											0.652***
											(0.170)
L.spread_swap	-0.003	-0.000	0.001	-0.002**	0.404***	-0.001	-0.002***	-0.003***	-0.001**	-0.002***	-0.000
	(0.003)	(0.000)	(0.007)	(0.001)	(0.112)	(0.001)	(0.000)	(0.001)	(0.000)	(0.001)	(0.001)
L.libor_usd_tbill	-0.011	0.013	-0.520	0.733***	-0.043	-0.226***	-0.035	-0.058	-0.085***	-0.046	-0.255**
	(0.231)	(0.037)	(0.386)	(0.115)	(0.222)	(0.084)	(0.054)	(0.128)	(0.017)	(0.096)	(0.110)
L.g_ea	0.114	0.036**	0.446*	0.015	-0.231**	0.173***	0.051***	0.204**	0.002	0.114***	0.092**
	(0.124)	(0.016)	(0.231)	(0.086)	(0.089)	(0.054)	(0.015)	(0.094)	(0.009)	(0.034)	(0.036)
L.g | g<0	-0.094	0.037	-0.099	0.051	-0.207	0.134	0.024*	-0.020	0.037***	-0.075	-0.037
	(0.190)	(0.024)	(0.223)	(0.094)	(1.091)	(0.087)	(0.013)	(0.073)	(0.009)	(0.048)	(0.050)
L.tier1											0.003
											(0.044)
L.tier1_fc											-0.042***
											(0.012)
Constant	1.070**	0.001	0.396	2.906***	2.055***	0.767***	0.660***	0.701**	-0.062	0.512***	0.697
	(0.467)	(0.136)	(0.453)	(0.465)	(0.468)	(0.169)	(0.165)	(0.281)	(0.104)	(0.128)	(0.628)
Observations	89	84	282	194	47	220	89	118	96	1,219	1,169
Adj R2	0.839	0.982	0.613	0.535	0.929	0.803	0.981	0.845	0.988	0.622	0.630
Number of cnid	2	2	6	5	1	5	2	3	3	29	29

Dependent variable = lending rate (bank specific). Regressors include: L.int_loans (lagged int_loans), g (GDP growth), inf (inflation rate), lt (10-year sovereign yield), funding cost (interest expense over interest-bearing liabilities), spread_swap (10-year sovereign bond yield over swap rate), libor_usd_tbill (3-month usd libor over 3-month US T-bill rate), g_ea (GDP growth in the euro area), g | g<0 (GDP growth negative). tier 1 (tier1 ratio), and tier1_fc (tier 1 ratio multiplied by funding costs). Lagged variables are denoted by L (t-1). The sample covers 2005Q1 through 2016Q4. Estimation using panel data with fixed effects at the country level (columns 1-9), and at the euro area level (columns 10 and 11). *** p<0.01, ** p<0.05, * p<0.1.

Appendix I. Risk Assessment Matrix

Sources of Risk	Likelihood	Expected Impact
Tighter global financial conditions	**High** Financial conditions could tighten as investors reassess policy fundamentals, term premia decompress (possibly associated with an upside inflation surprise), amid monetary normalization.	**High** • Less favorable financial conditions for vulnerable sectors and countries. • Higher funding costs for banks, especially those regarded as less sound. • Valuation losses on assets, reduced value of collateral, and lower recovery in default cases Loss of market confidence. Negative shocks to growth, worsening an already weak growth outlook.
Further pressure on traditional bank business models	**Medium** Strained bank balance sheets with a weak profitability outlook could lead to financial distress in one or more major financial institutions.	**Medium** Given slow progress in balance sheet repair in some countries and broader profitability concerns, such an event could reverberate through the entire financial sector and widen sovereign yield spreads within the banking union.
Structurally weak growth in key advanced economies relative to baseline	**High** Low productivity growth, a failure to fully address crisis legacies and undertake structural reforms, as well as persistently low inflation undermines medium-term growth.	**High** • Lower growth potential and higher output gaps compared to baseline due to weaker investment and persistent long-term unemployment. • Further deterioration in public debt sustainability, private balance sheets, intra-euro area rebalancing**.**
Significant slowdown in China and its spillovers	**Low-Medium** Too fast an adjustment and improper sequencing of actions in China to "de-risk" the financial system may weigh on near-term growth (Low). Over the medium term, overly ambitious growth targets lead to unsustainable policies and a sharp adjustment would weaken demand with adverse international spillovers (Medium).	**Medium** • Slower export growth, higher output gap • Lower growth and inflation weakens public debt sustainability and private balance sheets.
Brexit and other policy and geopolitical uncertainties	**Medium** Uncertainty regarding post-Brexit arrangements, global spillovers from difficult-to-predict U.S. policies, evolving political processes in some European countries, and other geopolitical developments.	**High** • Financial market disruptions associated with Brexit. • Increased investor uncertainty, exacerbating low investment and weak productivity, and undermining cyclical recovery.
Retreat from cross-border integration	**High** Protectionism and economic isolationism could reduce global and regional policy collaboration with negative consequences for trade, capital and labor flows, sentiment and growth.	**High** • Lower growth due to trade barriers. • Escalation of euro skepticism, leading to less cooperation and a reversal of integration. • Increase in policy-related risk premia.

Appendix II. Banking Sector Stress Testing Matrix

A. Banking Sector: Solvency Test			
Domain		Framework	
		TD by ECB	TD by FSAP Team
1. Institutional perimeter	Institutions included	Twenty-eight major banks incorporated in nine-euro area member states. The criteria used to determine the institutional perimeter include: 2018 EU-wide stress test sample of euro area banks; firm's balance sheet (size, vulnerability indicators), firms' share in the domestic market, and firms' role in the euro area payment system.	
	Market share	About 65 percent of total banking sector assets in the EA. This is in line with 2018 EU-wide stress test bank coverage and facilitates comparability of results.	
	Data and horizon	Effective date: December 2015. Data: 2016 EU-wide ST bank data submissions. Historical default rate series from NCAs provided in the context of the 2016 EU-wide ST. Scope of consolidation: Consolidated group basis. Perimeter of the banking group (CRD IV). Insurance activities are excluded; banking associates are included. 3-year stress testing horizon.	Effective date: December 2017. Data: Supervisory data : ITS files (FINREP, COREP) and STE files (Interest Rate Risk in the Banking Book (IRRBB), Market Risk Sensitivities); Public data sources: 2016 and 2017 EBA Transparency Exercise, Pillar 3 disclosures, ECB MIR statistics, Bloomberg, Dealogic, Haver Analytics, Moody's KMV, Fitch, IMF Global Assumptions (GAS), and IMF WEO. Scope of consolidation Consolidated group basis. Perimeter of the banking group (CRD IV). Insurance activities are excluded; banking associates are included. 3-year stress testing horizon.

A. Banking Sector: Solvency Test			
Domain		**Framework**	
		TD by ECB	**TD by FSAP Team**
	Stress testing process	The ECB re-run its own top down (TD) solvency tool using Oct 2017 WEO forecast paths (baseline) and forecast paths generated by IMF adverse scenario for EU economies. The ECB generated additional variables required to generate risk projections in a way which was consistent with the scenario (e.g. swap rates, real estate prices, credit growth, equity prices, European corporate bond yields, European iTraxx indices). The SSM used individual results submitted by banks for the 2016 EU-wide stress test to benchmark FSAP results at the bank-level (e.g. capital depletion, contribution to the capital shortfall by key driver).	The FSAP team conducted its own TD macroprudential stress test using Oct 2017 WEO forecast paths (baseline) and forecast paths generated by IMF's in-house models (adverse) for all 36 material geographies of participating banks. The FSAP team generated additional variables required to generate risk projections in a way which was consistent with the scenario (e.g. swap rates, yield curves, real estate prices, credit growth, equity prices, European corporate bond yields, Moody's corporate spreads).
2. Channels of risk propagation	Methodology	ECB used its own satellite models for credit risk projections, bank interest rates, net interest margins, market risk, and banks' fee & commission income, under a static balance sheet assumption. Wide range of granular satellite models described in STAMP€ (Feb 2017). Pre-provisioning net revenue (PPNR) subject to the constraints laid out in the 2018 EU-wide stress test methodological note.	Granular approach: Credit risk projections generated by geographical breakdown (36 jurisdictions: 9 home euro area countries, 11 other EU countries, and 16 outside EU countries) and product (7 asset classes: retail unsecured, retail secured, large corporates, SME, specialized lending, institutions, and central banks and central governments). Loan growth paths capture reduced credit demand in material jurisdictions and FX shocks from revaluation effects on foreign currency loans. Robust approach: Battery of empirical strategies to project baseline/adverse forecasts using country drivers, regional variables, and global factors based on (i) country level/bank-level/panel regressions over different lag structures; (ii) quantile regressions over different quantiles (0.1…0.9; 0.25…0.75); and (iii) Bayesian model averaging (BMA) with exogenous global factors and normal diffuse distribution.

A. Banking Sector: Solvency Test				
Domain		Framework		
		TD by ECB	TD by FSAP Team	
			For internally-modelled exposures (IRB), projection of PD, LGD, RWA, EaD. For standardized (STA) exposures, projection of new flows of defaulted exposures, coverage ratio for defaulted loans, and risk weight downgrade for performing exposures. Credit risk projections for IRB and STA exposures include credit loss impairment charges and shifts to RWAs. Traded risk impact from the revaluation of trading assets (HFT), assets at fair value (FVO), and available for sale (AFS) securities by counterparty: central government (including 50 sovereign issuers), credit institutions, other financial institutions, and non-financial corporates. Credit spreads on sovereign securities interpolated using bank-specific residual maturity at the book and issuer level. Credit spreads on other securities estimated on a hypothetical portfolio using a duration proxy. Valuation effects assessed using a modified duration approach. Hedges are considered ineffective under stress. Funding costs projected at the bank level using bank-specific funding structure by product (deposits and debt securities issued), counterparty (central banks, general governments, financial institutions, customers), type of contract (fixed, floating), and maturity bucket based on residual contractual maturity (fixed instruments) and re-pricing schedule (floating instruments): overnight, 1-3m, 3-6m, 6-12m, 1-2y, 2-3y, 3-4y, 4-5y). Funding projections capture systematic risk (linked to the scenario) and idiosyncratic risk (for spreads on debt instruments issued over benchmark). Funding rate shocks applied to all interest-bearing liabilities including derivatives. Lending rates projected at the bank level using bank-specific loan book composition (loans and advances to central banks, general governments, financial institutions, households and corporates). Lending projections capture systematic risk (linked to the scenario) and idiosyncratic risk (linked to bank-level funding cost paths under the stress testing horizon) with pass-through effects estimated

<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 ECB</th><th>TD by FSAP Team</th></tr>
<tr><td></td><td></td><td></td><td>empirically. Lending rate shocks applied to all assets in the banking book.</td></tr>
<tr><td rowspan="2">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 real estate prices, benchmark curves, and corporate spreads.
This scenario is characterized by a tightening of global financial conditions, term premium decompression, heightened uncertainty in EU and US on the back to de-globalization initiatives, sovereign risk concerns in high spread euro area economies, balance sheet vulnerabilities in EMEs linked to corporate debt at risk, and a reductions of trade flows and productivity losses. The specific shocks which broadly capture this scenario are as follows: Equity prices fall by 20 percent in the EA, UK and US; money market spreads wide by 75 basis points in the EA and by 50 basis points in the UK and US; long-term government bond yields rise by 150 basis points in high-spread EA economies, 75 basis points in low-spread EA economies, and 100 basis points in the UK and US; private investment falls by 10 percent and 6 percent in low-spread and high-spread EA, respectively; private consumption decreases by 3 percent and 2 percent in low-spread and high-spread EA, respectively; high trade barriers contribute to reductions in exports and imports by 20 percent in EA and US, and by 10 percent in the rest of the world; less efficient resource allocation reduce productivity by 1 percent in EA and US.
Euro area experiences a balance sheet recession and secular stagnation, concentrated in high spread economies. Overall, output contracts by 7.1 percent relative to the baseline by 2020, while consumer price inflation falls by 3.3 percentage points. This output loss is somewhat concentrated in high spread economies, which experience a contraction of 7.6 percent, versus 6.9 percent in low spread economies. Total employment falls by 5.9 percent in the euro area. The government debt ratio rises by 18.4 percentage points in high spread economies and by 13.3 percentage points in low spread economies by 2020, given lower nominal output and higher debt service costs.
This scenario constitutes a 2.0 standard deviation move in two-year cumulative real GDP growth rate by 2019, calculated over 1990–2016.</td></tr>
<tr><td>Sensitivity analysis</td><td></td><td>Sensitivity tests identify potential vulnerabilities to standardized shifts to risk-factors. These tests are focused on estimating the additional capital loss from replacing model-based shocks by 6 separate single-factor shocks:
• Interest rate risk: A +200 bps parallel up in risk-free curves generating valuation effects (excluding hedges) and bank-specific funding shocks and lending shocks;</td></tr>
</table>

A. Banking Sector: Solvency Test			
Domain		**Framework**	
		TD by ECB	**TD by FSAP Team**
			• *Decompression of risk premia (own sovereign):* A 200bps widening of own sovereign spread over swap curve; • *Decompression of risk premia (non-sovereign):* A 350bps widening of credit spreads over Bund (i.e. repeat of 2008 crisis); • *Tighter LGD floor on mortgage loans: A* policy shock leading to an LGD floor of 30 percent on retail mortgages in home jurisdiction; • *Credit rating downgrade:* For STA exposures where ratings are used, a 1-notch external rating downgrade on performing exposures (e.g. 8 percent increase in risk weight); • *Low-for-long:* Impact of a continuation of the current ultra-low rate environment on banks' net interest income. **Reverse stress test on valuation risk:** For complex banks (G-SIBs) effect of soft mispricing of L2 and L3 assets. Quantification of the mispricing which could theoretically result in a breach of CET1 minimum requirement including Pillar 1 requirements, Pillar 2 requirements, and phased-in buffers. **Solvency-funding cost feedback**: Exploration of compounding effect on bank capital depletion from the interaction of solvency risk and funding shocks. Funding cost projections on customer deposits and debt instruments are linked to projected bank capital ratios under stress using an iterative process over the stress testing horizon.
4. Risks and buffers	Positions/risk factors assessed	Traded risk losses recognized the first year of stress (instantaneous shock). Net trading income from equity positions, debt instruments, and trading derivatives. Interest income from defaulted loans accrued on a net basis (2018 EBA methodology).	Traded risk losses recognized the year that the shock hits (over the 3-year horizon), except for sensitivity tests (instantaneous shocks excluding low-for-long). Net trading income from equity positions, debt instruments, and trading derivatives. No interest income accrual from defaulted loans.

A. Banking Sector: Solvency Test			
Domain		**Framework**	
		TD by ECB	**TD by FSAP Team**
		Interest income from non-defaulting loans is estimated according to satellite models. Interest expenses at the country level (by product and maturity) and bank level (linked to the scenario). Net fee and commission income, non-interest income (e.g. insurance income, dividend income, other income), and operational expenses evolve with the scenario. No change in business models (no rebalancing of portfolio is allowed). Tax Rate 30 percent rate. Regulatory impact No conversion of additional Tier 1 capital is assumed during the stress horizon. If banks' capital ratio falls below regulatory minimum during the stress test horizon, no prompt corrective action is assumed.	Interest income from non-defaulting loans is estimated according to satellite models. Interest expenses increase due to rising funding costs linked to banks' funding structure and market shocks, with model-based pass-through on corporate and household loans. Net fee and commission income, non-interest income (e.g. insurance income, dividend income, other income), and operational expenses evolve with the scenario. No change in business models (no rebalancing of portfolio is allowed). Tax Rate 30 percent rate 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. If banks' capital ratio falls below regulatory minimum during the stress test horizon, no prompt corrective action is assumed.
	Behavioral adjustments	Static Balance Sheet: In line with 2018 EBA methodology. Maturing assets are replaced by exposures of the same type and risk.	Dynamic Balance Sheet Credit demand shocks are included while credit supply effects are disallowed. EaD from off-balance sheet exposures increases under stress, reflecting higher use of undrawn credit and liquidity facilities. EaD evolves with structural foreign exchange risk. Maturing assets are replaced by exposures of the same type and risk.
		Dividend Policy: Payout ratio according to 2018 EBA methodology.	Dividend Policy Dividend payout ratio linked to banks' profits, capital ratios, and history, subject to the following constraints: • Floor set at 30 percent (positive profits); • CCB schedule for Common Equity Tier I;

<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 ECB</th><th>TD by FSAP Team</th></tr>
<tr><td></td><td></td><td></td><td>• Statistical analysis on banks' dividend policies during stress episodes.</td></tr>
<tr><td></td><td></td><td><u>Parameter calibration</u>
Initial Point-in-Time (PiT) PD and LGD parameters for non-defaulted exposures for expected losses from 2016 EU-wide EBA stress test.
Through-the-cycle (TTC) PD and LGD parameters for non-defaulted exposures for unexpected losses (i.e. RWAs) from 2016 EU-wide EBA stress test.
Shifts to RWAs for IRB exposures.
Historical PDs are informed by NCAs' submissions of default rates, Moody's EDF rates, and PD proxies by Kamakura.</td><td><u>Parameter calibration</u>
Initial regulatory PD and LGD parameters (hybrid PiT and TTC models) using COREP supervisory data by geographic and portfolio breakdown on the obligor pool.
Calculations performed to extract PD and LGD for non-defaulted exposures using information related to gross defaulted exposures (09.01 and 09.02 templates) and breakdown by obligor grade (08.02).
Shifts to IRB and STA exposures.
Historical PDs informed by Moody's EDF proxies, Merton-model approach for sovereign spreads, and bank-specific PDs from Pillar 3 disclosures.</td></tr>
<tr><td></td><td>Regulatory standards</td><td colspan="2">Capital definition according to national implementation of Capital Requirements Directive (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 Basel III transitional path.
The CET1 hurdle rate consisting of a 4.5 percent Pillar 1 requirement, 0.625 percent capital conservation (CCB) buffer, and phased-in bank-specific G-SII. For reverse sensitivity test the CET1 hurdle rate also includes Pillar 2 requirement and systemic risk buffer (SRB).</td></tr>
<tr><td>6. Reporting format for results</td><td>Output presentation</td><td colspan="2">For the aggregate euro area banking system and by type of bank (i.e. G-SIBs, Less Complex Large Internationally Active Banks, Relatively Smaller Domestically-Oriented Banks):
• Distribution of capital ratios under baseline/adverse scenario (box plots);
• Contribution to profitability and capital depletion by driver;
• Average CET1, CAR, and Tier 1 leverage ratio;</td></tr>
</table>

B. Banking Sector: Liquidity Test			
Domain		**Framework**	
		TD by ECB	**TD by FSAP Team**
1. Institutional Perimeter	Institutions included	Discussions to be finalized with ECB.	29 banks on the consolidated basis
	Market share		Over 70 percent of total banking sector assets
	Output presentation		Supervisory data (ALMM Maturity Ladder Template STE) Consolidated basis Banks grouped by business model Baseline date: September 30, 2017
2. Channels of risk propagation	Methodology		Cash flow-based analysis using contractual and behavioral (where available) cash flow data for significant currencies with assumptions about combined interaction of funding and market liquidity and different degrees of central bank support. LCR and NSFR analysis using granular data templates Liquidity stock (maturity transformation) analysis using NFSR data Five days collateral freeze scenario assuming that collateral received is not available for rehypothecation
	Feedback loops and links with solvency analysis		Exploratory scenario: Solvency-Funding cost loop (standardized shock of 100 bps in funding costs). Financial-Macro feedback loop. Changes in credit cost and volumes of new loans lead to changes in key macro variables (GDP, Unemployment etc.).
3. Sensitivity analysis	Perimeter and type of analysis		LCR distribution and volatility across banks and significant currencies NSFR distribution across banks
4. Tail Shocks	Size of the shock		Baseline: business as usual (as reported by banks under normal market conditions). Behavioral assumptions: all maturing liabilities are rolled-over. 5-day collateral freeze scenario (due to cyber-risk related event at CCP) 1-month intermediate/severe market stress scenario: higher run-off rates on unsecured wholesale funding (incl. FX swaps), and undrawn committed credit/liquidity lines on top of the mild stress scenario; 1-months severe combined (market/idiosyncratic) scenario 3-months intermediate/severe market stress scenario: higher run-off rates on secured wholesale funding (particularly FX swaps) on top of the intermediate stress scenario.

B. Banking Sector: Liquidity Test			
Domain		Framework	
		TD by ECB	TD by FSAP Team
			3-months severe combined (market/idiosyncratic) scenario. Each scenario provides for three approaches to the CBC with decreasing reliance on the CB and increasing focus on market liquidity (e.g. asset liquidation, asset encumbrance and collateral swaps). All scenarios are EUR based (acc. across all currencies) and USD based. In sum, the total number of scenarios is 40 (four sets of embedded scenarios of increasing severity). Liquidity concentration test: loss of funding from the largest providers.

B. Banking Sector: Liquidity Test			
Domain		Framework	
		TD by ECB	TD by FSAP Team
5. Regulatory and Market-Based Standards and Parameters	Regulatory standards		Threshold for cash flow-based analysis: net cumulative funding gap falls below zero; Threshold for LCRs set to 100 percent.
	Fail criteria		Fail criteria for cash flow-based liquidity analysis in foreign currencies: decrease of CBC in USD below 0. Fail criteria for cash flow-based analysis across all currencies: CBC across all currencies below 0.
6. Reporting Format for Results	Output presentation		Number of banks with negative net cumulative funding gaps in EUR (acc. across all currencies) and USD; Aggregate negative cumulated counterbalancing capacity; Aggregate negative cumulated counterbalancing capacity;

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