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TECHNICAL NOTE—FINANCIAL STABILITY AND STRESS TESTING OF THE BANKING, INSURANCE, AND NON-FINANCIAL CORPORATE SECTORS

This Technical Note on Financial Stability and Stress Testing of the Banking, Insurance, and Non-Financial Corporate Sectors for the Denmark FSAP was prepared by a staff team of the International Monetary Fund as background documentation for the periodic consultation with the member country. It is based on the information available at the time it was completed in July 2020.

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July 15, 2020

TECHNICAL NOTE

FINANCIAL STABILITY AND STRESS TESTING OF THE BANKING, INSURANCE, AND NON-FINANCIAL CORPORATE SECTORS

Prepared By
Monetary and Capital Markets Department

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

CONTENTS

BOXES

FIGURES

TABLES

APPENDICES

Glossary

ATP	Arbejdsmarkedets Tillægspension
BSCR	Basic Solvency Capital Requirement
BU	Bottom-Up (stress test)
CCyB	Counter-cyclical Capital Buffer
CCB	Capital Conservation Buffer
DFSA	Danish Financial Supervisory Authority (Finanstilsynet)
DKK	Danish Krone
DN	Danmarks Nationalbank
EIOPA	European Insurance and Occupational Pensions Authority
ELA	Emergency Liquidity Assistance
EUR	Euro
EM	Emerging Markets
FSAP	Financial Sector Assessment Program
GFC	Global Financial Crisis
ICPFs	Insurance Companies and Pension Funds
IR	Interest Rate
LAC DT	Loss-Absorbing Capacity of Deferred Taxes
LAC TP	Loss-Absorbing Capacity of Technical Provisions
LCR	Liquidity Coverage Ratio
LGD	Loss Given Default
LTV	Loan-to-value Ratio
MCIs	Mortgage Credit Institutions
ORSA	Own Risk and Solvency Assessment
PD	Probability of Default
QRT	Quantitative Reporting Template
RAM	Risk Assessment Matrix
RoE	Return on Equity
RWA	Risk Weighted Assets
SRB	Systemic Risk Buffer
SCR	Solvency Capital Requirement
TD	Top-Down (stress test)
TPs	Technical Provisions
UL	Unit-linked and index-linked life insurance
VA	Volatility Adjustment

EXECUTIVE SUMMARY[1]

The Financial Sector Assessment Program (FSAP) work was conducted prior to the COVID-19 pandemic. This report, however, includes stability analysis and stress tests under updated illustrative scenarios to quantify the possible implications of the COVID-19 shock on bank solvency. An unusually high degree of caution must be exercised in interpreting the stress tests results and their implications or validity at the current juncture, due to heightened uncertainty around post COVID central projections and downside risks.

Financial vulnerabilities were elevated on the eve of the COVID-19 pandemic. Key financial vulnerabilities included high household leverage amid high real estate valuations following a long period of loose financial conditions. There were also signs of risk taking in some sectors, such as commercial real estate (CRE), and in addition, there were downside risks to bank profitability amid the low-interest-rate environment.

Top-down (TD) solvency tests assessed the resilience of the largest SIFIs (banks and MCIs) to shocks under three illustrative five-year scenarios. A "COVID central" scenario attempts to capture the abrupt deterioration of short-term economic prospects owing to the COVID-19 pandemic. This scenario focuses on the growth and unemployment implications of the COVID-19 shock, which are the main drivers of the credit loss estimates. It does not entail an abrupt tightening of financial conditions (including a sharp rise in risk premia) or a real estate downturn. A "COVID prolonged" scenario reflects realization of downside risks associated with longer containment measures leading to a more prolonged recession. It also assumes that there is no sharp tightening in financial conditions or a decline in house prices. In addition, a "Market shocks" adverse scenario complements the first two scenarios because it assumes a severe materialization of market risks—a sharp rise in asset risk premia (which adversely affects banks' funding costs) combined with a prolonged downturn in the domestic real estate market.

Group-level solvency stress tests results indicate that the COVID-19 shock would have a large and differentiated impact on SIFIs' capitalization ratios. Although the adverse conditions associated with the COVID-19 pandemic have a significant impact on capitalization ratios, all SIFIs would meet their minimum capital requirements (a 4.5 percent CET1 ratio). Under the COVID baseline, the aggregate CET1 ratio declines from 18.3 percent in 2019 to a low point of 13.4 percent in 2020, while the aggregate leverage ratio declines from 4.8 percent to 3.6 percent over the same period. In the COVID prolonged scenario, the aggregate CET1 ratio falls to a low point of 12.4 percent in 2022—reflecting the more protracted nature of the economic contraction—while the aggregate leverage ratio declines to 3.0 percent in 2024. The impact, however, is differentiated across SIFIs. In some cases, a few SIFIs need to partially use their capital conservation and/or SIFI buffers; and the leverage ratios of a few SIFIs fall below three percent.

[1] The sections corresponding to banking, mortgage credit institutions, and nonfinancial corporate sectors have been prepared by Mario Catalán, Ibrahim Ergen, and Deeksha Kale (IMF MCM); the section on insurance has been prepared by Timo Broszeit (external expert).

Importantly, given the unprecedented nature of the ongoing pandemic, these findings are associated with a substantial degree of uncertainty. There are downside risks in the sense that a further deterioration of macrofinancial conditions relative to those assumed in the scenarios could bring about a situation where some SIFIs breach minimum capital requirements.

Materialization of credit risk and cost of funding shocks are the main drivers of losses in the different scenarios. In the COVID scenarios, bank losses are mostly driven by the materialization of credit risk, which is predominantly influenced by GDP growth and the unemployment rate, while in the "market shocks" scenario, cost of funding shocks also contribute to losses. Likewise, the underlying MCI results indicate that the impact on capitalization is driven mostly by credit losses. Importantly, the tests assume that within-group guarantees and those provided by banks outside of the stress testing perimeter are available to cushion the impact of loan defaults on MCI capitalization ratios.

The TD liquidity stress tests for banks, implemented prior to the COVID pandemic, assessed their capacity to confront large withdrawals of funding based on cash flow and LCR analysis. The results indicated that all banks would be able to survive extreme funding shocks for 3 months or longer without external support.

The resilience of insurance companies was assessed through a top-down (TD) and bottom-up (BU) solvency stress test before the onset of the pandemic. The tests, run at the solo entity level, covered five life insurers, six occupational pension funds and five non-life insurers, accounting for more than 70 percent in each sector.

Under the "market shocks" adverse scenario, life insurers' solvency positions would be substantially impacted, while pension funds and non-life firms perform better. The BU tests indicate that although the industry is able to withstand severe asset price shocks, most of the solvency impact can be attributed to lower stock prices and the increase in domestic sovereign and covered bond yields. After stress, the median solvency capital requirement (SCR) ratio in the life sector drops from 188 to 127 percent, while in the non-life sector the ratio declines from 233 to 207 percent. One life company drops below a solvency ratio of 100 percent, and the capital needed to restore a full coverage of solvency requirements would only be a moderate fraction of the sample's aggregate capital. Sensitivity tests point to longevity risks and the resilience of non-life companies to climate-related catastrophic events.

Vulnerability analysis of the nonfinancial corporate sector used micro-data to estimate the drivers of firm-level failures and how sectoral risks are exacerbated by correlated defaults. NFC debt has grown rapidly in the highly cyclical sectors, with particularly strong buildup of risks in the real estate sector. Debt-at risk analysis points to a significant jump in default probabilities, particularly in the commercial real estate sector, under a "market shocks" adverse scenario.

Table 1. Denmark: Recommendations to Enhance Stability Analysis and Stress Testing	
Recommendations and Authority Responsible for Implementation	**Time**[1]
Risk analysis and stress testing of banks and mortgage credit institutions	
Broaden the country coverage of macroeconomic scenarios for the implementation of solvency tests (DN). Including (simplified) scenarios for foreign countries where Danish banks and MCIs have significant exposures (e.g. in the Nordic region) would help to refine the stress tests. The foreign country scenarios would allow to directly map materialization of macro-financial risks in foreign economies to Danish banks' losses on their foreign exposures under stress.	MT
Continue applying interest rate gap analysis for projection of SIFI banks' net interest income in future stress testing exercises (DN and DFSA). Standardize the application of the methodology developed during the FSAP for Denmark, including the requirement for SIFI banks to fill out and submit the detailed data templates (prepared by DFSA during the FSAP) for their use as inputs for the top-down exercise.	ST
Introduce refinements to satellite models of credit risk (DN and DFSA). DN and DFSA have a solid infrastructure for top-down credit risk assessment. There is, however, scope for improvement, depending on data availability from individual banks and MCIs. ***Banks***: (i) Develop country-specific credit risk models for internationally active banks. This would require collection of country-specific historical impairment and default rates for large banks such as Danske; (ii) Explore the feasibility of further developing top-down credit risk models by collecting longer histories of impairment rates at more granular levels, for individual banks and sectors; (iii) Complement available models based on impairment rates by developing satellite models based on default probabilities (PDs). This would require collecting data on historical default rates for each bank and industry/sector exposure type.	MT MT MT MT

Table 2. Denmark: Recommendations to Enhance Stability Analysis and Stress Testing (concluded)	
Mortgage credit institutions **(MCIs)**: (i) Explore the feasibility of collecting from MCIs historical data on loan impairment charges by loan type (e.g. owner-occupied homes, holiday houses, subsidized housing, manufacturing and manual industries, agricultural properties, etc.). Estimate specific models of credit risk, at aggregate level (across all MCIs) and for individual MCIs; (ii) Improve the availability of information on guarantees provided by distributing banks to individual MCIs.	MT
Update and further refine analysis for the household sector using micro-level data and the credit register to integrate it into the broader stability analysis of the financial sector (DN). The analysis could assess the resilience of households and default risks under scenarios with more protracted spikes in unemployment—than those observed during and after the GFC—and with uneven impact of unemployment across households.	MT
Integrate the non-financial corporate sector analysis into the broader stability analysis of the financial sectors (DN). Integrate corporate analysis with bank-level data using credit register. Improve the industry classification of firms in the data. For example: Classify better the "Other" category, and introduce information on sub-industries, such as a breakdown of the "real estate" sector into CRE and non-CRE groups.	MT
To continuously assess systemic risks, further develop and standardize the use of the (multi-layer) network model for interconnectedness and contagion developed by DN and IMF teams during the FSAP (DN).	ST
Insurance and Pension Fund Stress Testing (DFSA)	
Develop a stress testing framework which combines a top-down and a bottom-up perspective (DFSA, DN). In this context, use stress test results to challenge insurers' Own Risk and Solvency Assessments (ORSA) projections, and undertake horizontal reviews of ORSA projections (DFSA).	MT
Require at least the annual Quarterly Reporting Templates (QRTs) to be audited and require audit assurance for the systems and procedures used to complete the QRTs. Scrutinize QRT submissions more systematically and request re-submissions if necessary. Consider administrative fines for repeated misreporting (DFSA).	ST
[1] ST: Short term (1-3 years); MT: Medium Term (3-5 years).	

INTRODUCTION

1. Steady growth in recent years was abruptly interrupted by the COVID-19 crisis.

- During the 2008-2009 global financial crisis, the economy underwent a sharp downturn which was exacerbated by the burst of the domestic real estate bubble. The combination of the sharp fall in house prices and the high level of household debt dampened private consumption growth, resulting in a recovery which trailed that of regional peers. During the past few years, however, in an environment characterized by negative policy rates, the unemployment rate reached a 10-year low, and despite a positive output gap, the krone's tight peg to the euro has kept inflation low and stable.

- The domestic outbreak of the pandemic has led to a sudden stop in economic activity and a sharp deterioration of short-term economic prospects reflecting in part the necessary containment measures. Likewise, after a long period of accommodation, financial conditions have tightened sharply in March 2020. The timing and the shape of future recovery remain highly uncertain, and risks are to the downside. In particular, there is a concern that a further tightening of financial conditions or a second pandemic wave could expose financial vulnerabilities.

2. On the eve of the COVID-19 pandemic, key vulnerabilities were associated with the housing market and mortgage financing:

- ***Household debt:*** Notwithstanding a gradual downtrend, Denmark's high level of household (gross) debt remains an important vulnerability. Household net wealth is relatively high, but a large share of households' assets is illiquid (housing and pension savings), limiting buffers to deal with shocks. This large stock of debt renders household consumption more susceptible to a confluence of adverse interest rate, asset price, and income shocks, which could reinforce macrofinancial feedback loops in a highly interconnected economy. Although greater household leverage could stimulate near-term growth, it would also raise the chances of a slowdown over the medium term.

- ***Real estate prices:*** Nationwide house prices had stabilized in response to prudential measures and appeared to be broadly in line with fundamentals. By contrast, house prices in urban areas remained elevated through 2019. In fact, the downside risks to house prices associated with larger house price misalignments appear to be greater in Copenhagen relative to the national market.

- ***Mortgage loans:*** Despite improvements, the still high share of variable-rate mortgages (63 percent of the stock, of which 59 percent are non-amortizing) leave households sensitive to interest rate hikes.[2]

3. Indications of greater risk taking by financial intermediaries and nonfinancial firms and the changing risk profile of the commercial real estate and covered bond markets represent additional financial stability concerns:

- ***Risk taking:*** There was evidence of greater risk taking across segments of the banking and insurance sectors. Given persistently low interest rates and the attendant pressure on profitability, some medium-sized banks were aggressively extending credit to households with high loan-to-income ratios as they tried to further increase their market share in major urban areas (Copenhagen, Aarhus). Likewise, insurers had been searching for yield by increasingly investing in riskier assets, thereby increasingly exposing themselves to liquidity risks. The greater shift towards unit-linked products is supporting insurance companies' profitability, but transfers more risk to policyholders. This shift may reduce risk management incentives by insurers and would raise consumer protection concerns.

- ***Nonfinancial corporate (NFC) sector and CRE:*** Despite an overall decline before the COVID shock, there was evidence of rising leverage in cyclically-oriented firms which were already indebted against a backdrop of loosening credit standards for the NFC sector. In particular, the CRE market was characterized by rising prices, a large share of foreign investors, and there were concerns regarding the income generating capacity of CRE. At the same time, CRE was among the most leveraged corporate sectors and where debt had grown the fastest in recent years. Firm-level analysis, conducted before the onset of the pandemic, indicated that the CRE sector, accounting for about 30 percent of the total corporate debt, was especially vulnerable. Such fragilities, which are more acute in light of the COVID shock, are concerning because banks have sizeable exposures to the CRE market which in turn has significant interconnections with the rest of the financial system.[3]

- ***Covered bond market:*** Given the strong reliance on market-based funding, the increasing share of foreign investors confers diversification benefits, but at the same time increases the sensitivity of a regionally interconnected financial system to global investor sentiment. Although the Danish covered bond framework mitigates funding risks, there are substantial holdings of covered bonds across domestic financial institutions.

[2] Note that more than 50 percent of variable-rate mortgages have fixed-interest-rate periods that are greater than one year.

[3] The pandemic has likely aggravated these financial vulnerabilities to varying degrees. For example, highly indebted and/or lower-income households are relatively more susceptible to shocks—a concern that could become more acute amid a protracted unemployment spell. Likewise, a number of nonfinancial corporate sectors, some of which were highly leverage before the onset of the crisis, are being severely affected by pandemic. At the same time, the credit quality of medium-sized banks' corporate customers is considerably lower relative to SIFIs. Notwithstanding the government support, a possible sharp rise in insolvencies would further add the banking strains.

4. The stress tests quantified macro-financial risks and vulnerabilities to assess their relative importance, with a particular focus on the following main threats to stability:

Box 1. "Main Threats" to Financial Stability

Vulnerabilities	Risks
• The indebtedness of the household sector and high real estate valuations.	Mortgage defaults could be triggered by a surge in unemployment associated with a slowdown in the economy. Re-payment capacity would be particularly undermined by unemployment spells of longer-than-average duration affecting the younger and more highly indebted households
• Low profitability due to a continued decline in interest rates and signs of greater risk taking.	Net interest income may continue declining in a low interest rate environment. Going forward, banks may be unable to expand the base of deposits earning negative rates. They may also be unable to continue increasing fee income to fully offset the erosion of net interest income. Intensified risk taking may deteriorate the credit quality of loan portfolios.
• Interconnectedness, particularly through the covered bond market.	A disruption in the covered bond market is a very low probability but high impact event. It could be triggered by an extreme and unlikely surge in mortgage defaults that depletes MCIs' buffers. A spike in covered bond yields could lead to widespread mark-to-market losses, temporary reductions in market liquidity, and funding pressures in financial institutions. Capital outflows, driven by foreign investors' selling, could compound stress in the market.

5. In general, the objective of the FSAP stress testing exercise is to assess the capacity of the financial system to withstand extreme but plausible macroeconomic shocks. The tests are means to explore weaknesses in a financial system and the channels through which adverse shocks are transmitted. The FSAP stress testing process can help authorities identify informational and methodological gaps. Importantly, the FSAP tests can serve to determine priorities for policy action, including micro- and macro-prudential decisions aimed at reducing specific exposures or building capital and liquidity buffers. It is important to note that FSAP stress tests may differ from stress tests conducted by central banks, including those undertaken by the DN. Prior to the COVID outbreak, the FSAP team carried out tests in close cooperation with DN and DFSA staff and was given access to detailed supervisory data.

6. These stress testing results should be interpreted with caution, in particular for individual SIFIs. In addition to the large uncertainty associated with the scenarios, several limitations need to be recognized. The analysis presumes that pre-crisis relationships between macroeconomic and financial variables remain unchanged in the scenarios. Furthermore, in the

analysis, the relationship between growth and capitalization is non-linear, implying that deeper recessions have potentially disproportionate impacts on capital. This implies that stress test results are very sensitive to the severity of the scenarios. However, some second-round and non-linear effects, which are not fully captured in the analysis, could on the other hand imply an underestimation of losses.[4] Choices were made regarding hypothetical shocks, and the scenarios should not be (mis-) interpreted as macroeconomic "forecasts"—the scenarios do not necessarily coincide with IMF WEO projections. Importantly, under all the scenarios presented in this note, the implications on bank capital are subject to downside risks in the sense that the impact on capital might be more severe if the macroeconomic outcome turns out to be more negative than stipulated in the scenarios.

7. The stress tests examined the resilience of banks, MCIs, and insurance companies to solvency, liquidity, and contagion risks (Figure 1; Appendices I and II).

- The (top-down) **solvency stress tests** of banks and MCIs are based on illustrative five-year scenarios and sensitivity analyses. The analysis covers all seven SIFIs (representing 77 percent of the banking system's total assets). The tests are performed on the largest banks and MCIs individually, as well as at the group (consolidated) under three scenarios: a "COVID central" scenario, a "COVID prolonged" scenario, and a "market shocks" adverse scenario. Importantly, these scenarios are not meant to be forecasts and are associated with considerable uncertainty and downside risks.

- The (top-down) **liquidity stress tests** assessed the capacity of banks to confront large withdrawals of funding based on cash flow and LCR analysis before the COVID-19 pandemic. The implications of the COVID-19 pandemic for banking liquidity or potential system-wide contagion risks have not been assessed.

- **Stress tests for the insurance and pension sector** include bottom-up and top-down exercises, as well as risk analysis for ATP, the largest pension fund. Sensitivity analysis assessed the resilience of non-life companies to climate-related catastrophic events such as severe windstorms.

- **Corporate vulnerability analysis** uses micro-data to estimate the drivers of corporate failures and how sectoral risks are exacerbated by correlated defaults. The analysis then attempts to quantify the loss implications for banks' corporate exposures.

The analysis of **systemic liquidity** and the **interconnectedness and contagion risks** are developed in separate Technical Notes.[5]

[4] The possible amplification of the COVID shocks for banking liquidity or potential system-wide contagion risks have not been assessed, underscoring the uncertainty surrounding the solvency stress test results, including their implications for individual SIFIs.

[5] "Technical Note on Systemic Liquidity" and "Technical Note on Interconnectedness and Contagion Analysis" for the 2020 Denmark FSAP.

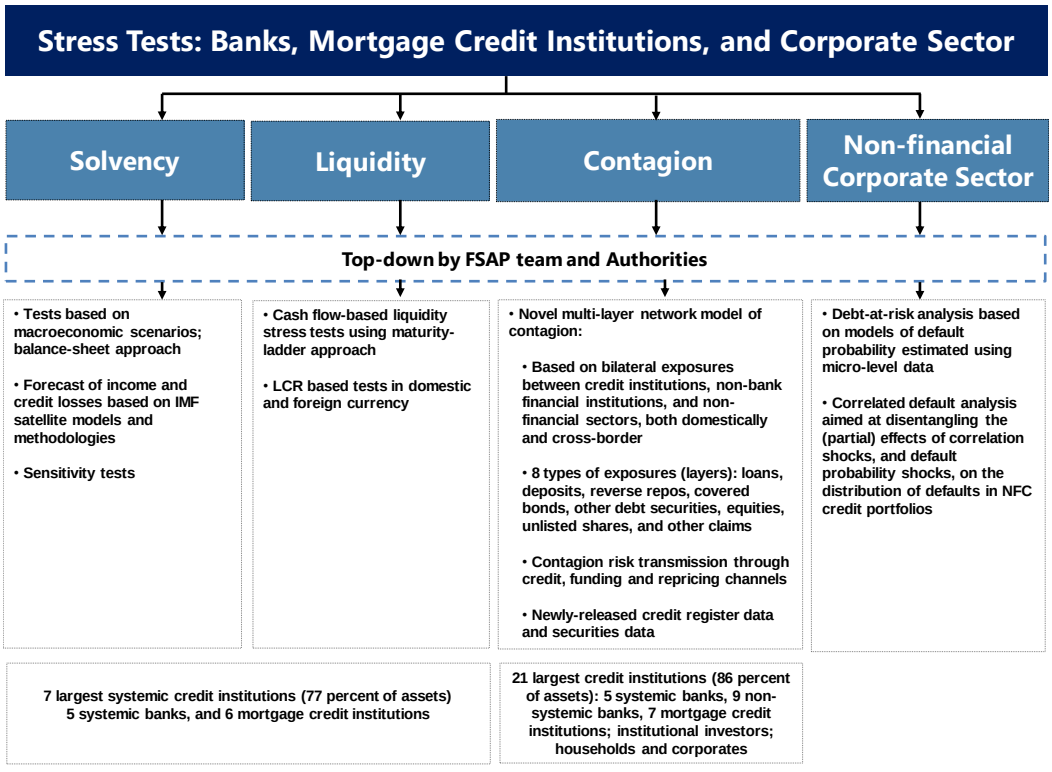
8. The stress testing exercise for the 2020 Denmark FSAP includes innovative features:

- *Detailed interest rates GAP analysis based on granular data collected for the FSAP exercise*. This enhancement relative to the previous FSAP is key in the current juncture, as a decline in net interest income has undermined bank profitability, particularly over the past 4 years. To assess whether this trend will continue, the analysis must account for cross-bank differences in maturity transformation, time-to-repricing, and other assets/liabilities characteristics. Based on granular analysis, we obtain refined projections of NII and profitability.

- *Top-down solvency tests of MCIs*. This exercise is conducted for the first time in an FSAP. In addition to the calculation of credit and market losses, the exercise features calculations of how the need for MCI's to top-up collateral in the presence of housing price shocks—so as to maintain LTV ratios—will affect their profitability.

- *Correlation in corporate defaults*. Expected credit losses in asset portfolios under stress depend not only on default probabilities of individual exposures, but also on the correlation of default events— diversification gets lower as borrower default correlation increases. We use default correlation models to separately estimate the effects of shocks to firm-specific PDs and shocks to default correlation on credit losses at the portfolio level.

Figure 1. Denmark: Stress Testing and Systemic Risk Analysis



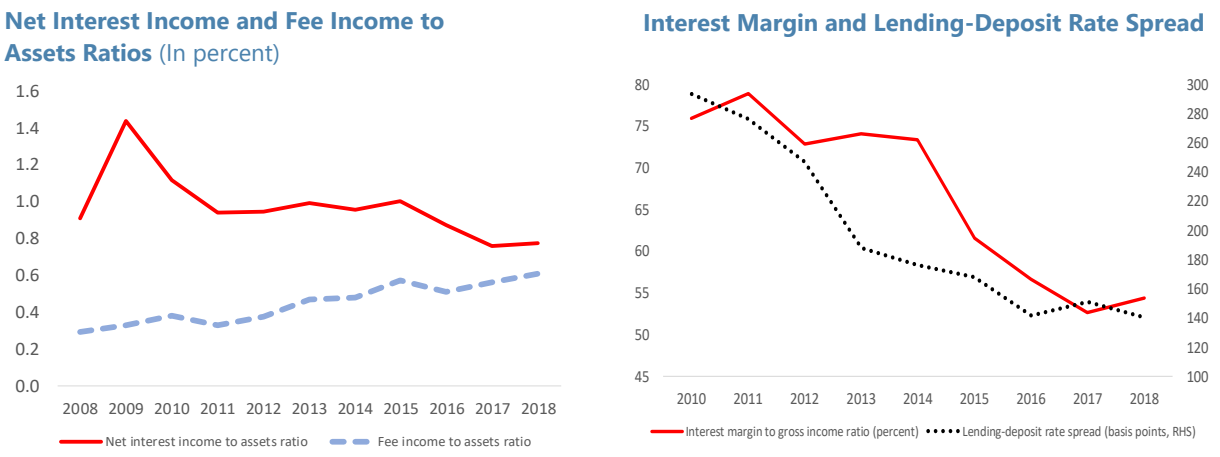
9. The remainder of this note is structured in five chapters. Chapter 1 describes the macro-financial risks and scenarios. Chapters 2 and 3 present the different components of solvency and liquidity stress tests of the banking and MCI sectors: their description, design, methodology for implementation, and results. Chapter 4 describes the methodology and results of tests corresponding to the insurance and pension fund sectors. Chapter 5 presents the analysis of the NFC sector.

CHAPTER 1: MACROFINANCIAL RISKS AND SCENARIOS

A. Macrofinancial Risks

10. Prior to the COVID-19 pandemic, bank profitability was envisaged to decline due to persistent low interest rates. Interest rates on assets and liabilities of banks adapt to lower rates only gradually. In the past few years, net interest income (NII) has declined steadily. In the early stages of the low-rate environment, banks were able to reduce their funding costs while interest income from borrowers was declining only gradually. As the low-rate environment became more persistent, however, the full impact on lending rates started to materialize and has compressed net interest margins, with little room left for further funding cost reductions (Figure 2). While new business lending rates for 2019 are lower than average lending rates of overall bank loan portfolios, the rates on new funding are about the same as average funding rates on all outstanding bank liabilities.

Figure 2. Denmark: Bank Profits and Interest Rates



Source: DN, IMF Financial Sector Indicators, and staff calculations.

11. The abovementioned vulnerabilities and the macroeconomic situation define the main risks faced by the Danish financial system. These risks, which could be mutually reinforcing given the high degree of sectoral and cross-border interconnectedness and financial vulnerabilities, can be summarized as follows (see also Box 1 above and the RAM in Appendix III):

- ***Prolonged Covid-19 outbreak***. Containment measures remain in place (in some places intensify or need to be re-introduced) through early 2021.

- Longer containment and uncertainties about the intensity and the duration of the outbreak reduce supply and domestic and external demand. A more protracted economic contraction in global growth would have a sustained negative impact on Danish exports, investment, and consumption. These risks could be exacerbated by pandemic-prompted protectionist actions as Denmark is a small open economy with many sectors—including shipping—deeply integrated in global value chains. Corporate-sector losses would be accompanied by further increases in unemployment, NPLs, and loan loss impairments weighing on bank profitability, possibly aggravated by tighter credit conditions, and adverse Nordic spillovers.

- Deteriorating economic fundamentals and the associated decline in risk appetite could result in a second wave of financial tightening (amplified as latent fragilities are unmasked). A protracted and correlated decline in asset prices would adversely affect the internationally exposed portfolios of ICPFs, erode household wealth, and weigh on consumption growth. Second-round effects are likely to be significant given the high degree of Nordic financial integration and ensuing adverse macrofinancial feedback loops given the extent of domestic interlinkages and elevated household indebtedness.

- ***Sharp house price correction:*** The trigger could be associated with the global shocks discussed above or could be more regional or domestic in nature. Given close financial linkages, a Nordic real estate correction could quickly spark regional spillovers. Domestically, the shock could be triggered by a reassessment of fundamentals that sets a vicious cycle in motion, whereby tighter financial conditions and depressed economic activity amplify the impact of the initial shock.

If these risks were to materialize, the vulnerabilities described above would amplify the adverse effects of shocks on the economy and the financial system.

B. Macroeconomic Scenarios

12. Given the risks described above, the stress tests were underpinned by three scenarios (Table 2 and Figures 3 and 4). Importantly, these scenarios are not meant to be forecasts and are associated with considerable uncertainty and downside risks:

- The first scenario, "COVID central," attempts to capture the abrupt deterioration of short-term economic prospects owing to the COVID-19 pandemic. It envisages a sharp fall in GDP of 8 percent in 2020 (reflecting in part the containment measures), followed by a rebound of 6 percent in 2021.[6] At the same time, the unemployment rate rises to 6.8 percent in 2020, before gradually declining. At the same time, the unemployment rate rises to 6.8 percent in 2020, before gradually declining. Note that this scenario focuses on the growth and unemployment implications of the COVID-19 shock, which are the main drivers of the credit loss estimates.

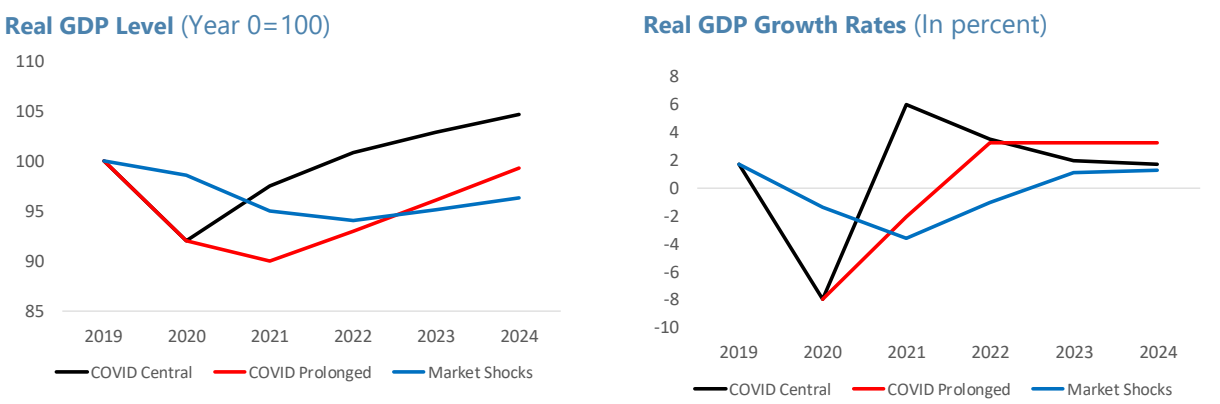
[6] Note that the GDP growth rate for the year 2020 in the COVID central scenario (-8 percent) is lower than the growth projected by the IMF WEO in April (-6.5 percent) and by the Danish Economic Council in June (-4.5 percent).

It does not entail an abrupt tightening of financial conditions (including a sharp rise in risk premia) or a real estate downturn.

- To reflect downside risks associated with longer containment measures, a second scenario with a more prolonged recession is considered ("COVID prolonged"). In this scenario, growth declines by 8 percent in 2020, but, instead of a rebound in 2021, the economy continues to contract (by 2.1 percent in 2021) before the recovery ensues in 2022.[7] The protracted economic contraction is accompanied by a large increase in the unemployment rate which rises to 11.8 percent in 2022 before steadily falling. This scenario also assumes that there is no sharp tightening in financial conditions or a decline in house prices.

- A third scenario, with more severe market shocks but less severe economic shocks, is also considered ("market shocks"). In particular, there is a sharp rise in asset risk premia (which adversely affects banks' funding costs) combined with a prolonged downturn in the domestic real estate market. These large market risk shocks occur amid a protracted recession (which is less severe in the short-term relative to the other two scenarios. Note that the "market shocks" scenario, designed before the onset of the COVID-19 pandemic, incorporates a combination of credit, market, and cost of funding shocks.[8]

Figure 3. Denmark: Macroeconomic Scenarios for Stress Tests: Real GDP



[7] The COVID prolonged scenario is characterized by a cumulative real GDP decline of 8.1 percent points relative to the COVID central scenario over two years (equivalent to 2.4 standard deviations). To illustrate, a standard deviation of (two-year cumulative) real GDP growth, calculated based on data for the period 1966–2018, is equal to 3.4 percentage points.

[8] This scenario was designed using as input the IMF's Flexible System of Global Models. Anderle et. al., "The Flexible System of Global Models—FSGM," *IMF Working Paper No. 15/*64. Key shocks used to generate the scenarios include consumption and investment shocks (domestic, external), asset prices shocks, as well as increases in various spreads (e.g., corporate, term).

Table 2. Denmark: Macroeconomic Scenarios for Stress Tests

(In percent, unless otherwise indicated)

		Stress Period				
	2019	2020	2021	2022	2023	2024
Real GDP growth						
COVID Central	1.7	-8.0	6.0	3.5	2.0	1.8
COVID Prolonged	1.7	-8.0	-2.1	3.3	3.3	3.3
Market Shocks	1.7	-1.4	-3.6	-1.0	1.1	1.3
Harmonized unemployment rate						
COVID Central	5.0	6.8	6.2	5.7	5.6	5.6
COVID Prolonged	5.0	6.8	10.4	11.8	11.0	10.0
Market Shocks	5.0	6.2	8.6	10.2	10.5	10.1
Consumer price inflation rate (based on CPI year average)						
COVID Central	1.3	0.6	0.9	1.2	1.4	1.5
COVID Prolonged	1.3	0.6	0.9	1.2	1.4	1.5
Market Shocks	1.3	-0.7	-0.9	-0.2	2.1	2.2
Nominal policy interest rate						
All Scenarios	-0.8	-0.9	-0.9	-0.8	-0.6	-0.5
Short term interbank nominal interest rate (3 month)						
All Scenarios	-0.8	1.7	2.3	2.6	1.4	0.3
Bank overall funding cost rate (shocks)[1/]						
Both COVID Scenarios		0.1	0.0	0.0	0.0	0.0
Market Shocks		0.6	0.9	1.0	0.8	0.4
Long term nominal interest rate (10 year sovereign bond yield)						
Both COVID Scenarios	-0.3	-0.6	-0.4	-0.1	0.2	0.6
Market Shocks	-0.3	-0.1	0.8	1.3	1.0	1.1
Nominal exchange rate change (DK/EUR; + is DK depreciation, in percent)						
All Scenarios	0.0	0.0	0.0	0.0	0.0	0.0
Housing prices (2019=100)						
Both COVID Scenarios	100.0	101.5	103.3	105.4	107.5	109.7
Market Shocks	100.0	91.2	82.4	77.5	79.1	80.6
Nominal growth of assets in the banking sector (for stress tests)[2/]						
COVID Central	3.5	0.0	6.9	4.9	3.7	3.6
COVID Prolonged	3.5	0.0	0.0	4.7	5.0	5.0
Market Shocks	3.5	0.0	0.0	0.0	3.6	3.9

Sources: IMF staff calculations.

Note: The scenarios are not meant to be forecasts and are associated with considerable uncertainty and downside risks; in addition, the COVID scenarios do not necessarily coincide with IMF WEO projections.

1/ Rate reflects overall cost of funding—calculated as a weighted average of retail and wholesale sources across all maturities.

2/ The balance sheets of financial institutions are assumed to grow at the nominal GDP growth rates, subject to a minimum zero bound.

13. External and a country-specific layers of numerical assumptions underlie the construction of the "market shocks" adverse scenario:

- ***External layer***. Escalating global trade tensions and a tightening of global financial conditions are the main drivers. In addition to their direct effects, these shocks depress business and consumer confidence, generating downturns in advanced and EM economies. The layer features an abrupt decompression of risk asset premia, which is amplified by low secondary market liquidity. Within the euro area, these tensions affect with particular intensity "high spread economies" and are reflected in higher money market interest rates, banks' cost of short-term funding, and long-term government bond yields. Also, the realization of financial stability risks implies that monetary normalization in the systemic advanced economies fails to materialize in the stress testing period (2020–24). In the Nordic region, Sweden, Norway and Finland are also assumed to be hit by extreme shocks under the scenario—in contrast to economies in the rest of the world, which are affected by less extreme shocks.[9]

- ***Country-specific layer***. Weakness in economic activity (resulting from the combination of external shocks) has knock on effects on domestic housing markets. Housing prices decline by 22 percent over three years, with an adverse impact on domestic consumption and residential investment. The scenario assumes that the exchange rate regime remains credible despite domestic and international stress, and that the DN is able to maintain negative policy rates (at 25 basis points below the projected ECB rates); in addition, fiscal policy remains neutral in the sense that only automatic stabilizers play a counter-cyclical role.

14. In the "market shocks" adverse scenario, the shift in market sentiment and the tightening of global financial conditions lead to greater risk differentiation in securities markets (Figure 4). Long term sovereign yields in Europe rise as economies slow down and fiscal positions weaken. Credit spreads, however, widen and yields in high-spread economies rise more sharply than in Denmark. Similarly, as a result of widespread de-risking, the credit spreads of financial and NFC issuers vis-à-vis sovereigns rise.[10]

15. The "market shocks" adverse scenario assumes differentiated cost of funding shocks across funding sources (Table 3). Differentiation of funding shocks across sources implies heterogeneous impact across banks. Specifically, banks more heavily reliant on wholesale funding are affected by larger shocks, while banks relying on deposit funding are affected by smaller shocks.

[9] Under the "market shocks" adverse scenario, the two-year cumulative deviations of real GDP from baseline projections in Sweden, Finland and Norway are 7.7, 10.5 and 8.8 percentage points, respectively—these numbers are equivalent to 2.1, 1.9, and 2.7 standard deviations.

[10] For the tests, yield curves were constructed for the following countries: Denmark, U.S., China, Japan, Germany, France, Italy, Sweden, Finland, Norway. Changes in yields in countries not included in the list were assumed to be equal to those of (similar) countries included in the list (e.g. securities issued in "high-spread" economies in Europe were re-priced using shifts in Italian bond yield curves).

Similarly, banks that rely heavily on short-term funding are affected more than banks that rely on long-term funding.[11,12]

Table 3. Denmark: Cost of Funding Shocks by Type of Liability
(Market shocks scenario, in percent)

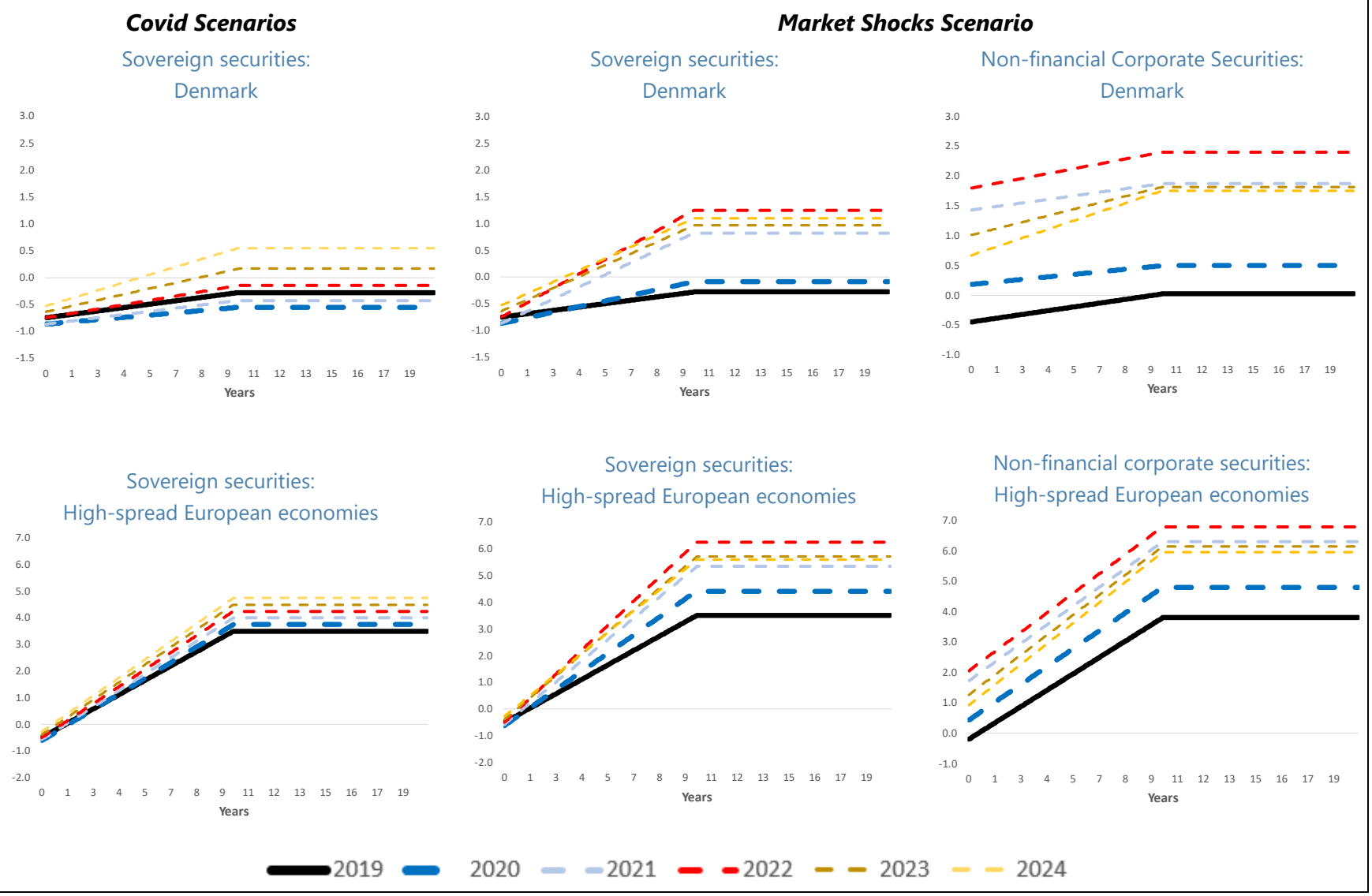
Liability Type	2020	2021	2022	2023	2024
Deposits (excl. repo) - Central banks - ELA	0.10	0.20	0.20	0.10	0.10
Deposits (excl. repo) - General governments - sight	0.10	0.20	0.20	0.10	0.10
Deposits (excl. repo) - General governments - term	0.10	0.20	0.20	0.10	0.10
Deposits (excl. repo) - Credit Institutions and other financial corporations - sight	2.40	2.90	3.10	2.00	1.00
Deposits (excl. repo) - Credit Institutions and other financial corporations - term	2.40	2.90	3.10	2.00	1.00
Deposits (excl. repo) - Non-financial corporations - sight	0.30	0.60	0.70	0.60	0.30
Deposits (excl. repo) - Non-financial corporations - term	0.50	1.00	1.10	1.00	0.50
Deposits (excl. repo) - Households - sight	0.15	0.30	0.40	0.30	0.15
Deposits (excl. repo) - Households - term	0.25	0.50	0.60	0.50	0.25
Deposits - Repo	0.40	0.80	0.90	0.80	0.40
Debt securities issued - Certificates of deposits	2.40	2.90	3.10	2.00	1.00
Debt securities issued - Asset-backed securities	2.40	2.90	3.10	2.00	1.00
Debt securities issued - Covered bonds	0.40	0.80	1.00	0.80	0.40
Debt securities issued - Other debt securities issued	2.40	2.90	3.10	2.00	1.00
Derivatives	0.00	0.00	0.00	0.00	0.00
Other liabilities	0.50	1.00	1.10	1.00	0.50

Note. Numbers indicate changes with respect to funding costs prevailing at end-2019. The average cost of funding for the system is calculated as a weighted average across funding sources, where weights are determined by relative volumes. Under the two COVID scenarios, funding shocks reflect what has been observed in the markets at this juncture (30 basis points for interbank lending and riskier debt securities and 15 basis points for covered bonds and repos in 2020).

[11] A highly granular/disaggregated approach to project various interest rates is key to realistically assessing the evolution of bank profitability in a low interest rate (baseline) environment, or under a stress scenario. (Chapter 2, section A below describes how interest rate paths, combined with information of time-to-repricing of assets and liabilities, impact bank's net interest income and profitability.)

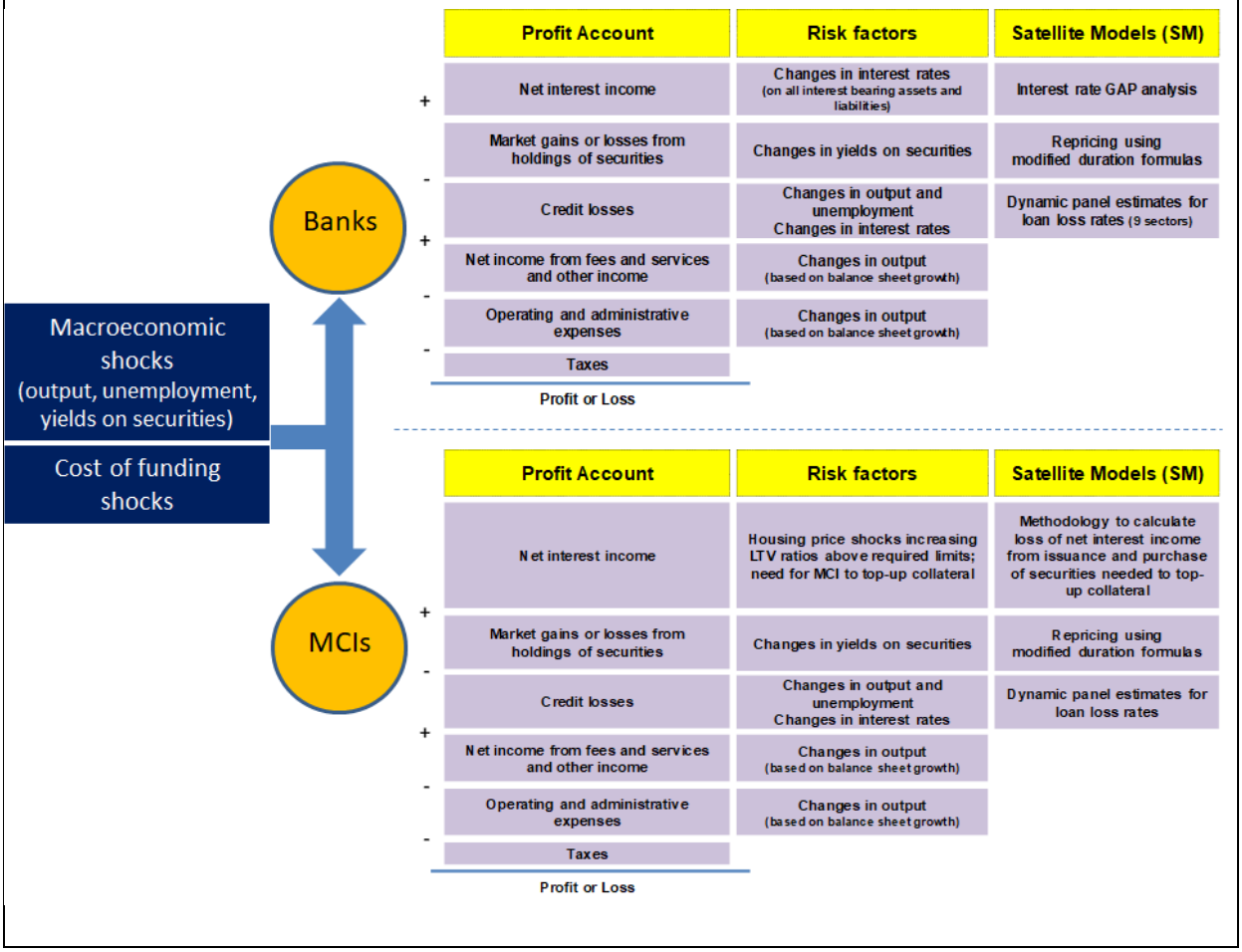
[12] Note that, relative to the previous FSAP, the "market shocks" adverse scenario was appropriately countercyclical. It was more severe than the scenario used in the previous FSAP. This was warranted given the envisaged expansion of the economy (before the COVID crisis) and the fact that financial conditions were markedly looser than those prevailing during the previous FSAP. Thus, the severity of FSAP scenarios are adjusted to reflect overall financial and macroeconomic conditions—albeit not in a mechanical, rules-based manner. This feature of stress testing exercises typically renders them more informative for macroprudential policy purposes.

Figure 4. Denmark: Yield Curves by Instrument and Macroeconomic Scenario
(Yields in percent)



16. Figure 5 describes, in a simplistic and schematic manner, the transmission channels of macro-financial shocks to banks and MCIs. In the adverse scenario, bank *credit losses* are driven by the slowdown in the economy and rising unemployment. In addition, net interest income is stressed through the partial pass-through of higher funding costs to lending rates. *Net interest income* is impacted by cost of funding shocks in two ways. First, these shocks cannot be passed on to borrowers immediately, due to maturity transformation (e.g., loans have longer maturity and time to repricing than deposits); second, a 50 percent pass-through of funding shocks to lending rates on new loans is assumed. And *market losses* are triggered by the spikes in sovereign, corporate, and covered bond yields. For MCIs, losses under the adverse scenario reflect (mostly) the materialization of mortgage default risk (*credit losses*) and the need to top-up collateral when house prices decline—so as to maintain LTV ratios of mortgage portfolios within required limits—which affects their *net interest income*.

Figure 5. Denmark: Macro-financial Transmission in Solvency Stress Tests



CHAPTER 2: SOLVENCY STRESS TESTS OF BANKS AND MORTGAGE CREDIT INSTITUTIONS

This chapter presents the description, methodology, and results of the top-down solvency stress tests for banks and MCIs on a consolidated (group level) basis. Section A discusses the solvency testing methodology based on macroeconomic scenarios for banks. Section B discusses the risks that are retained by MCIs given their role within groups and in the financial system, and the methodology for stress testing solvency risks in MCIs. Section C presents the methodology for consolidation of stress tests results at group-level and the corresponding results. Section D presents sensitivity analysis.

A. Banks: Solvency Tests Based on Macro Scenarios

Banks' Balance Sheets, Profits and Risk Exposures

17. Although the three scenarios differ, including with respect to their assumptions on financial conditions and house prices, the same methodology was used across the scenarios to quantify their implications on bank solvency—which was assessed using 2020 Q1 capital ratios (latest available data) as the starting point.

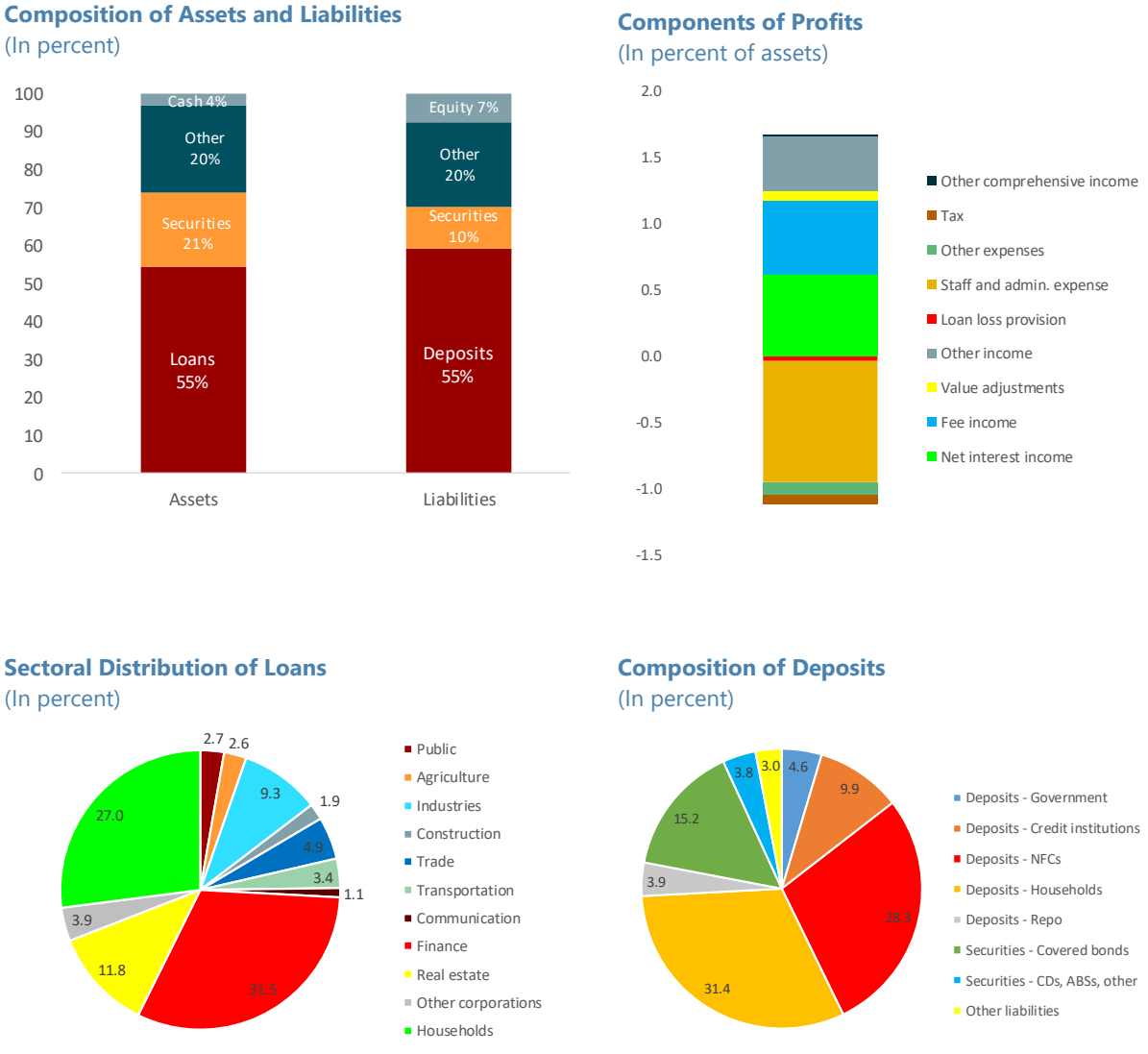
18. Heterogeneity in the sectoral composition of loan books accounts for differences in loan loss rates across banks. Although asset compositions of the five banks subject to stress testing seems to be homogenous at more aggregated levels, there is significant heterogeneity in their portfolios in terms of sectoral break-down of loans. While banks jointly have significant exposures to financial sector (32 percent), households (27 percent), real estate (12 percent) and manufacturing industries (9 percent) (Figure 6), the portfolio compositions at individual bank level reveals significant heterogeneity. While some banks have significantly concentrated exposures to the financial sector, others are more diversified into cyclical sectors such as agriculture, construction and trade. Since we project credit losses based on a panel regressions with sectoral cross-section, the banks with more exposure to high-risk cyclical sectors end up with higher loan loss rate than banks with concetrated exposures to low-risk sectors.

19. Heterogeneity in funding structure and maturity profiles account for differences in net interest income decline across banks. In terms of liability composition, there is also significant heterogeneity across banks. Some banks rely more on unstable sources of funding such as deposits from credit institutions and financial corporations and debt securities (CDs, ABSs) whereas other banks rely on more stable sources of funding such as deposits from households and non-financial corporates. Since we apply larger funding shocks to unstable funding sources in our scenarios, banks that rely more on unstable funding sources suffer larger declines in net interest income.

20. Net interest income is expected to decline for banks since lending rates on recent new business have been declining, while funding rates have been somewhat stable. In the early stages of low-rate environment, banks have reduced their funding costs while interest income from

borrowers was declining only gradually. However, as the low-rate environment took hold for an extended period, the full impact on lending rates started to materialize more recently, compressing net interest margins, with little room left for further funding cost reductions. For example, the new business lending rates for 2019 are approximately 0.1 percent lower than the overall average lending rate. However, the 2019 new business funding rates are approximately the same as overall average funding rates. This reflects the fact that banks do not have much room left to further reduce their funding costs.

Figure 6. Denmark: Banks: Components of Balance Sheets and Profits



Source: DN, DFA, and staff calculations.

21. It is important to note that lower risk weights act as an amplifier for both credit losses and losses due to the decline in net interest income. The RWA density for the five banks in our exercise ranges from 28 percent to 61 percent indicating significant heterogeneity. Every krona of loss reduces the capital in the numerator of the capitalization ratio by the same amount but lower risk weights amplify the impact since they have a lower denominator in the capitalization ratio. As a result, one of the banks that experienced significant credit losses in the test was able to withstand the losses relatively easily due to its high risk weights.

Macrofinancial Risk Transmission: Satellite Models and Methodologies

22. Satellite models and specific methodologies were used to assess the transmission of macroeconomic shocks to loan loss rates, profitability and capitalization of individual banks. Bank losses result from the materialization of credit, market, and interest rate risks, which we now discuss in turn.

Credit Losses

23. Loan loss rates (LLRs) under the scenarios were estimated for 9 different sectors using a dynamic panel regression model with sector specific fixed effects. The model projects sector-specific LLRs using real GDP growth rate, unemployment rate, and a short-term interest rate as independent variables. The model allows for non-linear effects by defining the dependent variable as the logistic transformation of the LLR. These effects imply larger subsequent increases in LLRs for sectors that are historically more cyclical as well as for sectors with higher LLRs at the starting point. Moreover, LLRs rise at an increasing rate as macroeconomic conditions deteriorate and is thus increasingly sensitive to the severity of the scenarios. (See Appendix IV for further details).

24. Estimates from the credit risk model suggest that LLRs would rise sharply in the "COVID-prolonged" and "market shocks" scenarios, albeit from unusually low levels (see Figure 9). System-wide LLRs have set new record lows and are virtually zero. Only the agriculture and trade sectors have somewhat high LLRs, with 1.1 percent and 0.4 percent respectively, but the weights of these sectors in bank portfolios are relatively small. These extremely low LLRs at the starting point are explained by the state of the economic and business cycle. Historically, we observe that the agricultural, real estate and construction sectors are more sensitive to economic cycles and therefore, the sector-specific fixed effect estimates for these sectors are lower (Appendix IV). The logit transformation for the dependent variable and the lower fixed effects imply larger projected losses for these sectors in the stress tests, simply reflecting their historical behavior.[13]

Net Interest Income

25. A detailed and highly granular approach was used to project bank net interest income. The FSAP team and the authorities collected detailed data from individual banks on the maturity structure and time to repricing for granular segments of assets and liabilities. On the assets side,

[13] Note that the stress tests didn't explicitly consider any of the government support measures in response to the COVID crisis.

loans and securities portfolios are classified into 6 and 3 categories respectively. On the liabilities side, deposits are reported in 10 different categories while issued debt securities are classified in 4 groups. For each item, banks reported the total volume at the end of starting quarter, average effective interest rates on the entire portfolio, and effective interest rates corresponding to "new business" activity during 2019. Asset and liability amounts are distributed into time to re-pricing intervals, which are in turn classified by original maturity.

26. Interest income and expense calculations under different scenarios were conducted following schedules of time-to-repricing and assigning new business rates as prices reset. The new business rates during the projection horizon are simply the new business rates of 2019 adjusted by idiosyncratic funding shocks. Figure 7 shows a numerical example that illustrates the calculation method: "trees" that track the repricing times and rates of each type of asset and liability item.[14] Note that, as the stress tests were performed under the "constant balance sheet assumption," maturing loans were always renewed at the rates corresponding to "new business" (lending was not interrupted).[15]

Market Losses

27. Market valuation losses corresponding to holdings of sovereign and non-sovereign debt securities were measured through changes in yields leading to re-pricing based on a modified duration approach. For every country and type of issuer, yield curves were constructed by linear interpolation of short- and long-term interest rates, as specified in the macroeconomic scenarios (see Chapter 1 and Figure 5). By tracking the shifts in yield curves over time, changes in yields were obtained for any given (modified) duration, and these were applied to calculate haircuts and re-price bond portfolios in all accounts (held for trading, available for sale, fair-valued, and held-to-maturity), excluding floating rate securities, according to the following formula:

$$\frac{\partial \text{Valuation}}{\text{Valuation}} = -MD \cdot \partial y_{MD}$$

where MD is the modified duration of the portfolio, and ∂y_{MD} is the change in the yield caused by the shift in the yield curve (vis-à-vis the value prevailing in the previous year), and measured at a point in time that matches the modified duration of the portfolio.

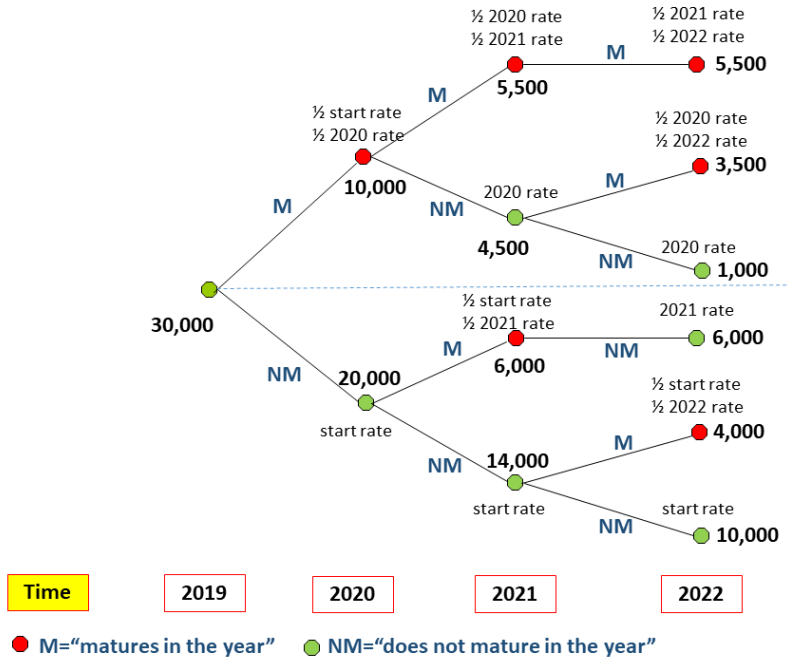
[14] Note that actual calculations are more complex than those shown in the example. While the stylized example corresponds to a 3-year time horizon, in the actual test this method is applied for a 5-year horizon. Despite these differences, the stylized example can be easily extended and generalized to span longer horizons.

[15] In the "market shocks" scenario, there is a significant tightening of financial conditions, and therefore, the cost of funding shocks and the pass-through assumption drive the net interest income results—only 15 percent of the net interest income reduction can be attributed to the maturity mismatch between assets and liabilities. In contrast, in the COVID scenarios, there is no tightening of financial conditions and about 60 percent of the reduction in net interest income is driven by the asset-liability maturity mismatch.

Figure 7. Denmark: Calculation of Interest Income in Stress Tests (Example)

Consider a hypothetical example of a loan portfolio with a given maturity structure.

	Matures in				
2019	2020			2021	2022
Total volume	Total amount (in EUR million)	of which: with original maturity <=1Y	of which: with original maturity >1 and <=2Y	Total amount	Total amount
30,000	10,000	5,500	3,500	6,000	4,000



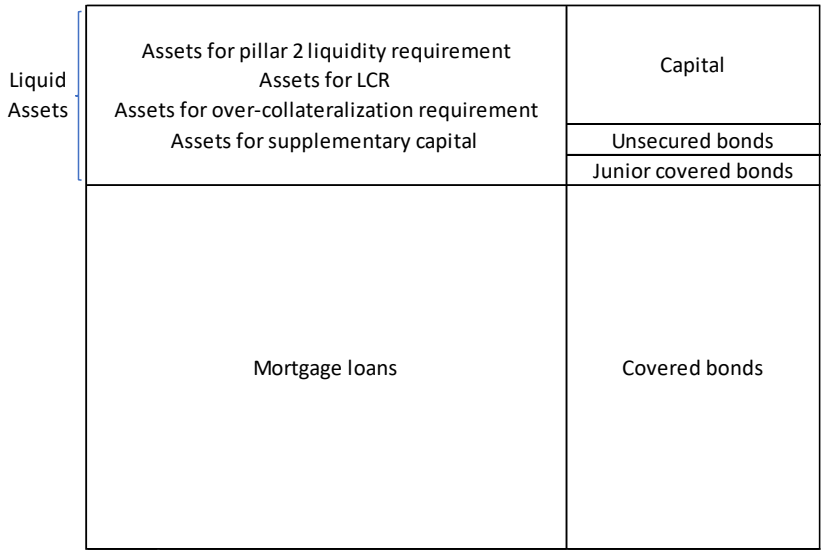
Consider a hypothetical loan portfolio valued at 30,000 DKK at the end of 2019. A 10,000 DKK amount matures (M) or reprices in 2020, while the remaining 20,000 DKK does not mature (M); these amounts are reflected in the left-most upper and lower branch of the tree respectively. Note that 6,000 of that remaining 20,000 DKK reprices in 2021 according to the data table and is reflected in the lower-half of the "tree". As the original time to repricing for the 6,000 DKK was longer than 2 years and it just gets repriced in 2021, it will not reprice again in 2022)—thus, this sub-branch needs no further splitting. Similarly, for the remaining amount of 14,000 DKK that has not yet matured in 2021, the data table and the tree indicate that 4,000 DKK would reprice in 2022. This completes the description for the lower half of the tree. As for the upper-half, the 10,000 DKK that repriced in 2020 is re-invested, with a maturity structure that matches the "original maturity" distribution reported in the data—5,500 DKK will reprice the following year, 3,500 DKK will reprice after two years, and the remaining 1,000 DKK will not reprice until a later date. Finally, the re-setting of rates reflects the continuous maturity of loans during a particular year—and hence, the typical loan in the portfolio yields the starting rate for ½ year and the new (re-set) rate for the rest of the year.

B. Mortgage Credit Institutions: Solvency Tests Based on Macroeconomic Scenarios

Role of MCIs in the Financial System and Risk Profiles

28. Within financial groups, mortgage credit institutions specialize in the provision of mortgage loans financed by issuance of covered bonds. MCIs do not have independent branch offices; bank branches/offices provide the entry point for mortgage applications by potential borrowers. Although the mortgages are originated in bank branches, these are pooled and placed in bankruptcy-remote capital centers managed by MCIs—each MCI has a number of capital centers. MCIs' capital centers typically have the balance sheet structure depicted in Figure 8.

Figure 8. Denmark: MCIs Capital Centers: Balance Sheet Structure



Note: The figure shows the balance sheet components for illustrative purposes. The relative sizes of items do not necessarily reflect actual relative magnitudes.

29. A complex but well-designed institutional and regulatory set up defines the risks that passed onto covered bond holders, those that are retained by MCIs, and the buffers available to absorb potential losses.[16] Some noteworthy features of the system that limit MCIs' risks and provide additional loss absorption capacity include: over-collateralization requirements; guarantees provided by banks against loan defaults; a matching principle embedded in current regulations

[16] It is not the purpose of this note to describe in detail the institutional and regulatory framework in which MCIs operate. The following sources provide detailed overviews: Danske Bank's "Nordic Covered Bond Handbook" (various editions; Nykredit's "Danish Covered Bonds" (various editions; Gundersen Poul, Stig Hesselberg, and Sean Hove (2011); and IMF (2014).

which ensures that MCIs pass the interest rate risk from covered bond investors to borrowers completely; and very limited exposure to funding liquidity risk (see Box 2).

Tests Based on Macro Scenarios: Methodology

30. The strategy for stress testing MCIs was designed with due and thorough consideration of the institutional and regulatory features of the system. The TD solvency stress tests assessed the capacity of MCIs to withstand the effects of adverse shocks that generate losses through three main channels.

- *Credit losses*. Along with guarantees provided by banks, the capital buffers of MCIs are first in line to absorb losses associated with loan defaults.
    - Loan loss rates (LLRs) under the adverse scenario were estimated using a dynamic time series regression model. The model projects mortgage LLRs using real GDP growth rate, the unemployment rate, a short-term interest rate and inflation as independent variables. The model allows for non-linear effects by defining the dependent variable as the logistic transformation of the LLR—LLRs rise at an increasing rate as macroeconomic conditions deteriorate and is thus increasingly sensitive to the severity of the scenarios. (See Appendix VI for further details).
    - Estimates from the credit risk model suggest that LLRs would rise gradually in the adverse scenario, from unusually low levels. LLRs at the starting point are virtually at zero. As the risk factors deteriorate, the LLRs gradually rise and peak at 1.0 percent in the last year of the scenario—the main driver of mortgage defaults is the unemployment rate which peaks toward the end of the horizon. The projected LLRs exhibit strong persistence, associated with a significant coefficient on the lagged dependent variable in the model.
- *Market losses*. Capital also absorbs any downward repricing of securities held in capital centers for the purpose of covered bond (over-)collateralization. The repricing methodology is the same as that used for the banking sector stress tests—the analysis was conducted by DN staff based on yield curves provided by IMF staff as part of the scenario.
- *Loss of net interest income*. Net interest income is adversely impacted when the MCIs must issue junior bonds to top-up collateral in capital centers—due to a negative spread via-a-vis sovereign bonds. In the stress tests, the top-up collateral needs of MCIs are calculated as follows: when housing prices (index) decline, LTV ratios rise above the (80/60 percent limits, depending on mortgage type) and MCIs must issue bonds to buy and place sovereign securities in the capital centers—thus reducing the LTV again to permissible levels.

31. Importantly, the tests account for benefits from guarantees. Note that the tests assume that within-group guarantees and those provided by banks outside of the stress testing perimeter are available to cushion the impact of loan defaults on MCIs' capitalization ratios. After accounting

for these guarantees, all MCIs can fully absorb losses through the release of the CCyB and by drawing down their excess capital buffers.

C. Consolidated (Group-level) Results for Solvency Tests Based on Macro Scenarios

32. This section discusses the methodology and results of solvency stress tests performed at the consolidated (group) level. The groups comprise the banks and MCIs of Danske Group, Jyske group, and the Nykredit Group. These groups, the two remaining solo banks (Sydbank and Spar Nord Bank), and the two solo MCIs (DLR Kredit and Nordea Kredit) comprise the 7 systemic credit institutions for which we present results.

33. Three important methodological issues must be addressed in consolidating the results of banks and MCIs to obtain group-level results.

1) ***Projection of RWAs for the group***. For each group, the reported amount of group-level RWAs is lower than the sum of the RWAs of the bank and MCI in the group; thus, the projected RWAs for the bank and MCI cannot be simply added up to project group-level RWAs. Instead, we proceed as described in Appendix VII.

2) ***Intra-group flows of profits and dividends***. The financial groups include some subsidiaries that are not part of our stress testing exercise. We stress only the income from subsidiaries that are subject to the stress test; the income from excluded subsidiaries is assumed to be constant at the level observed in 2019.

3) ***Interest on intra-group cross exposures***. The interest payments and income flows associated with within-group (inter-company) exposures are netted out. This is in contrast to the solo-level stress tests described above, where net interest income projections based on GAP analysis include payments and income from within-group (inter-company) exposures.

Results

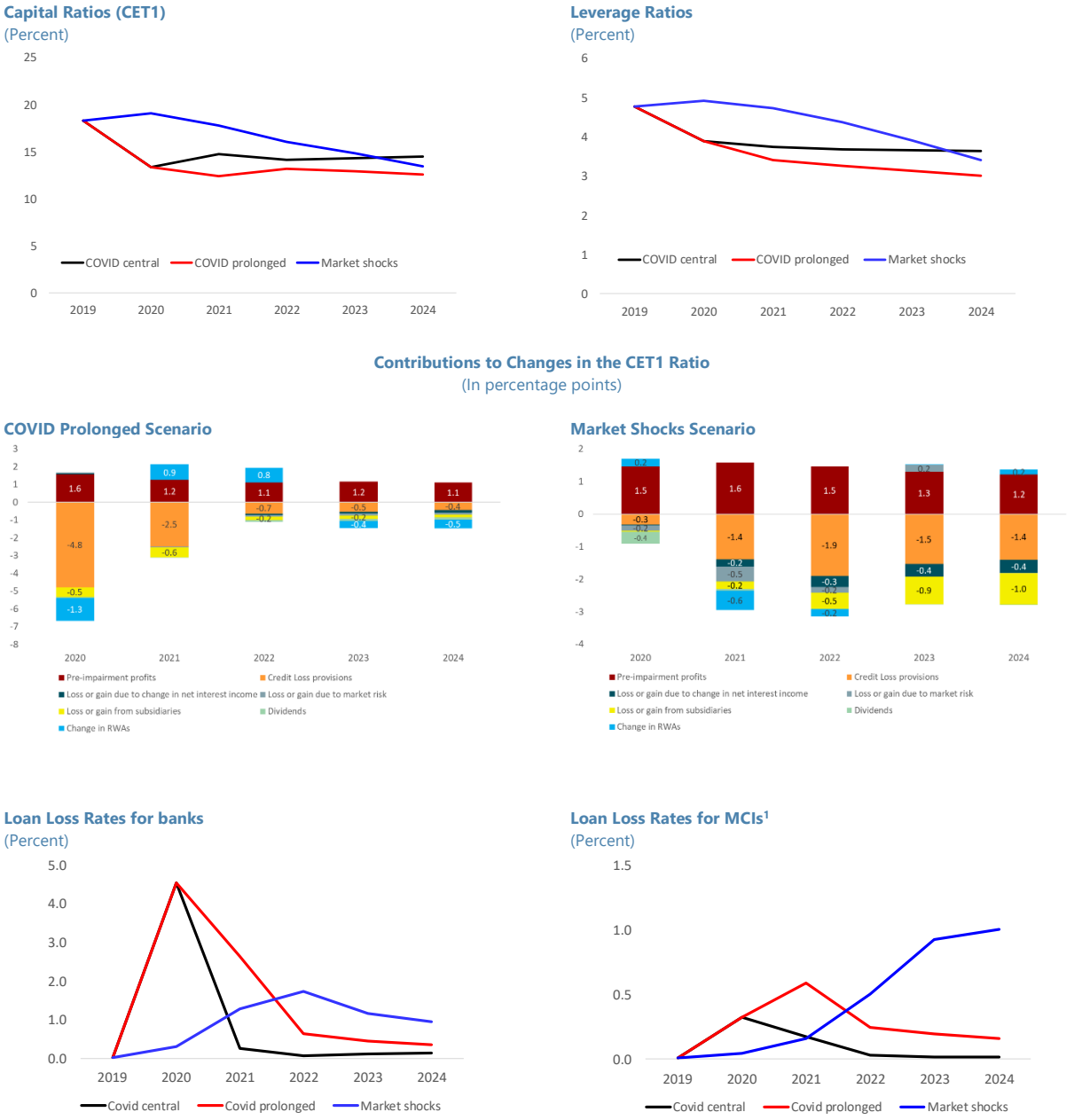
34. The illustrative scenarios reveal a large impact on capital which varies across SIFIs:

- Under the "COVID central" scenario, the aggregate CET1 ratio declines from 18.3 percent in 2019 to a low point of 13.4 percent in 2020, while the aggregate leverage ratio would decline from 4.8 percent to 3.6 percent over the same period (Figure 9). The materialization of credit risk, which is predominantly influenced by GDP growth and the unemployment rate, is the main driver of the losses. All SIFIs meet their minimum capital requirements (a 4.5 percent CET1 ratio) under this scenario, however, the impact on capital varies. Specifically, one out of the seven SIFIs must partially tap into its capital conservation buffer (CCB) to fully absorb the losses under stress. The leverage ratio (which is currently planned for implementation in mid-2021) for one SIFI also falls below the three percent threshold.

- In the context of the "COVID prolonged" scenario, the aggregate CET1 ratio falls to a low point of 12.4 percent in 2022, reflecting the more protracted nature of the economic contraction. The aggregate leverage ratio would decline to 3.0 percent in 2024. Under this scenario, while all SIFIs still meet their minimum capital requirements, the impact on capital is more differentiated. While one SIFI makes partial use of its CCB, another SIFI needs to partially use its SIFI buffer. Likewise, the leverage ratios of a few SIFIs fall below three percent.

Figure 9. Denmark: Solvency Stress Tests for Banking Groups

Stress tests indicate that the COVID shock would have a large impact on SIFIs' capitalization ratios.



Source: IMF staff calculations.
Note: The loan loss rates for MCIs reflect loan losses before the application of loan loss guarantees.

- Under the "market shocks" scenario, the capitalization ratios reach their respective troughs at the end of the stress testing horizon: the aggregate CET1 ratio and the leverage ratio decrease to 13.4 percent and 3.4 percent, respectively, in 2024. Although this scenario assumes significantly more severe market shocks and a lasting domestic real estate downturn, the results are primarily driven by the protracted nature of the envisaged downturn. In this case, a few SIFIs make partial use of their CCBs and a few SIFIs' leverage ratios dip slightly below three percent.

35. In the COVID scenarios, the CET1 reduction is driven by front-loaded credit losses in both parent and subsidiary entities. In these scenarios, bank credit losses are estimated to reach unprecedented high levels in 2020, but the impact of cost of funding shocks and market risk are limited.[17] This is because we use the cost of funding shocks that have been realized so far in 2020 only for this scenario.

36. In contrast, in the "market shocks" scenario, the CET1 reduction is driven by credit losses in parent entities during the first three years, but losses of subsidiaries also become significant later on (Figure 9). This because the pre-COVID adverse scenario envisages a more moderate but protracted GDP decline which continues for three years. Also, the recovery is not robust, resulting in sizable backloaded losses. As a result, projected CET1 ratios decline throughout the stress horizon and reach bottom at 12.2 percent in 2024. In this scenario, reduced net interest income due to large cost of funding shocks, and losses due to repricing of securities driven by yield curve shifts, also exert a significant contribution to declines in CET1 ratios.

37. These results should be interpreted with a high degree of caution. In addition to the large uncertainty associated with these scenarios, several limitations need to be recognized. In the analysis, the relationship between growth and capitalization is non-linear, implying that deeper recessions have potentially disproportionate impacts on capital. This implies that stress test results are very sensitive to the severity of the scenarios. However, some second-round and non-linear effects, which are not fully captured in the analysis, could on the other hand imply an underestimation of losses.[18] Importantly, the analysis suggests that a further deterioration of economic prospects and tighter financial conditions, relative to those assumed under the scenarios, could bring about a situation where one or more SIFIs breach minimum capital requirements.

D. Banks: Pre-COVID Sensitivity Tests

38. Sensitivity tests assessed the vulnerabilities of the banking system to concentration risk under various scenarios for defaults of large exposures and LGDs, and the impact of the introduction of Basel III output floors on capitalization ratios (Figure 10).

[17] These scenarios focus on the growth and unemployment implications of the COVID-19 shock and do not entail an abrupt tightening of financial conditions (including a sharp rise in risk premia) or a real estate downturn,

[18] The analysis also presumes that pre-crisis relationships between macroeconomic and financial variables remain unchanged.

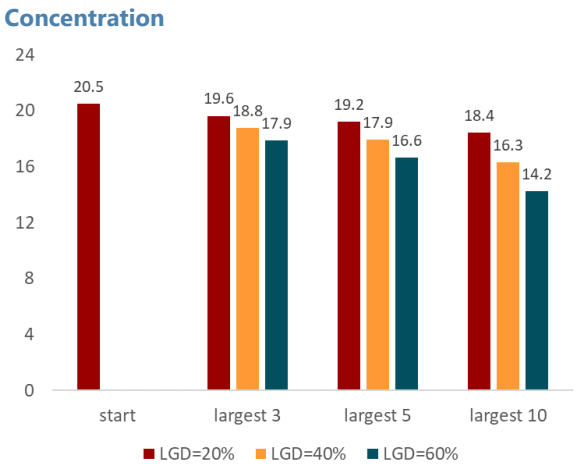
Sensitivity to Failure of Large Exposures (Concentration)

39. Concentration risk was tested by assessing the impact of default of three, five and ten largest, non-sovereign exposures. The sum of largest ten exposures for all five banks subject to the stress testing exercise represents 51 percent of their aggregate CET1 regulatory capital. The concentration sensitivity test was conducted in a static fashion. In other words, we assess the instantaneous impact of different shocks on the banks' capitalization ratios at the starting quarter. Banks' risk-weighted assets were assumed to stay constant and pre-impairment income was not allowed to offset the impact of the shocks on profits and capital.

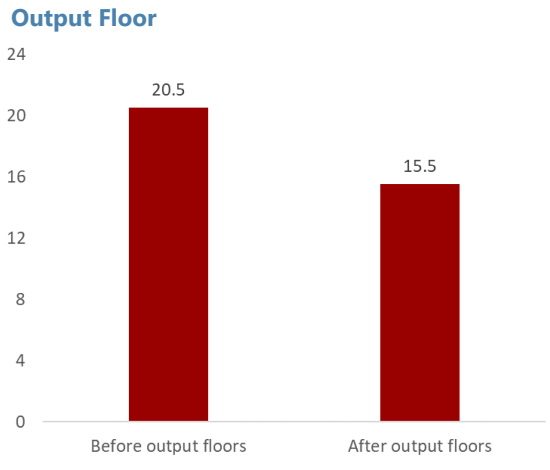
40. This illustrative pre-COVID test results show that the simultaneous default of three, five and ten largest exposures would reduce the CET1 capital ratio to 18.8, 17.9 and 16.3 percent, respectively, from the current 20.5 percent level under the 40 percent LGD assumption (Figure 10). All banks remain with excess capital above their minimum requirements and macro-prudential buffers in this test. A more stringent test shows that a simultaneous failure of the largest ten borrowers with an LGD of 60 percent—admittedly an extremely low probability event—would reduce the CET1 capital to 14.2 percent causing one of the five banks to deplete its CCyB buffer and partially use the CCB buffer.

Figure 10. Denmark: Results of Pre-COVID Sensitivity Tests for Banks

The Danish banks are well capitalized against concentration risks such as simultaneous default of largest 3,5,10 exposures with high LGDs.



The output floors will increase the RWAs by 34% when fully phased-in. The Danish banks are well-capitalized to withstand the impact from Basel-III output floors.



Sensitivity to the Introduction of Basel III Output Floors

41. Before the onset of the pandemic, we also conducted a sensitivity analysis to gauge the impact of Basel III output floors. When fully implemented, RWAs will be floored at the 72.5 percent of standardized RWAs for banks using advanced IRB methods. The Basel output floor will

rise gradually starting in 2023 and be fully phased-in by 2028. Publicly available analytic studies by the industry and Danish authorities indicate that the RWAs will increase by approximately 34 percent in the Danish banking sector by the time the regulation is fully phased-in in 2028 (Figure 10). Therefore, we conduct this analysis in a static fashion and assess the impact on the starting capitalization ratios as if the floors were fully phased-in today for the four IRB banks.

42. Following a 34 percent increase in RWAs for the IRB banks, the aggregate capitalization ratio for the banks go down significantly from 20.5 percent to 15.5 percent. However, pre-COVID shock results suggest that all four IRB banks can withstand this increase in RWAs without using their macro-prudential buffers. A caveat of this analysis is that it is conducted in a static manner. Note that the results cannot be directly combined with the insights of section C as the exact dynamics of the output floor during an economic downturn has not yet been analyzed. It is possible that the effect of the output floor will be lower (than 34 percent) during a recession where IRB risk weights of performing exposures will be higher. Moreover, the output floor will only partially be phased-in during the stress testing horizon which ends in 2024.

CHAPTER 3. LIQUIDITY STRESS TESTS OF BANKS AND MORTGAGE CREDIT INSTITUTIONS

In this chapter, Section A presents the description, methodology, and results of the top-down liquidity stress tests of banks on a solo basis. Section B describes liquidity risks faced by MCIs and the new pillar II liquidity requirements designed by the authorities.

A. Pre-COVID Liquidity Stress Tests of Banks

43. Liquidity stress tests based on a maturity ladder analysis were undertaken to assess the capacity of banks to withstand severe funding pressures.[19] Cash-flow based liquidity stress tests were implemented through a TD approach, using information on the time structure of contractual cash flows generated by assets and liabilities. The tests assessed resilience to strong shocks characterized by run-off rates on funding sources calibrated by type, and liquidation of assets subject to valuation haircuts. Specifically, the exercise captured (i) a bank's liquidity needs derived from outflows; (ii) its available standby liquidity from inflows; and (iii) its buffers available to counterbalance liquidity gaps.

44. Funding pressures were captured through specific time profiles of run-off rates for different funding sources (Appendix VIII). A set of general principles, consistent with historical experience and empirical studies of depositor and investor behavior in extreme but plausible conditions, guided the choice of run-off rates. First, more informed and sophisticated depositors withdraw funding more rapidly than less informed depositors—run-off rates applied to wholesale funding sources are higher than those applied to retail funding sources. Second, run-off rates on secured funding sources are lower than those applied on unsecured funding sources. Third, under stress, sight deposits are/or deposits protected by deposit insurance are withdrawn at a slower pace than time deposits and/or those uninsured. Fourth, regarding the intensity and persistence of the funding liquidity pressures, it is assumed that cash outflows would be protracted—lasting for up to one year. However, run-off rates are assumed to vary over time, with the highest rates corresponding to short-term maturity buckets (0–90 days) and the lowest rates corresponding to longer-term time buckets (after 180 days).

45. For different assets and maturity buckets, roll-off rates were applied to convert maturing amounts into cash proceeds (Appendix VIII). Specifically, 100 percent roll-off rates were applied to all maturing asset items except for loans to retail customers (70 percent).[20] Banks can counterbalance negative funding gaps by using their cash and securities holdings. In the tests, banks were allowed to cover negative balances of cash inflows relative to cash outflows by using their secured instruments, covered bonds, sovereign and non-sovereign securities. As a last resort,

[19] For methodological details, see IMF Guidance Note on Stress Testing, "Treatment of Liquidity Risks in Stress Tests," Number 11, November 2015.

[20] These represent the cash inflows that a bank can generate under the going concern assumption: its actions do not compromise banking relations with important borrowers and cause no significant business disruptions.

banks could use assets as collateral to obtain liquidity and ELA from the DN. The pass-fail criterion is defined by the ELA provision: a bank that needs ELA to continue operating is considered to have failed the test.

46. The results of the pre-COVID tests, suggest that all banks would have been able to survive intense liquidity pressures without external support for several months. In particular, based on September 2019 COREP reporting data, the survival period for all banks was longer than 3 months under the assumed shocks—survival periods for three of the 5 banks would have lasted 5 months or longer. Tighter financial conditions relative to those assumed in the tests, however, could affect bank's access to liquidity and funding costs unevenly and may result in acute liquidity strains for some banks.

47. In addition, a series of sensitivity tests based on the liquidity coverage ratio (LCR) assessed resilience of banks to cash inflows and outflows shocks, in all currencies and in EUR. For all currencies, LCR ratios in Figure 11 correspond to five different liquidity scenarios: (i) LCR baseline; (ii) freezing of "non-HQLA" repo market (higher cash outflows); (iii) covered bond market stress via higher yields and haircuts (lower HQLA);[21] (iv) higher run-off rates on retail liabilities and reduced inflows from retail counter-parties[22] ("Retail shocks", higher outflows and lower inflows); (v) higher run-off rates on financing from wholesale sources, reduced inflows from wholesale counterparties, and higher asset haircuts reducing the banks' counterbalancing capacity[23] ("Wholesale and CBC" higher outflows, lower HQLA). For EUR LCR, only (i), (iii), (iv) and (v) are reported as repos in EUR are not significant—scenario 2 is redundant. Note that the calculation of the LCR in EUR follows the DFSA methodology on the pillar II liquidity requirement.

48. The LCR tests suggest that HQLA buffers would be sufficient to absorb extreme (short-term) liquidity shocks. In the test for all currencies, results indicate that 3 of the 5 banks would have post-shock LCRs at about 100 percent or above; the LCRs of the two other banks would remain above 65 percent after the liquidity shocks. For foreign currency (EUR) tests, the results point to more limited exposures and additional capacity of banks to absorb shocks: the post-shock LCRs of 3 of the 5 banks remain close to or above 100 percent, while those of the two remaining banks end up in the 80-100 percent range.

49. Overall, the analysis suggests that the banking system could withstand significant withdrawals of short-term funding. Although the liquidity stress tests were conducted before the

[21] The scenario assumes that the Danish covered bond market experiences a severe market drop in value. Specifically, for level 1B covered bonds, the liquidation values decline from 93 percent to 75 percent (assumed haircuts rise from 7 percent to 25 percent); for level 2A covered bonds, the liquidation values decline from 85 percent to 65 percent (haircuts rise from 15 percent to 35 percent).

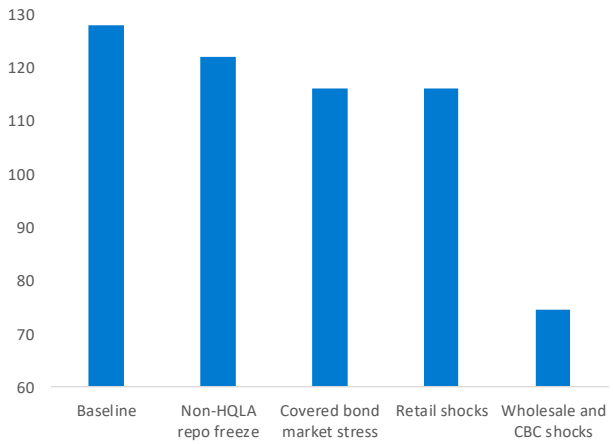
[22] The "Retail shocks (IMF)" scenario doubles the LCR run-off rates applied to demand deposits and multiplies by 5 the LCR rates on undrawn but committed credit and liquidity lines; it also reduces by ½ the roll-off rates on inflows from retail counterparties.

[23] Relative to the LCR, the "Wholesale and CBC (IMF)" scenario doubles run-off rates on unsecured wholesale funding sources and on secured funding backed by non-Level 1 or non-Level 2A assets. It reduces by ½ the roll-off rates on inflows from institutional counterparties (NFCs and financial institutions). And it assumes lower liquidation values of Level 2A assets (from 85 percent to 75 percent) and Level 2B assets (from 50-75 percent to 40-65 percent).

onset of the COVID-19 pandemic, the shocks assumed in the tests were significantly larger than those that have materialized in 2020 Q1. According to the May 2020 DN Financial Stability Report (FSR), systemic banks, in aggregate, could cover their liquidity needs under a severe liquidity stress scenario. The FSR notes that the overall liquidity situation for systemic banks has not been materially affected by the COVID-19 pandemic as of mid-March. Moreover, the median LCR across systemic banks increased to 198 percent in April 2020 from 174 percent at end-2019.

Figure 11. Denmark: Sensitivity Tests of Liquidity Risk Based on the LCR[1,2]

(Aggregate LCRs in all currencies for the 5 largest banks, in percent)



Source: DN staff calculations.

1/ The calculations are based on COREP reporting and incorporate both the 70/30 cap and the 75 percent inflow cap used in the EU LCR.

2/ Based on September 2019 data.

B. Liquidity Risk in Mortgage Credit Institutions

50. As a result of market practices and institutional features, MCIs face limited exposure to liquidity risks by design. Covered bonds issued in recent years include clauses that protect MCIs against funding liquidity risk. In the extreme and unlikely event that an MCIs is unable to issue new bonds in the market, bond holders can be forced to roll-over their positions for up to thirty years (one year at a time).[24]

51. New pillar II requirements have further strengthened the capacity of MCIs to withstand liquidity shocks associated with potential disruptions in the mortgage prepayment and re-mortgaging business (Box II). Still, MCIs can face other types of liquidity risks. Sharp changes in interest rates often prompt households to "re-mortgage"—pre-pay their existing

[24] Making use of this option would relieve immediate liquidity pressures but it would also generate reputational and other costs for an MCI. Thus, MCIs have strong incentives to avoid such situations and to hold sufficient liquidity buffers (in addition to those required by regulation).

mortgages and enter into new mortgage contracts with different terms. Under existing rules, a household who wants to pre-pay a mortgage must give the lender a 60-day advance notice that obliges the household to pay the mortgage in full. Under normal circumstances, in the ensuing 60-day period, households can easily obtain new mortgages; in fact, most (but not all) households typically lock-in the terms of a new mortgage when giving notice of prepayment to the original lender. Difficulties could arise if households with "open positions"—those that have not locked-in new mortgages at the time of giving the pre-payment notice—are unable to obtain new financing during the 60-day period due to an extreme and unlikely disruption of the covered bond market—which would impede a normal supply of new mortgages. If a given percent of outstanding mortgages with open positions fail to be pre-paid as planned—due to a covered bond market disruption—MCIs would suffer a reduction in cash inflows and would need to tap their available liquidity buffers to make the associated covered bond payments. These risks motivate the new pillar II add-ons described in Box II.

Box 2. Liquidity MCIs

Background and Current Pillar II Liquidity Requirement

The Danish FSA has granted five Danish specialised MCIs (SMCIs) exemptions according to Article 26 in the LCR Delegated Regulation (LCR DR). According to these exemptions, the cash flows related to mortgage lending are netted.

To cover liquidity risks in the SMCIs, which are not covered by the LCR (i.e. refinancing risk) and to ensure a minimum amount of liquid assets in the SMCIs, the Danish FSA has imposed a Pillar II liquidity requirement. The SMCIs are required to hold a liquidity buffer of 2.5 percent of their total lending (called "LCR floor requirement"). This buffer must be composed of assets meeting the definition of high-quality liquid assets (HQLA) in the LCR DR, but the caps in Article 17 of the LCR DR for different HQLA categories do not apply.

The SMCIs are required to comply with the LCR floor requirement alongside the LCR requirement, but the assets used as buffer for the LCR floor requirement can also be used as HQLA in the LCR and vice versa. In reality, the LCR floor requirement is (almost always) the binding requirement.

The regulation is changing for the SMCIs when the OC requirement in the Covered Bonds Directive comes into force. Thus, the Danish FSA has looked into the liquidity risk in the SMCIs and the Danish LCR floor requirement. This has resulted in a revision of the Pillar II liquidity requirement, which is outlined below.

The New Model for Pillar II Liquidity Add-ons

The Danish FSA will replace the existing LCR floor requirement with a more traditional risk-based Pillar II requirement containing at least three specific Pillar II add-ons.

The purpose of this is mainly to ensure that the Pillar II add-ons better reflect the specific liquidity risks entailed in each SMCIs business model thus giving the SMCIs an incentive to reduce risks in their business model. Furthermore, the new model will bring the Pillar II requirement more in line with EU standards by defining the liquidity buffer according to the LCR DR and by mirroring the practice of setting specific add-ons, which is already used in relation to Pillar II capital requirements.

Box 2. Liquidity MCIs (continued)

The Danish FSA has developed a guidance on which the SMCIs can base their determinations of Pillar II liquidity add-ons. The Danish FSA distinguishes between at least two types of Pillar II add-ons: Pillar II A add-ons and Pillar II B add-ons. The Danish FSA expects the SMCIs to set at least two Pillar II A add-ons, one for unknown arrears and one for unknown open conversions, and a Pillar B add-on for refinancing risk. The size of the add-ons depends on how much risk the SMCI's business model entails.

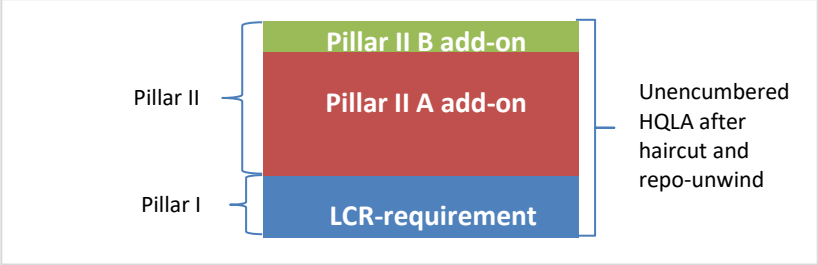
The purpose of the guidance is to enable the SMCIs to rely on the established quantitative benchmarks and methods that the Danish FSA uses in practice. It is also important that the individual SMCI addresses its own risks, experiences and historical data.

The SMCIs must adopt a prudent approach in calculating the Pillar II liquidity add-ons. If the Danish FSA considers that a SMCI has not calculated its Pillar II liquidity add-ons in an appropriately prudent manner, and does not have a sufficient liquidity buffer, the Danish FSA will impose a Pillar II liquidity add-on on the SMCI. This is the same practice used in relation to capital according to CRD.

All the SMCIs must in the future hold liquid assets to cover the LCR requirement, Pillar II A add-ons and potentially a Pillar II B add-on, in accordance with Figure 1.

Like the LCR requirement, both add-ons must be covered with unencumbered HQLA after haircuts and caps (Article 17) according to the LCR DR.

Box Figure 1. The SMCIs Pillar I LCR-requirement and Pillar II Liquidity Add-ons



The Three Pillar II Add-ons

The Danish FSA expects the SMCIs to set at least two Pillar II A add-ons for uncertainty concerning the borrower's ability to pay (unknown arrears) and uncertainty associated with open conversions (unknown open conversions) respectively. The SMCIs must also set a Pillar II B add-on for refinancing risks depending on how much HQLA the SMCI already holds to fulfil the requirement for supplementary collateral (according to CRR Article 129), and the requirement of extra collateral, which is being introduced by the recently adopted Covered Bonds Directive (OC requirement, Article 15). In theory, there can be other Pillar II add-ons, if the SMCIs have other liquidity risks, which are not captured by the existing liquidity requirements.

1. Pillar II A Add-ons

In the two Pillar II A add-ons, the SMCIs must assess, based on historical data, the maximum levels of arrears for private and corporate customers, as well as the risk of outflow from open conversions under stress (the risks related to remortgages without lock-in of the new loan).

Box 2. Liquidity MCIs (continued)

Arrears

The arrears that the SMCIs have reason to expect for the next 30 days must be included in the LCR requirement according to Article 32 in LCR DR. As a recession materialises in arrears, the SMCI's LCR requirement will increase, as expected arrears must be included in the LCR.

However, not all arrears are expected. The Danish FSA considers it necessary to ensure that the SMCIs have the liquidity to handle a recession, when unemployment rises more than expected and borrowers either do not pay or are late with their payments.

Pillar II A add-ons for arrears will ensure that the SMCIs have sufficient liquidity to handle increased arrears during a recession. The Pillar II A add-on for arrears is determined as a percentage of future interest and principal payments in an unlikely, but not inconceivable, stress scenario. It is therefore up to the individual SMCI to determine the percentages for private and business customers based on its own risks, experiences and historical data. The add-on regarding arrears is calculated with a deduction for expected arrears, as these are included in the LCR requirement.

Open Conversions

Open conversions are when the borrower repays his loan by the date of payment in order to convert to a new loan, but where the new loan has not been locked in 30 days before the date of payment on the covered bonds. The loan must be terminated for conversion at least two months before the date of payment, while the securing of conversion proceeds needs to be done at the latest two days before the date of payment. The proceeds must be used for the repayment of drawn and expiring covered bonds, and therefore cannot be postponed if the covered bonds to the new loan cannot be sold.

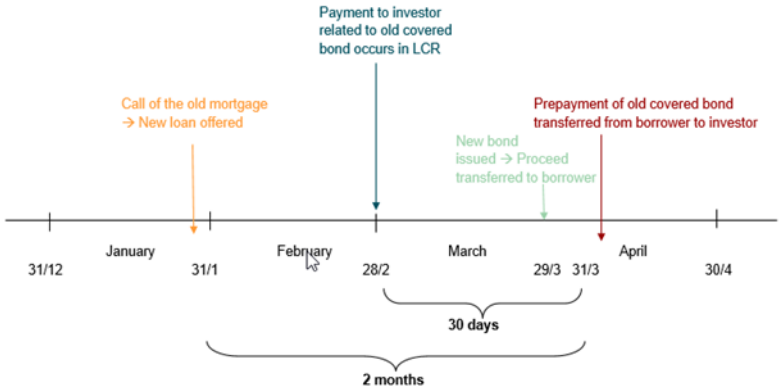
If the borrower does not get a fixed-price interest rate agreement, there is a risk that the covered bonds financing the new loan cannot be sold and the old loan is therefore not repaid (repayment). Although the borrower is contractually obliged to repay, the SMCI has a liquidity risk, as the SMCI has the obligation to the investor.

Open conversions are included as a regular outflow with a weight of 100 pct. in the LCR requirement. Open conversions are included in LCR 30 days before the date of payment and until the date of payment, as LCR must be calculated daily.

The Danish FSA will introduce a Pillar II A add-on for open conversions to cover unknown open conversions. This is to make sure, that the SMCIs have a sufficient amount of HQLA in a stress scenario where the SMCI may experience a large number of borrowers, which do not choose to make a fixed-price agreement on the interest rate and thus a large volume of open conversions.

Box 2. Liquidity MCIs (continued)

Box Figure 2: Open Conversions Where the New Covered Bonds are Issued



Prior to a conversion trend (typically initiated by larger movements in the interest rate level) with potentially a large volume of open conversions, it is thus important that the SMCIs have HQLA to cover a certain amount of these open conversions when they enter the LCR 30-day window, rather than starting with no liquidity to cover this risk. The Danish FSA also wishes to ensure that the SMCI's liquidity buffers do not vary dramatically between dates of payment, i.e. in the months when open conversions are not included in the LCR requirement.

The Danish FSA's new guidance will specify that the Pillar II A add-on for open conversions should amount to at least 30 pct. of the open conversions in an unlikely, but not inconceivable, stress scenario.

If the amount of open conversions, that is included in the LCR requirement 30 days before date of payment, is lower than the amount of open conversions that is used in the pillar II A add-on, the SMCI has to take the difference between these two amounts as a pillar A add-on in the months where open conversions are included in the LCR calculation. In the months where there are more than 30 days to the date of payment, the SMCI shall take the 30 pct. of the whole amount of open conversions in an unlikely, but not inconceivable, stress scenario as a pillar II A add-on.

The two Pillar II A add-ons will ensure a more stable liquidity requirement, as they create a minimum amount of unencumbered HQLA which each SMCI must hold.

2. Pillar II B Add-on

At refinancing auctions, there is a theoretical risk of demand being so low that the SMCI has to buy some of its own covered bonds to avoid the auction failing. However, this risk is not covered by the LCR requirement, as refinancing takes place before the 30-day LCR window. The Danish FSA will therefore introduce standardised liquidity stress testing across the SMCIs to ensure that the SMCIs have enough liquidity to handle such a situation. This stress test may result in a Pillar II B add-on. Until now, this risk has in a general been captured by the LCR floor requirement.

The Danish FSA finds that SMCIs, which use HQLA to meet the requirement for supplementary collateral and the future OC requirement, are better equipped to handle refinancing risks, than SMCIs, which meet these two requirements with assets, which are not HQLA, such as their own covered bonds or warranties. The more HQLA the SMCIs have, the better positioned they will be in a stress scenario, as it will be easier to sell HQLA in order to generate liquidity than own issued covered bonds.

Box 2. Liquidity MCIs (concluded)

The Pillar II B add-on regarding refinancing risks is forward-looking and looks at the budgeted need for refinancing for the coming date of payment, which means it looks three months ahead.

The SMCIs must generally assume that they will have to buy 30 pct. of their own covered bonds to avoid that an auction fails. If the SMCI does not have sufficient HQLA, the SMCI will have to set a Pillar II B add-on. The Pillar II B add-on will thereby ensure that there is a sufficient amount of HQLA for the SMCI to be able to sell HQLA and buy its own covered bonds to avoid the auction failing.

The model implies that a SMCI, which uses HQLA to meet the requirement for supplementary collateral and the future OC requirement, will likely be able to handle a situation where an auction partially fails by selling HQLA and instead buying its own covered bonds at auction.

The SMCIs may thus use their own covered bonds to meet the future OC requirement and the requirement for supplementary collateral. The SMCIs will continue to meet these two requirements when they use their own covered bonds, which they have bought on the auction. Each SMCI will then have to set a Pillar II B add-on to have a sufficient amount of HQLA.

In general, the SMCIs will probably not have to set a Pillar II B add-on at the moment, as each SMCI is expected to use a sufficient amount of HQLA as supplementary collateral and to meet the future OC requirement. The Danish FSA hereby wishes to give the SMCIs an incentive to use HQLA as supplementary collateral and to meet the future OC requirement. This is to make sure that the SMCIs have a high amount of HQLA.

The Danish FSA considers that 30 percent reflects an appropriate risk for the SMCIs in going concern. There is of course a low risk that an auction will fail completely, and that 100 pct. of the auction thus cannot be refinanced. In this case, the maturity extension trigger will extend the covered bonds, according to Danish law. It is not realistic for the SMCIs to have liquidity in advance to handle the full risk of a failed refinancing auction, as this would be too high a requirement and unnecessary in view of the likelihood of an auction failing.

The new Pillar II liquidity add-ons explicitly address risks not covered by the Pillar I LCR requirement in the form of unknown arrears, unknown open conversions and refinancing risks.

Observation period. There will be an observation period until the OC requirement comes into force. The pillar II add-ons shall be reported in the observation period from December 31th 2019 and until the entry into force. The LCR floor requirement will remain during the observation period. When the OC requirement comes into force, the pillar II add-ons are expected to enter into force and the LCR floor requirement will be cancelled. The current calibration of the pillar II add-ons may be adjustment during the observation period if needed.

CHAPTER 4. INSURANCE AND PENSION FUND STRESS TESTING

A. Scope and Sample of the Stress Test

52. The resilience of insurance companies was assessed through a top-down (TD) and bottom-up (BU) solvency stress test. The tests covered five life insurers, six occupational pension funds and five non-life insurers, accounting for more than 70 percent in each sector,[25] measured by gross written premiums. Furthermore, Arbejdsmarkedets Tillægspension (ATP) was included, a compulsory pension scheme within the first pillar of the Danish pension system. Contrary to the other participants in the exercise, ATP is not subject to the solvency requirements of the Solvency II Directive.[26] The reference date for the stress test exercise was set to 30 June 2019.

53. The pre-COVID stress test was run at the solo entity level and thereby excluded business performed by foreign subsidiaries. Only a few of the larger Danish insurance groups have set up foreign subsidiaries and branches, and typically their number and contribution to the respective group's results and risk profile is very limited. Hence, by focusing on the Danish entity, a fairly comprehensive view on relevant risks can be achieved.

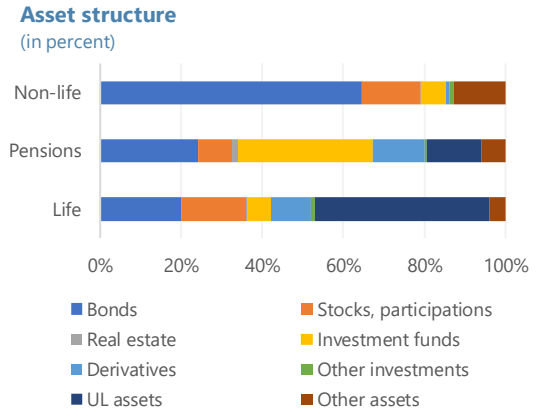
54. Danish insurers have successfully reduced their asset-liability risks and also transferred some market risks to policyholders (Figure 12). To a large degree, Danish life insurers have been shifting from traditional to unit-linked policies, effectively reducing their own market risk exposure. Additionally, the Danish Financial Supervision Authority (DFSA) has required insurance companies early on to prioritize a prudent asset-liability management, contributing to a reduction in maturity mismatches. The exposure to stocks and participations is a bit higher than in other EU countries, while real estate exposures, both directly held and indirectly via investment funds, are rather low. Structurally, insurers still have a currency mismatch between assets and liabilities: While liabilities of life insurers and pension funds are almost exclusively denominated in Danish kroner, the domestic capital market is not sufficiently deep to absorb the investments of the long-term savings industry. Life insurers and pension funds therefore hold sizable portions of their assets abroad, denominated in foreign currencies. However, the currency mismatch is largely hedged through cross-currency swaps and forwards.

[25] Danish branches of foreign insurers were excluded from the market share calculation.

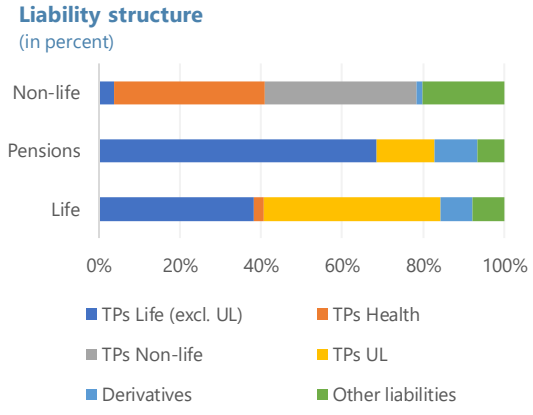
[26] See Box 3 for details.

Figure 12. Denmark: Insurance Asset and Liability Characteristics

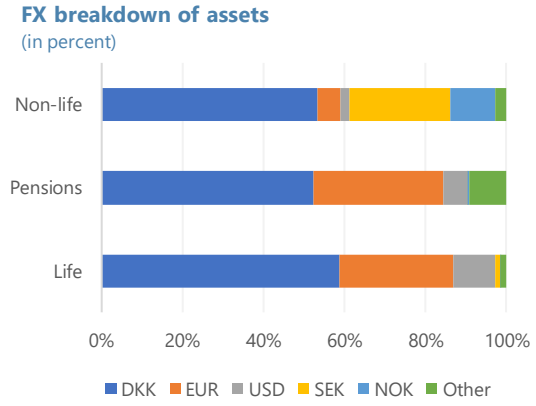
Assets are diversified, but exposures to stocks and participations are higher than for the average EU firm.



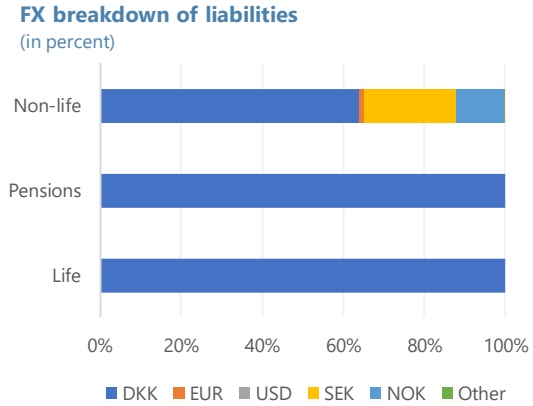
Technical provisions for unit-linked account for one third of life insurers' liabilities.



Between 40 and 50 percent of assets are not denominated in DKK (with FX exposures being mostly EUR)...



...while liabilities of life insurers and pension funds are entirely denominated in DKK.

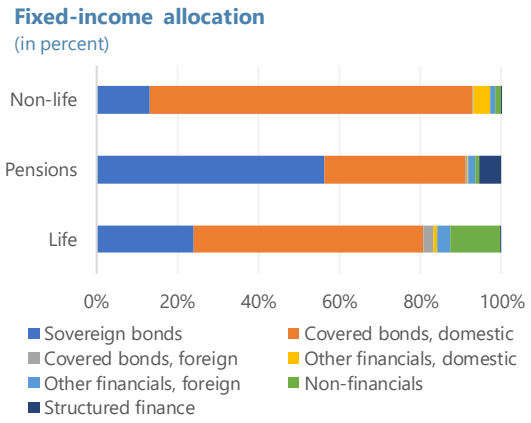


Sources: IMF staff calculations based on company submissions.

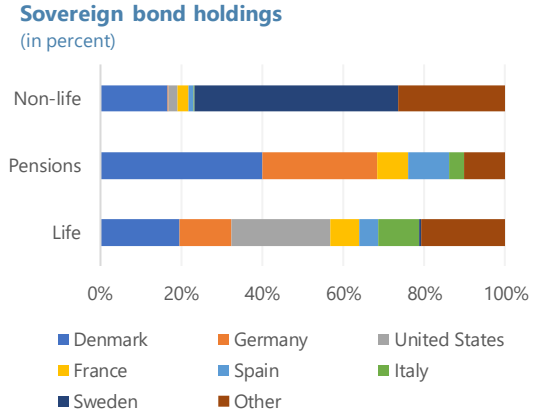
55. Investment holdings of the insurers participating in the stress test are characterized by a high share in fixed-income securities, particularly in domestic mortgage bonds (Figure 13). Corporate bond investments are of a good credit quality with 68 percent being rated A or better, and 94 percent being investment grade. Sovereign bond exposures are dominated by domestic exposures (50 percent), but also a sizable share in bonds issued by high-yield sovereigns in the Euro Area, mostly Italian and Spanish government bonds.

Figure 13. Denmark: Insurance Asset Allocation

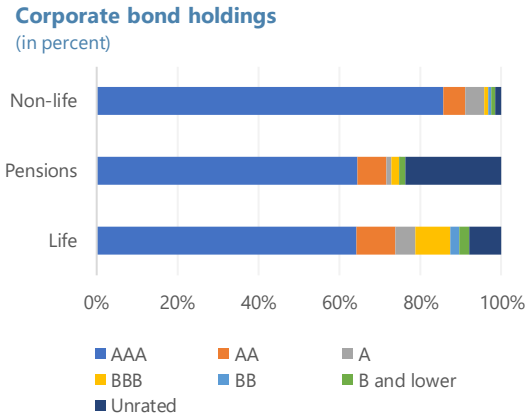
Fixed-income assets are heavily tilted towards domestic covered bonds…



…while sovereign bonds are much more diversified, especially amongst life companies.



Overall, credit quality is very high with around two thirds of corporate bonds being rated AAA.



Sources: IMF staff calculations based on company submissions.

B. Scenario Specification

56. The scenario builds on the narrative and severity of the "market shocks" adverse scenario and is also subject to uncertainty and downside risks. Note that this scenario encompassed several market shocks which resulted in a combined stress scenario that was considerably more severe than what was observed in 2020 Q1. The scenario's narrative, which centers around

- escalating global trade tensions and a tightening of global financial conditions which depress business and consumer confidence;

- weaknesses in economic activity with a knock-on effect on domestic housing markets, funding pressures for the banking system comes, and the yields of covered bonds moving up in tandem with yields of sovereign bonds,

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

57. To cover the most relevant risk factors for an insurer's balance sheet, specifically the market risk shocks were defined more granularly. The scenario includes shocks to the risk-free interest rate, equity and property prices, credit spreads of corporate and sovereign bonds, losses on mortgage loans (Table 4).[27] Moreover, the market shocks resulted in a combined stress scenario that was considerably more severe than what was observed in 2020 Q1. Given the increase of credit spreads in the scenario, also the volatility adjustment (VA) increases, following the Solvency II calculation method. In effect, this offsets to some degree the negative impact of the credit spread shock.

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

- Insurers calculated the sensitivities for longevity (modeled as a permanent 25 percent decrease in mortality rates, applied to all policies) and mortality shocks (modeled as a permanent 15 percent increase in mortality rates, applied to all policies) as well as a pandemic event (modeled as a temporary 35 percent increase in disability-morbidity rates as well as a temporary 10 percent increase in mortality rates for the next 12 months).

- Insurers further provided an estimate of the impact of a historic catastrophic event, specifically windstorm "Anatol" which had hit Denmark in 1999, based on current exposures—a windstorm of this severity is considered to occur once in 80 years. In addition, insurance undertakings provided the reinsurance recoverables from the participant's five largest reinsurers (on a group basis).

59. An additional single-factor shock, assuming the default of the largest banking counterparty, complements the stress test. The result of this sensitivity analysis is not added to the results of the scenarios. The following haircuts on exposures were applied:

[27] For details on the scenario, refer to the Insurance Stress Testing Matrix in Appendix II.

- a 100 percent write-off for equity exposures, subordinated bonds and loans, uncollateralized OTC derivative exposures, as well as guarantees for the counterparties' liabilities,
- a 50 percent write-off for unsecured bonds and loans,
- a 15 percent write-off for mortgage bonds, deposits (beyond those exposures protected by a deposit guarantee scheme), loaned securities, and collateralized OTC derivative exposures.

Table 4. Denmark: Specification of Market and Credit Risk Shocks for the Insurance Stress Test

Equity	listed	domestic	-26.5%
		other advanced economies	-20.0%
		emerging and developing economies	-25.0%
	unlisted and participations		-12.0%
Private equity			-12.0%
Hedge funds			-12.0%

Property	Residential	domestic	-22.0%
		foreign	-7.7%
	Commercial	domestic	-26.4%
		foreign	-9.2%

			without VA	with VA
Risk-free interest rate *(change in percentage points)*	DKK	1y	0.0%	0.1%
		10y	0.3%	0.4%
	EUR	1y	0.0%	0.2%
		10y	0.5%	0.6%
	USD	1y	-1.9%	-1.7%
		10y	0.1%	0.3%
	GBP	1y	-2.4%	-2.1%
		10y	0.1%	0.5%

Sovereign bond spreads *(change in percentage points)*	Denmark	1.1%
	Finland	1.0%
	France	0.7%
	Germany	0.4%
	Italy	2.0%
	Norway	1.1%
	Spain	1.0%
	Sweden	1.0%
	United Kingdom	1.0%
	United States	0.0%
	Emerging and developing economies	1.5%

			AAA	AA	A	BBB	BB	B and lower	Unrated
Corporate bond spreads *(change in percentage points)*	financials	covered bonds, domestic	0.8%	1,0%	1.2%	1.5%	2.0%	2.8%	2.0%
		covered bonds, foreign	0.4%	0.6%	0.9%	1.3%	2.0%	2.8%	2.0%
		other bonds, domestic	1.0%	1.2%	1.5%	1.8%	2.2%	3,0%	2.2%
		other bonds, foreign	0.5%	0.8%	1.1%	1.6%	2.2%	3,0%	2.2%
	non-financials		0.4%	0.6%	0.9%	1.3%	2.0%	2.8%	2.0%
Structured finance			0.4%	0.6%	0.9%	1.3%	2.0%	2.8%	2.0%

Notes: More details on the stressed risk-free interest rate curves can be found in Appendix IX.

Source: IMF staff.

C. Capital Standards and Modelling Assumptions

60. Solvency II was implemented in the European Union in 2016 and forms the basis for the insurance stress test. [28] As a general principle of Solvency II, assets and liabilities are valued mark-to-market. However, some notable deviations from the market-consistent framework are allowed for insurance liabilities, especially with regard to the discount rate which can incorporate long-term guarantee (LTG) measures and transitional measures. In the BU exercise, insurers were requested to provide data on selected balance sheet and solvency data with and without these measures, both before and after stress.

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

62. Insurance companies have a broad range of risk-mitigating mechanisms in place which the stress test aimed to make transparent. The loss-absorbing effects of technical provisions (via profit sharing) and deferred taxes were reported separately. Management actions could only be included by companies in the BU calculations as far as these were non-discretionary rules already in place at the reference date.

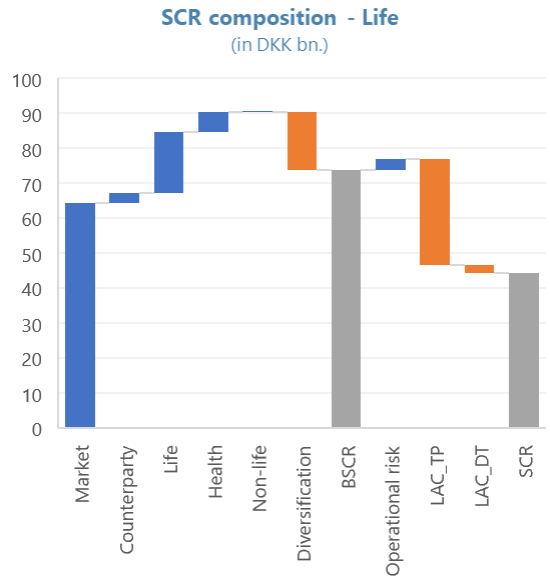
63. All participants record SCR ratios before stress well above the regulatory threshold of 100 percent. Market risks are the dominant component of insurers' solvency capital requirements, and diversification at the level of the Basic Solvency Capital Requirements (BSCR) is modest for life and pension companies, but more relevant for non-life firms. The loss-absorbing capacity of technical provisions (LAC TP), however, is very large for pension funds. Of the aggregate diversified losses represented by the BSCR, the LAC TP covers approximately 80 percent, with the remaining 20 percent—the SCR—to be covered by own funds (Figure 14).

64. Danish insurers are equipped with high-quality capital. Almost 90 percent of eligible own funds of the life companies are unrestricted Tier 1 capital, while less than 1 percent is comprised of Tier 3. Pension companies use only unrestricted Tier 1 capital instruments, and also among the non-life companies, the number of firms which have issued Tier 2 or Tier 3 instruments is very small—on aggregate, however, non-Tier 1 instruments account for almost 13 percent.

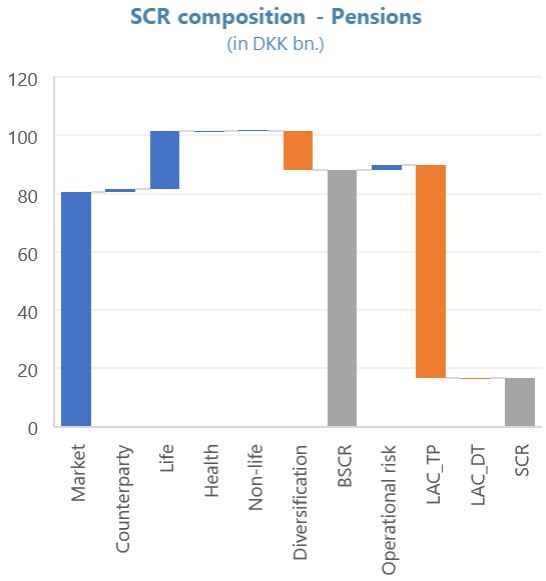
[28] Directive 2009/138/EC of the European Parliament and of the Council of 25 November 2009 on the taking-up and pursuit of the business of Insurance and Reinsurance.

Figure 14. Denmark: Solvency Capital Requirement and Own Funds

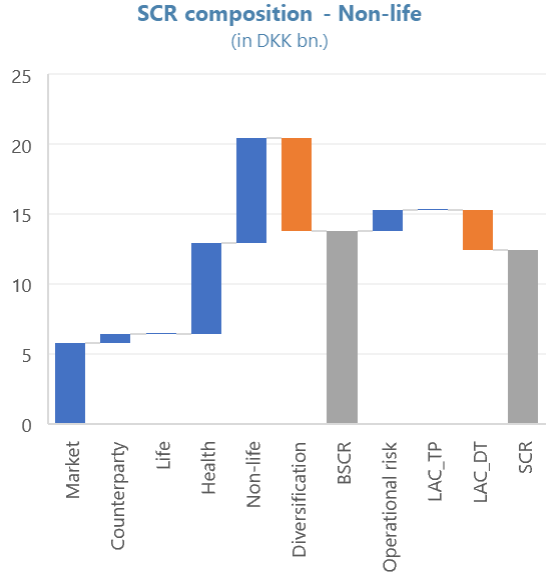
Market risk is by far the most important component of the solvency capital requirement of life insurers.



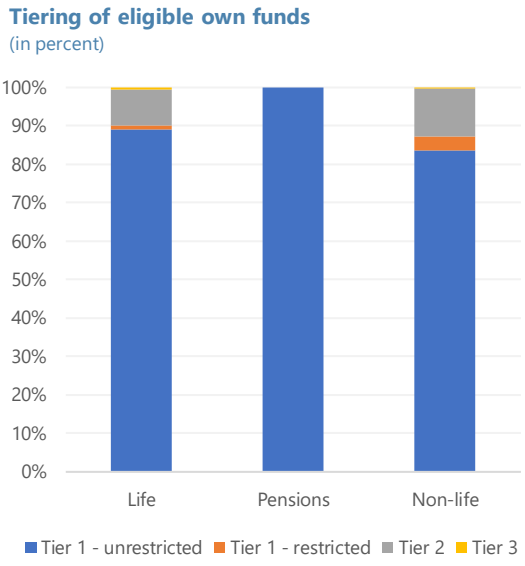
Pension funds benefit from a very large loss-absorbing capacity of technical provisions which reduce the SCR.



Market, health and non-life underwriting risks contribute almost equally to the SCR of non-life companies, resulting in a large diversification benefit.



Quality of capital is quite high with almost 92 percent being unrestricted Tier 1, and less than 1 percent Tier 3.



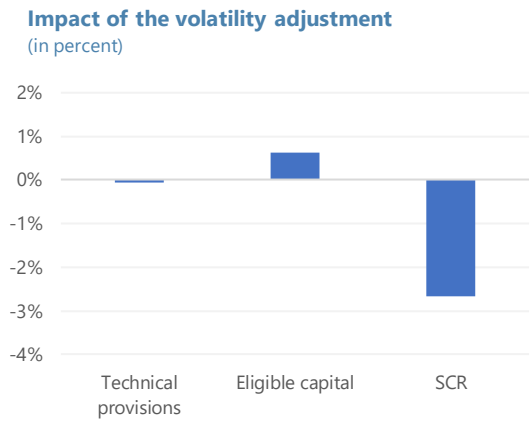
Notes: The first three panels also include SCR components of partial internal model users, but not of full internal model users.

Source: IMF staff calculations based on company submissions.

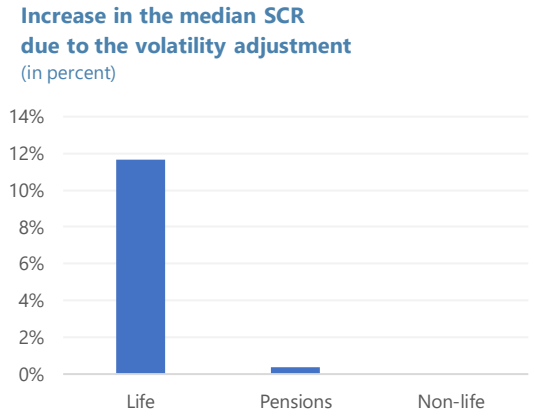
65. The Long-Term Guarantee (LTG) measures and transitionals have only a minor role in the Danish market on an aggregate level (Figure 15). Danish companies use mainly the Volatility Adjustment (VA), including 13 of the stress test companies. As the level of the VA has declined in early 2019 due to a new calculation methodology, its impact on the SCR of the stress test companies was rather limited as of mid-2019: Technical provisions are 0.1 percent lower with these measures, eligible own funds 0.6 percent higher and the SCR 2.7 percent lower. Accordingly, the median SCR ratio of the life sample increases by 12 percentage points (188 instead of 176 percent).

Figure 15. Denmark: Impact of the Volatility Adjustment

The volatility adjustment has only a limited effect on the stress test companies, reducing technical provisions by 0.1 percent and the SCR by 2.7 percent.



The SCR coverage of the median life company increases by 12 percentage points after taking into account the VA, while for pension funds and non-life insurers the impact is marginal or even non-existing.



Source: IMF staff calculations based on company submissions.

Bottom-up Stress Test

66. The methodology for the bottom-up (BU) was aligned with recent stress tests conducted by the European Insurance and Occupational Pensions Authority (EIOPA). Insurance companies participating in the stress test calculated the instantaneous impact of the scenario on their balance sheet and ultimately their solvency position on a best effort basis. Simplifications were allowed if their impact had only a marginal impact on the results. Insurers reported their balance sheet, own funds, SCR composition, impact of LTG measures and transitionals, both before and after stress.

67. Undertakings were also requested to provide a three-year projection of business development under the baseline and the adverse scenario. Key figures to be projected included gross written premiums, gross claims, lapse rates, investment returns, net earnings, gross technical provisions, own funds, and the SCR. Projections had to be made in line with the macrofinancial scenario while the market value of investments was assumed to stay constant after the occurrence of shocks at the reference date (instantaneous shock). Therefore, any recovery in profitability, and

ultimately solvency, would be driven solely by the underwriting business and recurring investment income from interest, dividends and rents.

Top-down Stress Test

68. To benchmark the results of the BU stress test, an additional top-down (TD) stress test was run by the FSAP team, based on input data received from the DFSA and the companies. The Solvency II quantitative reporting templates (QRTs) were used as the main source of input:

- Balance sheet (S.02.01),
- Asset-by-asset investment holdings (S.06.02),
- Own funds (S.23.01), and
- Technical provisions (S.12.01) and cash-flow projections for the upcoming 50 years in line with the Solvency II contract boundaries (S.13.01).

69. For the TD stress test, the shocks specified in the scenario were applied to the investment assets and insurance liabilities. Haircuts in line with the adverse scenario were applied to the market value of directly held assets. A look-through was not applied, so investment fund holdings were stressed with the corresponding shocks for the underlying asset classes. Fixed-income assets were re-valued with the stressed term structure (per currency). Similarly, technical provisions (except for unit-linked business) after stress were approximated with the stressed term structure including the volatility adjustment. For unit-linked business, the decline in liabilities mirrored the market value loss of underlying assets. Derivatives, which form a large part of insurers' assets and liabilities,[29] were not modeled separately in the TD exercise as granular data on derivative positions lacks sufficient reporting quality.[30]

70. The re-calculation of the SCR after stress was limited to selected risk modules. In the market risk module, the capital charges for equity risk, spread risk and property risk were proportionately adjusted in line with the change in exposures due to the stress. Furthermore, the equity risk capital charge was corrected for the symmetric equity adjustment which changes from -1.7 to -10.0 percentage points after the fall in equity prices, that is the capital charge used for the re-calculation of the SCR is only 29 percent after stress. The capital charge for life underwritings risk and health underwriting risk was assumed to change proportionately with the technical provisions after the application of the stressed discount curve. All other components, including the capital charge for counterparty default risk, non-life underwriting risk and operational risk were assumed unchanged. For internal model users, the TD calculations including the aggregation of capital

[29] See Appendix X.

[30] The large-scale use of derivatives gives rise to concerns about liquidity risks stemming from margin calls. In an analysis published in November 2019, the DN concludes that in the event of large interest rate increases within a short period of time, the sector will need to post cash deposits of DKK 100 billion as variation margin for open derivative contracts. See http://www.nationalbanken.dk/en/publications/Pages/2019/11/Pension-companies-will-have-large-liquidity-needs-if-interest-rates-rise.aspx.

charges in the SCR calculation were made in a simplified approach broadly in line with the standard formula.

71. The broad range of risk-mitigating mechanisms that insurance companies have in place which add further complexity to a TD stress test. The loss-absorbing effects of technical provisions cannot be deduced, based on the Solvency II regulatory reporting, as it depends on management actions regarding future discretionary benefits—any such management action would however build on assumptions on how policyholders might react to changes in those benefits, in particular whether they might lapse their policies. For the stress test, it was assumed that insurance companies would cut future discretionary benefits only over a more medium term in order to limit policyholders' incentives to lapse—benefits being projected for years 5 to 8 after the reference date were assumed to be decreased by 15 percent, and by 25 percent beyond this period. The loss-absorbing capacity of deferred taxes was assumed to remain constant in the adverse scenario, which is a conservative simplification.

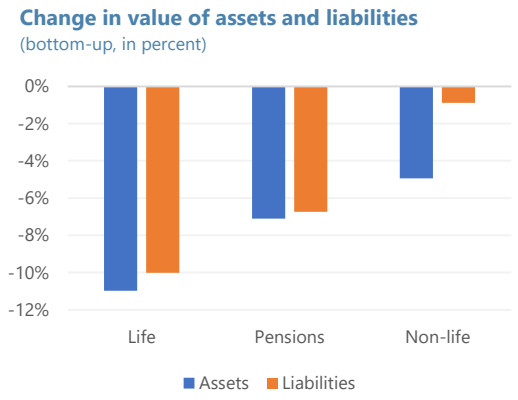
D. Results of the Scenario Analysis

72. In the pre-COVID adverse scenario life insurers' solvency position would be substantially impacted while pension funds and non-life firms perform better (Figure 16). The industry is able to withstand severe asset price shocks according to the Solvency II framework, despite vulnerabilities on the asset side. Based on the aggregate BU numbers, the value of assets declines by 11, 7 and 5 percent, in the life, pensions and non-life sub-sample, respectively. To a large extent, these losses are compensated in the life and pension sector by a decline in liabilities, stemming from higher risk-free rates and exacerbated by the assumed increase of the volatility adjustment (VA) which counterbalances excessive spikes in credit spreads which are not driven purely by a deterioration in underlying credit risks. Accordingly, the ratio of assets over liabilities declines only marginally in the life sector, from 105 to 104 percent. In the non-life sector, the ratio declines more as liabilities are less sensitive to interest rate changes, from 124 to 119 percent. The pre-COVID TD calculations broadly confirm the balance sheet impact, indicating slightly lower net asset values, which however is mainly driven by an underestimation of the mitigating impact of derivative hedging.

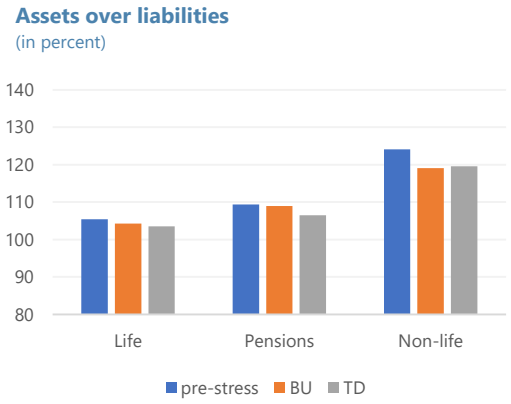
73. The pre-COVID tests indicate that, on aggregate, Danish insurers appear sufficiently capitalized after stress despite a large decline in solvency rate amongst life companies. The median solvency ratio in the life sector drops from 188 to 127 percent, while in the non-life sector the ratio declines from 233 to 207 percent. One life company drops below a solvency ratio of 100 percent, and the capital needed to restore a full coverage of solvency requirements would only be a moderate fraction of the sample's aggregate capital. Slightly counter-intuitive, the solvency ratio of the majority of pension companies rises after stress, and declines only marginally for the others. This is mainly driven by substantial product-inherent buffers related to unguaranteed products, or so called "conditional" guarantees which give some management discretion to change benefits in stressed situations. In addition, the asset allocation of the pension funds included in the sample tends to be very conservative.

Figure 16. Denmark: Insurance Stress Test Results

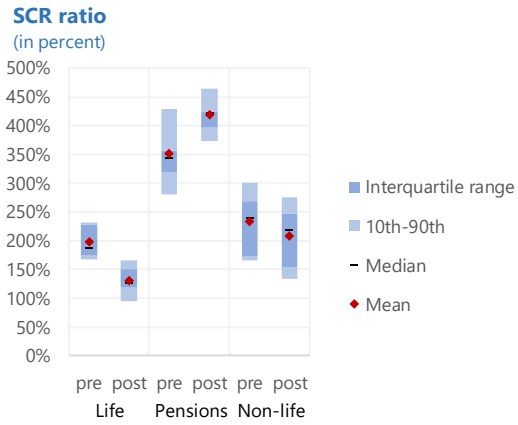
The impact of stress on asset prices is largely offset by lower liabilities, at least for life and pension companies which benefit from higher discount rates.



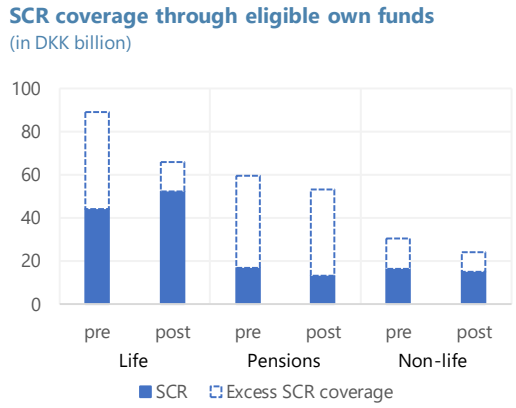
The top-down calculations broadly confirm the balance sheet impact, but tend to underestimate the mitigating impact of derivatives.



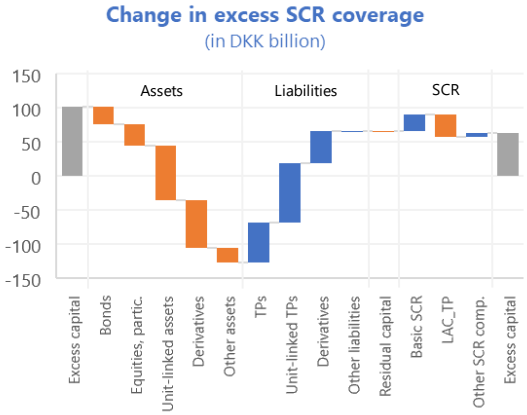
Solvency ratios decline significantly in the life sector, but even increase in the pension sector.



Life companies would see their SCR increase in the stress scenario, adding to a lower SCR coverage.



The excess SCR coverage declines due to rising spreads and falling equity prices, but benefits from lower TPs.



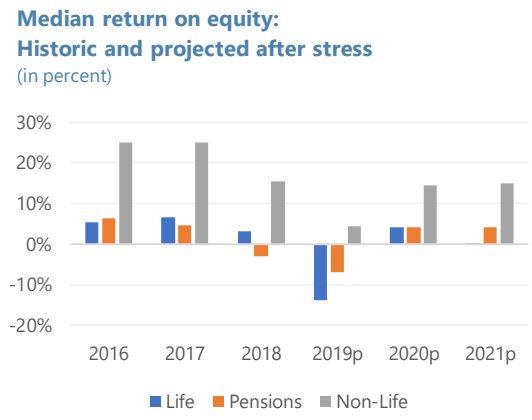
Sources: IMF staff calculations based on company submissions.

74. Most of the solvency impact can be attributed to the increase in corporate bond spreads, in particular for domestic sovereign and covered bonds. This effect is partially offset by decreasing insurance liabilities, benefiting from slightly higher discount rates. Life insurers would see their capital requirements increase as the stress reduces the loss-absorbing capacity of technical provisions substantially.

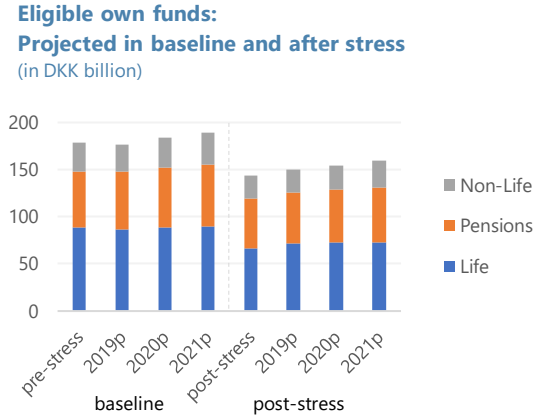
75. Over a medium-term horizon, life insurers and pension funds would face some challenges to their profitability (Figure 17). Most life insurers and pension funds included in the sample would record a negative return on equity (RoE) in the first year of the projection horizon between -5 and -25 percent. Almost all companies are expected to be back in positive terrain in the following year, although in the life and pension sector, the RoE would mostly be only in the lower single digits. Still, all sectors are able to slowly rebuild their capital after stress, most notably the non-life firms which benefit from their profitable underwriting business.

Figure 17. Denmark: Medium-Term Projections After Stress

Profitability would be severely impacted in the first year after stress, but partly recover, especially in the non-life sector.



Despite a significant drop in eligible capital right after the stress event, all sectors are able to slowly rebuild their capital, most notably the non-life firms.



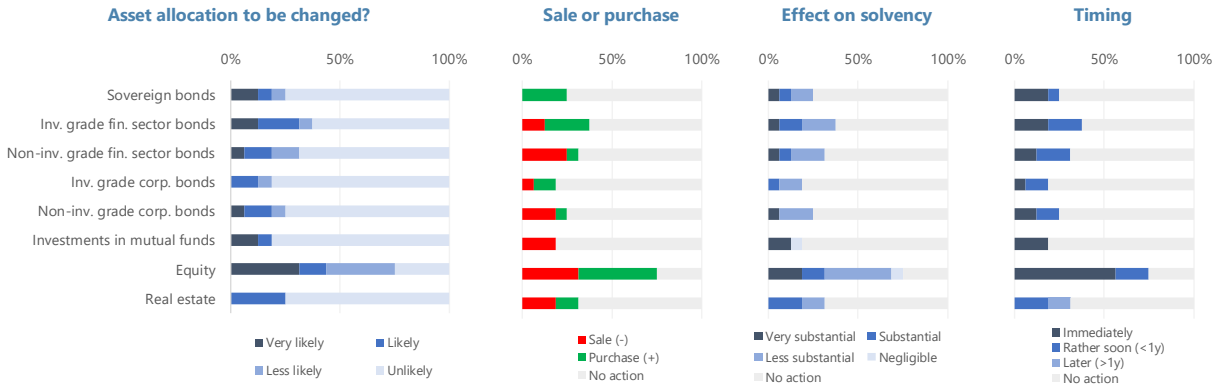
Sources: IMF staff calculations based on company submissions.

76. Overall, the insurance sector seems capable to withstand the losses simulated under the adverse scenarios without materially amplifying market risks or tightening market liquidity (Figure 18). Pre-COVID stress tests on insurance companies also focused on the sector's capacity to absorb rather than amplify the impact of macroeconomic and financial shocks. Given the size of the Danish insurance and pension sector and its critical role in providing funding for the public and the financial sector, the exercise looked at the companies' possible reactions aimed at restoring solvency and profitability after the materialization of the adverse scenario, as well as the potential negative external effects related to these. While life companies are considering some changes in their asset allocation after shock in order to reduce their capital requirement and thereby improve their solvency position, such actions would unlikely be taken in a disruptive manner, but actually spread over several weeks or even months—especially as the need for action is limited for

the large majority of undertakings. Assets likely being divested include equity and corporate bonds below investment grade, and instead investments in sovereign and covered bonds would be increased. Mitigating the overall impact on financial markets, non-life insurers would likely rebalance their portfolios and might even expand their investment in equity and property.

Figure 18. Denmark: Insurers' Management Actions

Insurers do not expect substantial changes in their asset allocation after stress. While some life insurers expect some de-risking and a switch into sovereign and mortgage bonds, a few non-life insurers would even increase their exposures to stocks and real estate.



Sources: IMF staff calculations based on company submissions.

77. ATP shows a considerable degree of resilience in the pre-COVID stress test. Its individual reserve requirement remains covered by a significant margin.[31] Close asset-liability management in the hedging portfolio—covering the guaranteed pension liabilities—almost completely offsets the declining value of bond holdings as the valuation of liabilities decreases accordingly. The bonus potential which can be distributed to beneficiaries beyond the guaranteed amount shrinks, mainly driven by higher spreads, but also the shocks to equity and participations have a material impact. The stress reduces ATP's profits, which would turn negative in the first year of the projection horizon and remain flat in the following two years assuming that asset prices would not recover.

[31] ATP is not subject to Solvency II and calculates its required capital based on a 3-months expected shortfall with a 99 percent confidence level.

Box 3. ATP

ATP was set up in 1964 as an independent institution, established by statute, to manage the Livslang Pension scheme and also to perform administrative services on behalf of external parties. The Livslang Pension is a supplement to the state-funded old-age pension. Together, they constitute the first pillar of the Danish pension system, providing basic financial security for pensioners.

ATP Livslang Pension is a mandatory scheme for all wage earners as well as the vast majority of transfer income recipients. Moreover, voluntary contributions are possible under certain circumstances. ATP has over 5.2 million members, one million of whom are pensioners receiving life-long pension from ATP. The system has reached a mature stage, so that in recent years, payouts from ATP have exceeded contributions.

Pension contributions paid to ATP are divided into guarantee contributions (80 percent) and bonus contributions (20 percent). The guarantee contributions are used for life-long, guaranteed pension benefits to ATP's members, while the bonus contributions are passed on to the bonus potential which covers ATP's risks and increases, over time, the life-long guaranteed pension in the form of bonus.

The Danish Ministry of Employment has the primary legislative authority in ATP's activity area. It is also responsible for the supervision of ATP. In addition, the DFSA supervises certain financial, managerial and pension-related matters.

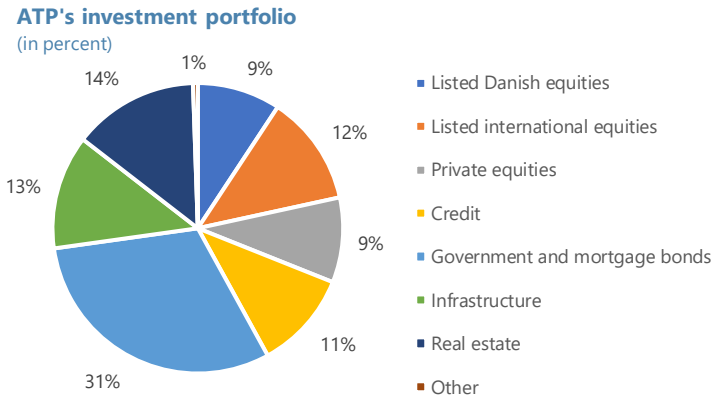
ATP's investments are divided into a hedging portfolio and an investment portfolio, reflecting the structure of the pension product:

- The objective of the hedging portfolio is to safeguard ATP's ability, at all times, to deliver on the guarantees issued. The hedging strategy is to ensure that the market value of the hedging portfolio after tax fluctuates in line with the guaranteed benefits when interest rates change.

- The principal objective of the investment portfolio is to generate a return that will allow ATP both to raise the guaranteed benefits, thereby preserving the long-term purchasing power of the pensions, and to build up reserves for unforeseen events such as increased life expectancies. The investment portfolio is managed in order to obtain a stable return that is as independent of economic cycles as possible.

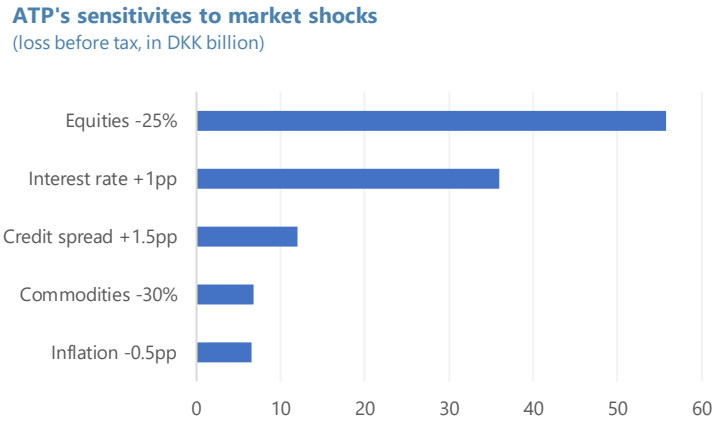
(DKK million, unless stated otherwise)	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
Contributions	9,049	9,055	9,572	9,703	9,871	10,061
Pension benefits	13,661	14,566	15,454	16,075	16,878	17,054
Investment return	116,752	6,584	60,149	15.879	24,108	107,340
Net profit	2,481	5,402	-785	17,239	-25,585	33,893
Bonus potential	95,831	101,242	100,454	117,695	92,086	125,980
Total pension provisions	704,423	705,214	759,251	768,576	785,459	885,608
Total assets	812,433	781228	869,746	893,483	906,735	1,024,472
Return before tax on pension savings returns (in percent)	23.3	1.1	10.1	2.5	3.7	16.2
Bonus rate (in percent)	15.8	16.8	15.2	18.1	13.3	16.6

Box 3. ATP (concluded)



Government and mortgage bonds are the largest single asset class in ATP's investment portfolio (31 percent), but substantial exposures exist towards less liquid assets like real estate (14 percent), infrastructure (13 percent) and private equity (9 percent).

ATP regularly discloses its sensitivities to market shocks. Most relevant is a 25 percent decline in equity prices which would cause a loss (before tax) of around DKK 55 bn. While also a 1 percentage point increase in interest rates is relevant, spread increases or changes to commodity prices and inflation are less concerning.



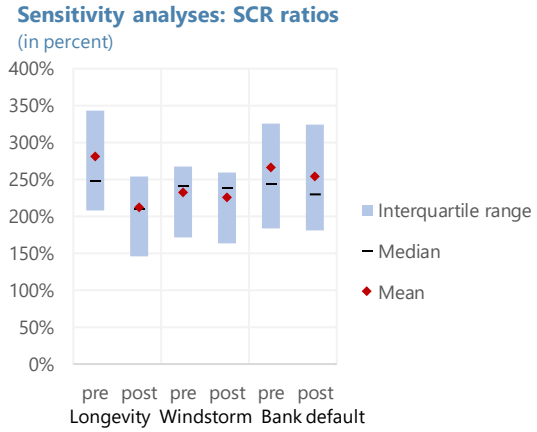
Source: ATP and IMF staff calculations.

E. Results of the Sensitivity Analyses

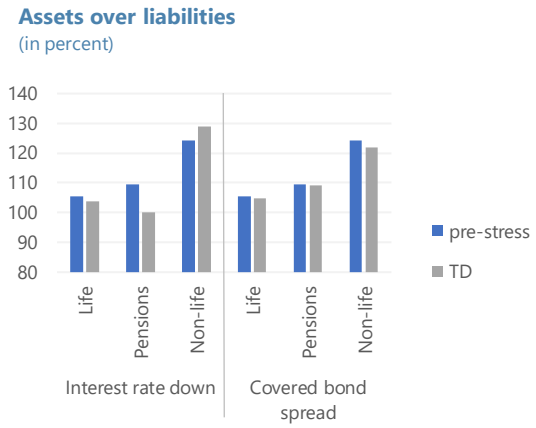
78. Sensitivity tests, conducted before the intensification of the COVID crisis, point out longevity risks and the resilience of non-life companies to single catastrophic events (Figure 19). A strong increase in life expectancy would reduce the median SCR ratio of life insurers and pension funds to 210 percent (-37 percentage points). Higher mortality rates however, including temporarily stemming from a severe epidemic (which is distinct from the COVID outbreak and was anticipated before the crisis), reduces annuity payments, while coverage for sickness pay and hospitalization are only moderate. Non-life insurers are mainly exposed to windstorms and cloudbursts, of which the latter occur more frequent, but remain very local events with moderate losses per event. A repetition of windstorm Anatol, which hit Denmark in 1999 would result in a reduction of non-life insurers' own funds of only 1 percent as risks are largely ceded to reinsurers.

Figure 19. Denmark: Sensitivity Analyses

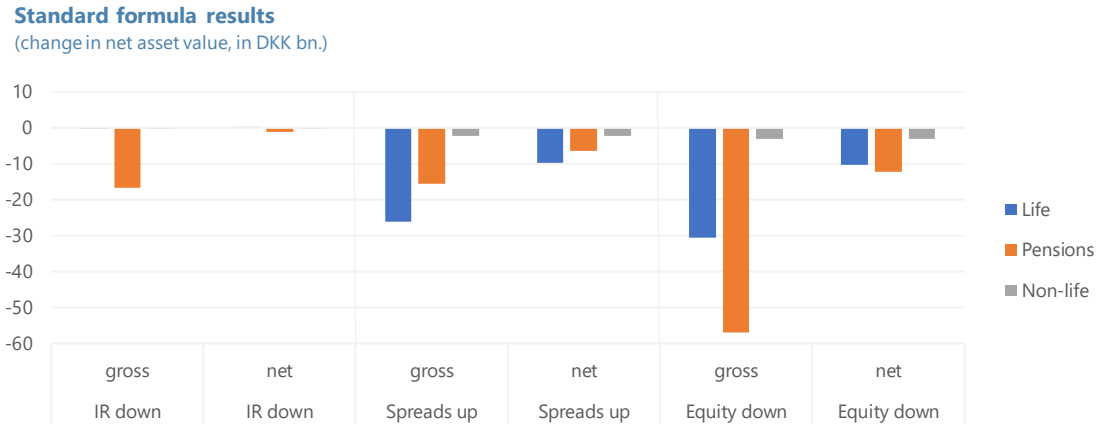
The longevity shock has a major negative impact on SCR ratios, while a severe windstorm and the default of the largest banking counterparty have only a marginal effect.



Further TD calculations reveal vulnerabilities stemming from lower interest rates (specifically for pension funds) and, to a lesser degree, from higher covered bond spreads.



The Solvency II standard formula provides insights into market risk sensitivities, both before (gross) and after (net) profit sharing with policyholders. Lower future discretionary benefits significantly reduce risks for life insurers and pension funds.



Notes: The bottom-up sensitivity analyses covered only the relevant sectors, i.e. longevity in the life and pension sectors, windstorm in the non-life sector, and the banking counterparty default in all sectors.

Sources: IMF staff calculations based on company submissions.

79. Further vulnerabilities exist related to lower interest rates, higher covered bond spreads, and stock market declines, but losses would partially be borne by policyholders. According to the TD calculation, pension funds would experience a substantial decline in their available capital after a severe downward shock to the risk-free interest rate term structure (-100 basis points parallel shift for maturities up to 20 years), with the ratio of assets over liabilities moving close to 100 percent. However, as the TD calculation underestimates the mitigating impact from derivative hedging, comparing this to the BU exercise demonstrates the importance of pension funds' interest rate hedging. A 200 basis points increase in domestic covered bond spreads would have a much smaller impact, as the effective durations of these holdings are relatively short. The

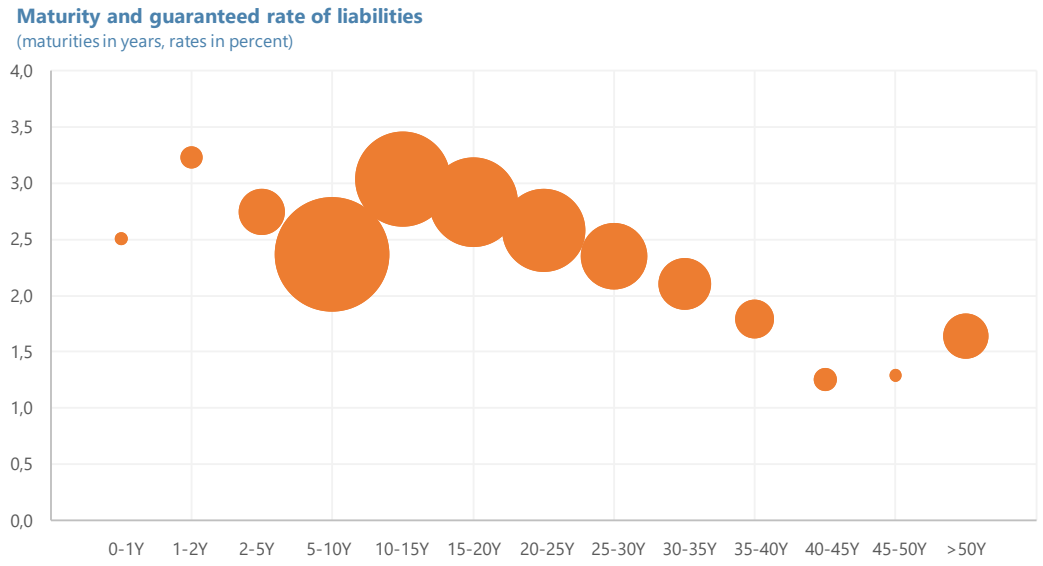
importance of risk mitigation through profit sharing, also known as the loss-absorbing capacity of technical provisions, can be seen in the companies' SCR reporting which builds on sensitivities to individual risk factors. Some of the shocks prescribed in the standard formula (value-at-risk with a 1-year horizon and a 99.5 confidence level) cause substantial declines in the net asset value, but appear much more manageable with reduced future discretionary benefits for policyholders.

F. Challenges in the Low-Yield Environment

80. Profitability in the life sector is challenged by low interest rates. Profitability has been maintained with positive returns on equity in both life and non-life insurance throughout 2009-2018. However, high guaranteed interest rates in life insurance policies continue to impede profitability, given a large (though constantly declining) legacy portfolio of contracts with high guarantees. Low interest rates and longer life expectancies have put pressure on life insurance and pension products with guarantees due to higher technical provisions required in order to ensure that companies are able to meet their guarantees. A large (though constantly declining) legacy portfolio of contracts still offers guarantees of more than 3 percent—these contracts still account for 23 percent of all life technical provisions, and many of these contracts still have remaining maturities of more than ten years (Figure 20).

Figure 20. Denmark: Guaranteed Rates in Life Insurance

For longer maturities, interest rate guarantees on life policies are continuously declining, but a sizable portion of legacy business with guarantees above 3 percent might continue to weigh on life insurers' profitability well into the 2030s.



Notes: Each bubble represents the value of net insurance liabilities and the guaranteed technical interest rate expiring in a given maturity bucket. Due to data availability, the graph only includes four life insurers.

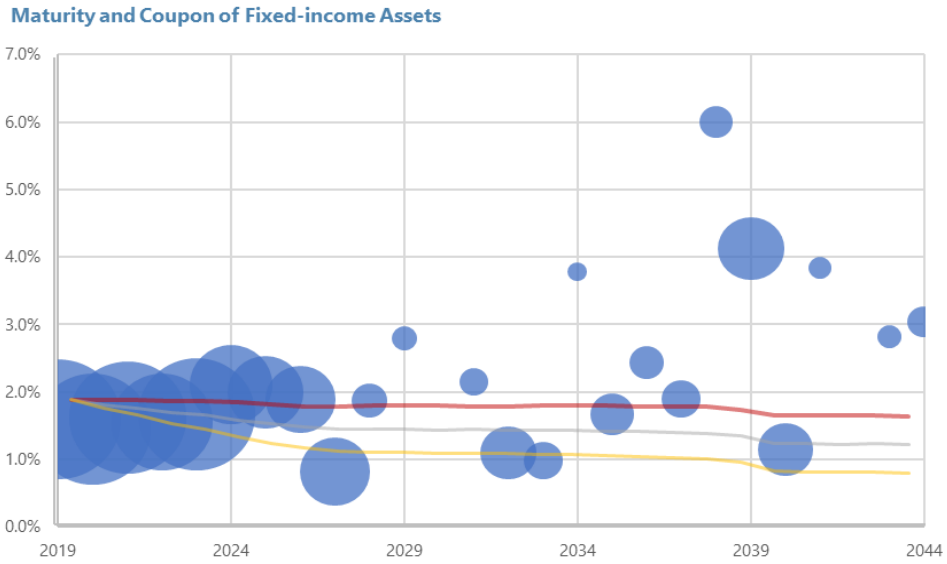
Sources: IMF staff calculations based on company submissions.

81. Over a medium-term horizon, insurers will face declining investment returns as higher-coupon bonds they hold expire (Figure 21). Danish insurers have been coping with low

interest rates already for many years which is reflected in their fixed-income investments which carry relatively low coupon rates. Bonds expiring over the next five years mostly pay coupons between 1 and 2 percent. Hence, compared to some other European peers, the reinvestment risk is moderate, but aggravates with the recent continued decline in interest rates. While insurers which are more active in non-life and unit-linked life business are less affected and could sustain the current low-yield environment for a prolonged period, companies with a high legacy stock of guarantees on their policies are likely to experience a drain on their profitability.

Figure 21. Denmark: Reinvestment Risks

With an average coupon rate already below 1.9 percent, Danish insurers have only moderate reinvestment risks compared to EU peers.



Notes: Each bubble represents the nominal value (size) and the coupon of fixed-income instruments expiring in a given year. The orange, grey and yellow lines show a projection of the average coupon, assuming that all maturing instruments are reinvested at a rate of 1.5, 1.0 and 0.5 percent, respectively.

Sources: IMF staff calculations based on company submissions.

G. Recommendations

82. The DFSA, in cooperation with Danmarks Nationalbank, is encouraged to further expand its set of regular macroprudential stress tests. The test should blend the bottom-up and top-down perspective, and results should be used to challenge companies' Own Risk and Solvency Assessments (ORSA) as well as underlying projections for future business, specifically the expectations for premium growth and investment returns.

83. The DFSA should intensify its data quality checks and enforce high-quality supervisory reporting. As a basis for the DFSA's risk analysis work, supervisory reporting should be thoroughly scrutinized, and companies should be required to re-submit corrections of misreported data without undue delay. To incentivize correct reporting, the DFSA should require at least the annual QRTs to be audited, and require audit assurance for the systems and procedures used to complete the QRTs.

CHAPTER 5. NON-FINANCIAL CORPORATE SECTOR

This chapter presents the analysis for the NFC sector based on micro-level data conducted before the onset of the pandemic. Section A is descriptive and covers developments and vulnerabilities in the NFC sector. Section B uses econometric techniques to disentangle the macroeconomic and firm-specific determinants of NFC defaults. Section C presents analysis of correlated defaults in loan portfolios.[32]

A. Recent Trends and Vulnerabilities

84. Debt levels in the non-financial corporate sector have been mostly stable in recent years while indicators of debt repayment capacity have returned to pre-global financial crisis levels. The NFC debt-to-GDP ratio in Denmark has remained stable, with a slight downward trend from 2015 to 2018, and is below the debt ratios of peer European countries. At the same time, the debt service ratio has been declining since 2013, influenced by the low level of interest rates.

85. IMF and DN staff conducted analysis using disaggregated firm-level data on Danish NFCs for the period 2003-2017. The information is collected from the Danish Central Business Register, which covers all limited companies. The register reports firm-level data on balance sheet and profit and loss statements. It categorizes firms in bankruptcy and firms that have ceased to exist due to compulsory dissolution.[33] Firm size is defined in terms of number of employees—small (<50), medium (50-249), and large (>250). Firms in the finance and insurance sectors are excluded and NFCs are categorized into 8 sectors: agriculture, building and construction, information, manufacturing and extraction, real estate, trade, transport, and other corporates (Table 5).

Table 5. Denmark: Coverage of NFCs in the Micro-level Dataset

	2009	2013	2017
Number of firms	106,470	110,858	142,106
Share of Firms (in percent)			
By size			
Small	97.5	98.1	97.9
Medium	2.1	1.6	1.7
Large	0.4	0.3	0.3
By sector			
Agriculture, forestry, and fishing	2.1	2.1	2.1
Building and construction	12.8	11.9	11.2
Information	6.5	7.3	7.7
Manufacturing and extraction	9.4	8.6	7.8
Other	29.5	32.0	34.5
Real estate	13.4	13.7	14.4
Trade	22.9	21.5	19.5
Transport	3.3	3.0	2.8

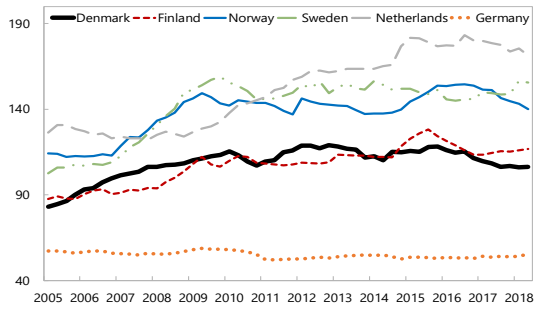
Note: Small (1-49 employees), medium (50-249 employees), large (>249 employees). Source: DN.

[32] Please note that the NFC analysis was implemented as a separate exercise—independent of the solvency tests based on macroeconomic scenarios.

[33] This can only be determined with a lag of two years.

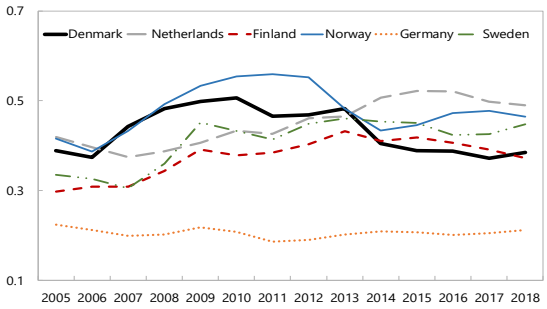
Figure 22. Denmark: Debt of Non-financial Corporations (NFCs)

Debt-to-GDP Ratio in Selected Countries (In percent)



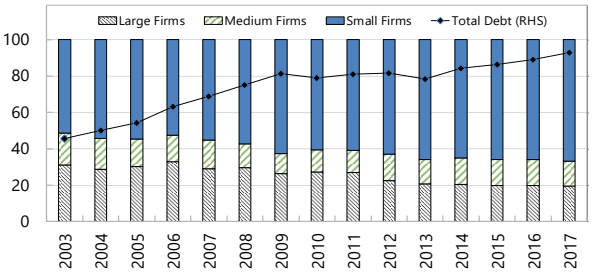
Source: BIS

Debt Service-to-Income Ratio in Selected Countries



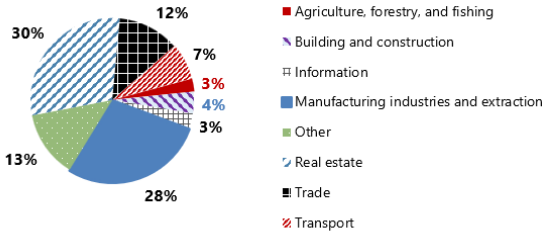
Source: BIS
Note: The debt service ratio is calculated as the debt service costs (interest payments and debt

Debt by Firm Size (Share in percent, total debt in billion DKK)



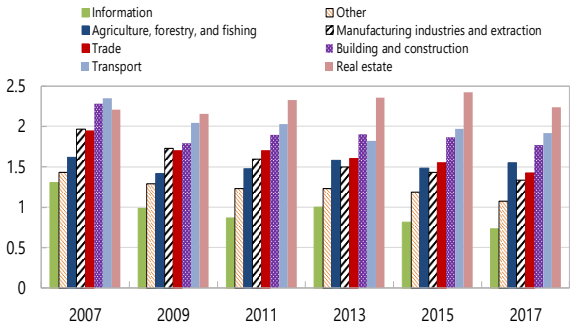
Source: Danmark Nationalbank

Debt by Sector in 2017 (Total NFC debt 1,400 billion DKK)



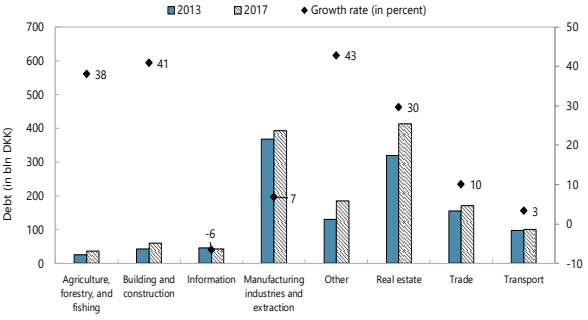
Source: Danmark Nationalbank

Debt-to-Equity Ratios, by Sector (Median, ratio)



Source: Danmark Nationalbank

Debt Growth by Sector (2013-2017) (Debt in billion DKK)



Source: Danmark Nationalbank

86. Outstanding corporate sector debt is mostly concentrated in the manufacturing and real estate sectors and increasingly in small firms. Three sectors, namely (commercial) real estate, manufacturing industries (including extraction) and trade, account for 70 percent of the total NFC debt. The share of debt concentrated in small firms has increased steadily for the past decade and is now above 60 percent of total debt. The (commercial) real estate sector is of particular interest from a risk perspective, given that it represents 30 percent of total NFC debt and that firms in this sector are highly leveraged and atomistic. Table 6 shows selected financial indicators for firms (by size). ROE ratios have rebounded across all sectors and firm size categories after the 2009 decline, but they have not returned to pre-crisis levels for small and medium firms. Meanwhile, liquidity ratios have improved across the board and debt-to-equity ratios have been declining for all firm sizes and most sectors—(commercial) real estate and transport are the sectors with the highest leverage ratios.

Table 6. Denmark: ROE, Leverage, and Liquidity of NFCs (2007-17)

By Firm Size	2007	2009	2011	2013	2015	2017
Return on equity (median, percent)						
All firms	**15.9**	**4.4**	**10.4**	**9.9**	**11.5**	**11.5**
Large firms	17.9	12.8	15.6	12.7	16.6	17.1
Medium firms	29.8	12.5	18.2	18.5	22.4	22.9
Small firms	15.3	4.1	10.1	9.7	11.2	11.1
Liquidity ratio (median, ratio)						
All firms	**1.23**	**1.19**	**1.21**	**1.23**	**1.27**	**1.32**
Large firms	1.20	1.17	1.17	1.23	1.24	1.25
Medium firms	1.25	1.26	1.29	1.33	1.37	1.36
Small firms	1.23	1.19	1.21	1.22	1.26	1.32
Debt-to-equity Ratio (median, ratio)						
All firms	**1.97**	**1.70**	**1.71**	**1.73**	**1.70**	**1.59**
Large firms	1.75	1.79	1.63	1.50	1.66	1.58
Medium firms	2.23	1.95	1.89	1.84	1.73	1.65
Small firms	1.95	1.68	1.71	1.72	1.70	1.59

Note: The definitions are as follows. Return on equity: earnings before interest and taxes (EBIT) divided by equity. Liquidity ratio (or current ratio): ratio of current assets to current liabilities—it reflects the ability of the firm to cover its short-term debt (coming due within a year or less) with its current assets. Debt-to-equity: total debt to equity, where total debt includes long- and short-term debt from all sources (including banks).

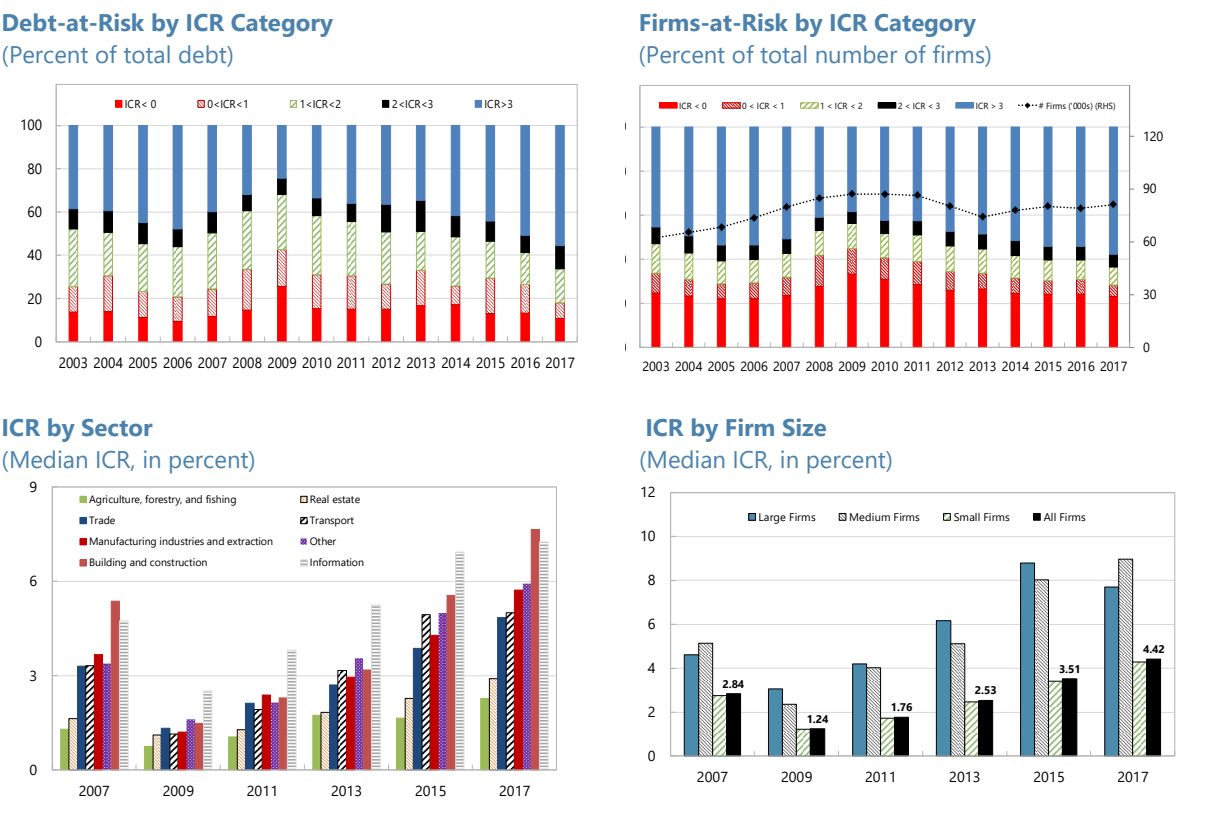
87. Measures of debt-at-risk (DaR) and firms-at-risk (FaR) based on the interest coverage ratio (ICR) show a declining vulnerability of Danish NFCs. The interest cover ratio (ICR), defined as the ratio of EBITDA to interest payments due in the same period, reflects the firm's ability to service its debt using current profits without drawing down on its financial assets. Thus, higher ICRs indicate stronger debt servicing capacity. ICR thresholds of 1.5 or 2 are typically used to identify

NFCs that are at risk of not being able to service their debts. In Denmark, NFC ICRs have gradually recovered from the low levels reached during the GFC, but the recovery has been uneven across firms by sector and size. In particular, it is worth noting that small firms still exhibit relatively low ICR levels (Figure 23), and that the 25th percentile of the ICR distribution corresponds to a small negative number—which indicates that at least 25 percent of the firms have zero or negative earnings.

88. However, firms with low ICRs hold a sizable proportion of debt. In 2017, 44 percent of outstanding debt was held by firms with ICR below 2, and 24 percent of the debt was held by firms with negative earnings. While this figure was as high as 37 percent in 2009, the proportion of firms and debt issued by firms with negative earnings remains high.

89. And debt growth points to increasing riskiness of credit allocated to the NFC sector. As noted in the AIM, mid-sized banks and MCIs have increasingly relaxed lending standards, while analysis by DN suggests that the riskiness of credit allocation in the corporate sector has been increasing since 2013. In addition, the bottom-right panel in Figure 22 shows that debt growth has been substantial in sectors with enhanced vulnerability—characterized by high leverage, small and numerous firms, and below-average interest coverage ratios (e.g. real estate).

Figure 23. Denmark: Indicators of Debt Service Capacity in the NFC Sector



Source: DN.

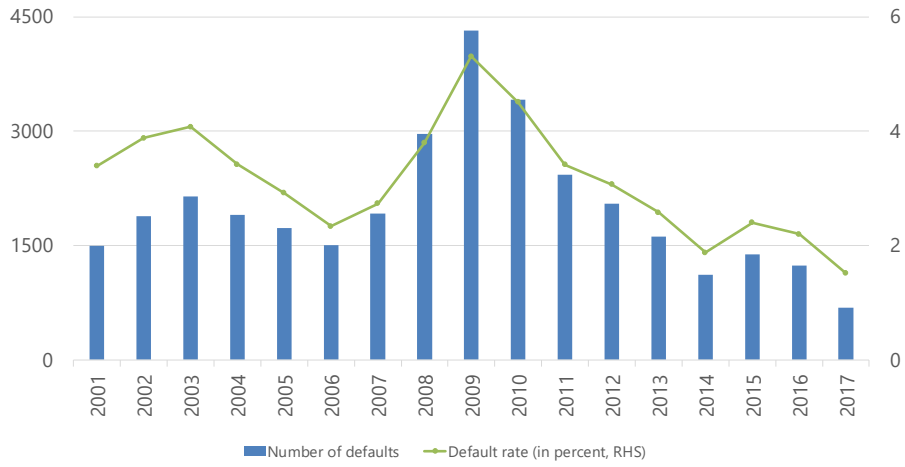
B. Empirical Analysis of Corporate Defaults

Modeling Default Probabilities with Micro Data

90. Corporate vulnerabilities could threaten financial stability by exacerbating the impact of adverse macroeconomic shocks on bankruptcies and non-performing loans, and thereby negatively impacting banks' profits and capitalization. Thus, it is imperative to understand how firm-specific and macroeconomic factors are linked to default events.

91. A glance at the data reveals that default rates of NFCs have reached historic lows, after having spiked during the GFC (Figure 24). Between 2008-2010, there was a sharp and widespread rise in the number of bankruptcies across sectors. In addition, the post-GFC downward trend reversed temporarily in 2015-16 owing to one-off steps taken by the Danish Business Authority to identify fraudulent companies and unregistered enterprises with no declared owners, and to initiate the company closures in probate court. Historical data also reveals a positive correlation between leverage (defined as the ratio of debt-to-assets) and default rates within sectors.

Figure 24. Denmark: Historical Default Rates in the NFC Sector

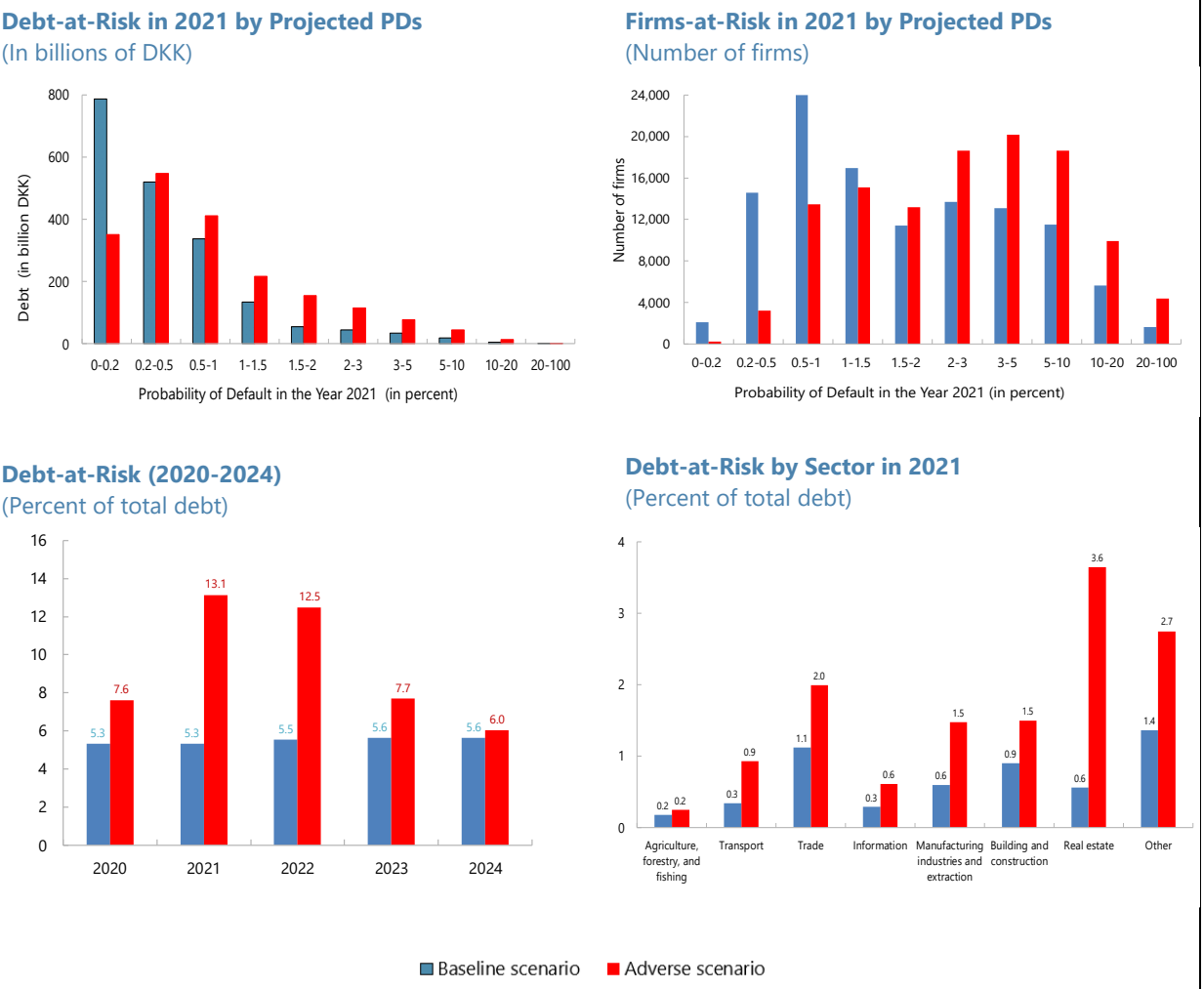


92. The authorities and the IMF team estimated default probability models using as input a granular (micro) dataset (see Appendix XI for further details). The model was used to address the following questions: (A) What is the relation between corporate debt levels and the probabilities of default (PD) of Danish firms? (B) How do tightening in macro-financial conditions (shocks) affect PDs?

93. Before the outbreak of the pandemic, the debt-at-risk of (commercial) real estate sector appears to be especially sensitive to worsening macrofinancial conditions. The team used the model to project firm- and sector-level PDs under adverse scenarios and uncovered the firms and debt amounts that are "at-risk." Debt issued by firms with projected PDs greater or equal to 2 percent was considered "at-risk." Figure 25 shows that debt-at-risk as a percentage of total NFC

debt would increase from 5.3 percent to 13.1 percent by 2022 in the pre-COVID adverse scenario. Importantly, the analysis also shows the (relative) high vulnerability of the (commercial) real estate sector, given that a six-fold jump increase is projected for this sector in the adverse scenario.

Figure 25. Denmark: Default Risk in the Non-financial Corporate Sector Under a pre-COVID Baseline[1] and the "Market Shocks" Scenario



1/ This exercise was implemented prior to the COVID-19 outbreak. The pre-COVID baseline scenario (based on October 2019 WEO projections) assumed the following growth rates for the economy: 1.9 percent in 2020, 1.7 percent in 2021, 1.6 percent in 2022, and 1.5 percent per year in 2023-24.

C. Correlated Default Analysis

94. Ignoring correlation in defaults of firms can result in underestimation of portfolio-level credit risk. The risk reduction effect of diversification in portfolios gets lower as the correlation of firm defaults increases.

95. Default correlation models were developed to separately quantify the effects of shocks to firm-specific PDs and shocks to cross-firm default correlations on credit losses at the portfolio level. The methodology consists of the following steps:

- First, default correlations are computed from 'realized' or 'historical' data on Danish firm defaults, corresponding to the period 2003-2018.[34] In particular, given I groups of firms (e.g. firms grouped by industry), we computed industry-specific default rates p_i and both within- and cross-industry default correlations ρ_{ii}^D and ρ_{ij}^D, where $i, j \ \varepsilon \{1, 2, ..., I\}$.

- Second, distributions of (number of) firm defaults in loan portfolios are generated using as input default rates and asset correlations. The values of firm assets are (ex-ante) random variables, and firm defaults are determined by distance to distress and (ex-post) realized values of firm assets. In this way, the correlation of defaults across firms can be induced by the underlying correlation in firms' assets. A numerical procedure is implemented to find the asset correlation parameters that generate default distributions with moments (average default rates and correlations) that match those observed in the historical data.

96. Simulations show that default correlation shocks affecting well diversified loan portfolios could trigger significant credit losses, even if default probabilities remain low (Figure 26). We simulate (10,000 times) the number of firms defaulting in (hypothetical) loan portfolios comprising 50 and 200 firms and obtain the distributions shown in Figure 26. The simulations were performed under three different sets of parameters: 1) firm-specific PDs and cross-firm correlation parameters matching those observed in the historical data; 2) stressed PDs (3 times the historical default rate) and historical correlation; 3) historical PDs (default rates) and stressed correlations (3 times the historical correlation).

[34] To calculate default rates and correlations from historical data, we apply the methodologies presented in studies for the U.S., including Nagpal (2001) and Moody's (2008) and Frey and McNeil (2001).

Figure 26. Denmark: Effects of PD and Default Correlation Shocks in NFC Credit Portfolios

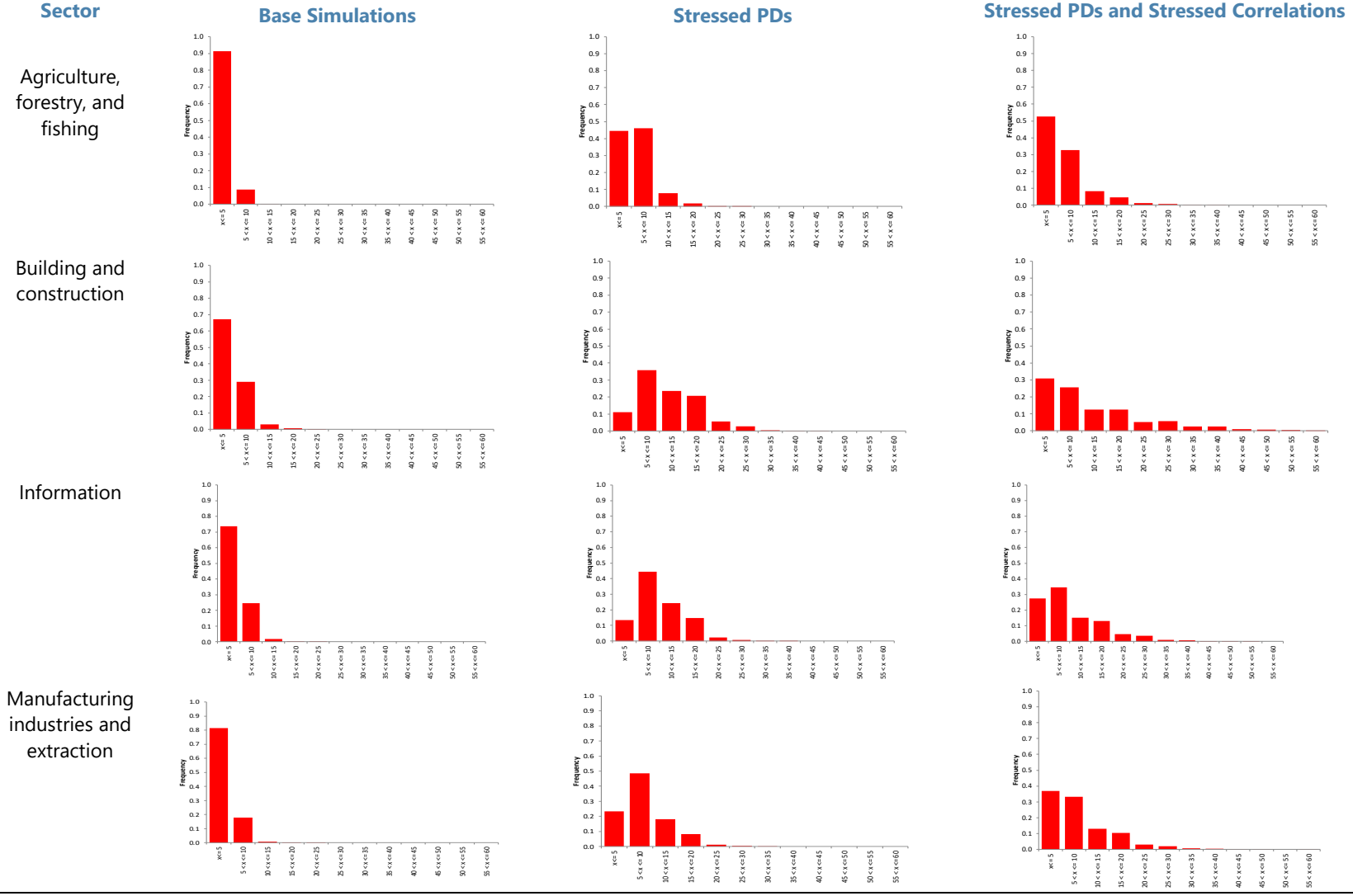
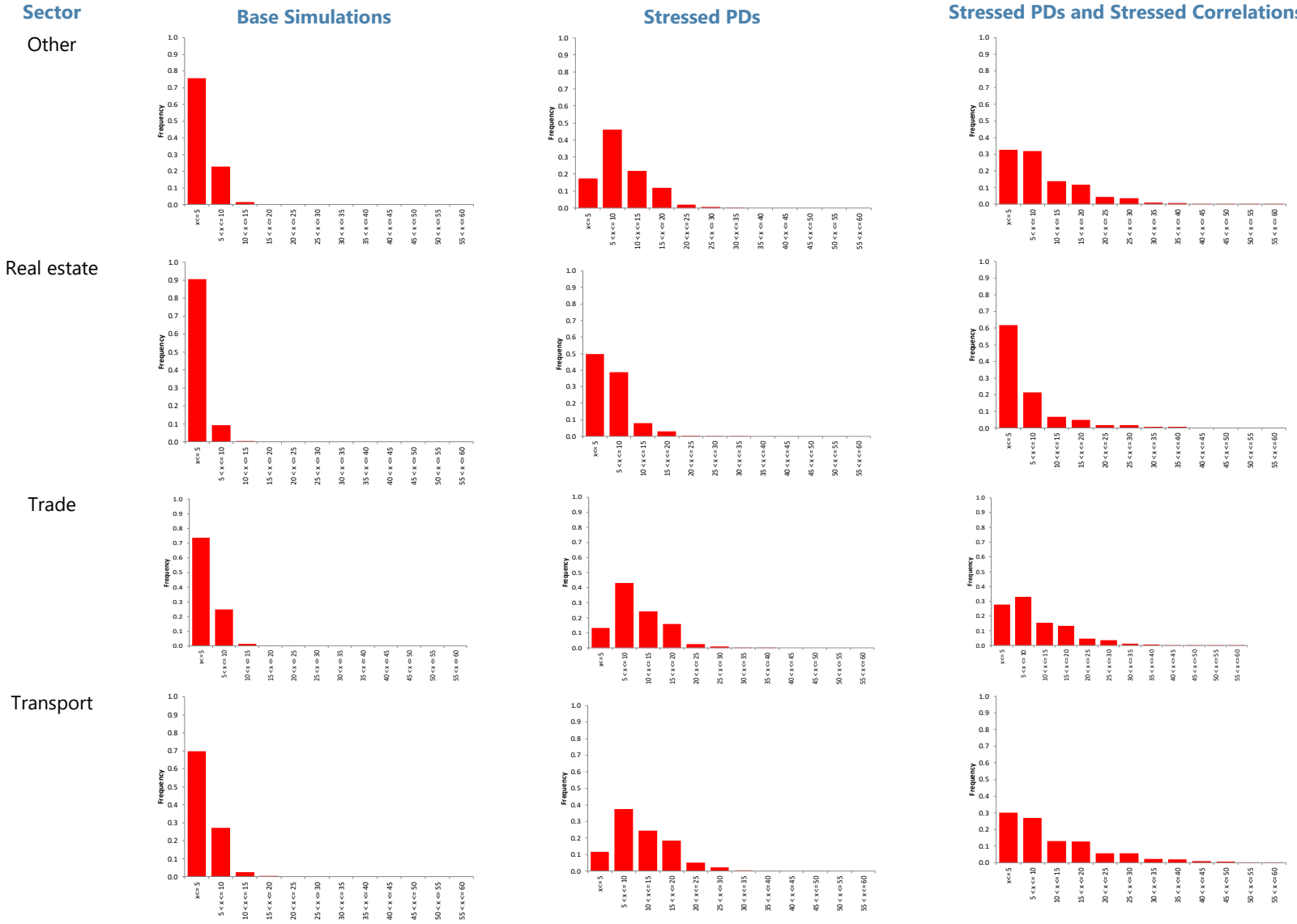


Figure 26. Denmark: Effects of PD and Default Correlation Shocks in NFC Credit Portfolios (concluded)



Appendix I. Banking Sector Stress Testing Matrix (STeM)

Domain		Top-down (IMF FSAP team, DN, DFSA)
CREDIT INSTITUTIONS: SOLVENCY RISK		
1. Institutional Perimeter	Institutions included	• 7 systemic credit institutions: Danske Bank Group, Jyske Bank Group, Nykredit Realkredit Group, Sydbank, SparNord Bank, DLR Kredit, Nordea Kredit. • 5 commercial banks (unconsolidated): Danske Bank, Nykredit Bank, Jyske Bank, Sydbank. Spar Nord Bank. • 6 mortgage credit institutions (unconsolidated): Realkredit Danmark, Nykredit Realkredit, Totalkredit, Jyske Realkredit, DLR Kredit, Nordea Kredit.
	Market share	• The 7 largest systemic credit institutions cover approximately 77 percent of the total assets for credit institutions.
	Data source and baseline date	• Data for banks: Bank-by-bank supervisory data including (i) Credit risk-sensitive exposures including loans and guarantees aggregated at sectoral level, (ii) Market risk-sensitive exposures, including sovereign and covered bond exposures at individual security level and, (iii) interest rate sensitive assets and liabilities for conducting gap analysis. • Baseline Date: 30 September 2019
2. Channels of Risk Propagation	Approach	• Balance sheet-based approach.
	Macro-financial transmission: satellite models and methodologies	Banks: Macro-financial shocks trigger losses associated with credit and market risks, and loss of net interest income. • Credit risk: Loss calculations are based on a panel regression model for logit transformed sectoral impairment rates with annual frequency. Regressors include the lagged dependent variable, unemployment rate and its first lag, GDP growth rate and its first lag, short term interest rate and its first lag. Parameter estimates account for differences in riskiness of sectors and sectoral composition of individual bank portfolios. • Market risk: Market losses from holdings of debt instruments (sovereign and other) are calculated based on full re-valuation of each individual security incorporating the impact from hedges as well. Since security level holding data cannot be shared with the IMF, the IMF provided the shocks to the yield curves for a variety of debt instruments and the DN stress testing team performed the calculations.

Domain		Top-down (IMF FSAP team, DN, DFSA)
CREDIT INSTITUTIONS: SOLVENCY RISK		
		• Net interest income: A gap analysis is conducted based on granular data on asset/liability structure of individual banks broken into types of funding sources and time to re-pricing buckets. Tested banks were approached and asked to fill in data templates prepared by the FSAP for this purpose. The gap analysis evaluates how cost of funding shocks affect net interest income, where these shocks are partially passed onto lending rates on new loans. Cost of funding shocks are defined by liability type, so funding composition affects the overall cost of funding of individual banks--those banks that rely more on wholesale funding and funding with shorter maturities suffer larger increases in funding costs during the stress period. • Pre-impairment income for banks: Income in the absence of shocks is assumed to stay at the level observed for the last 4 quarters (2018Q4-2019Q3) with the additional feature that non-performing loans will not generate any income. MCIs: As MCIs only retain some risks, in the stress tests they are affected by the following shocks: 1) materialization of credit risk; 2) materialization of market risk leading to downward repricing of securities held in capital centers for the purpose of (over-)collateralization; 3) their net interest income is adversely impacted when the MCIs must issue junior bonds to top-up collateral in capital centers-- at a negative spread vis-a-vis sovereign bonds. • Credit risk: Loss calculations are based on a time series regression for logit transformed aggregate impairment rates. This approach enables the model to differentiate between the economic sectors and accounts for the riskiness of different sectors. However, the differentiated impact of the COVID-19 shock on specific sectors is not considered. Regressors include the lagged dependent variable, GDP growth rate and its lag, unemployment rate and its lag, short-term interest rate and its lag, inflation and its lag. • Top-up collateral needs: These are calculated as follows: when housing prices (index) decline, LTV ratios rise above the (80/60 percent limits, depending on mortgage type) and MCIs must issue bonds to buy and place sovereign securities in the capital centers--thus reducing the LTV again to the LTV thresholds. This issuance and purchase of bonds with different yields causes a decline in net interest income. • Market risk: same as banks.

Domain		Top-down (IMF FSAP team, DN, DFSA)
CREDIT INSTITUTIONS: SOLVENCY RISK		
		Credit growth: Assumed to grow with the nominal GDP growth rate, floored at 0.
	Stress test horizon	• Five years (2020–2024)
3. Tail shocks	Scenario analysis	• Scenario based tests assess the impact of shocks on the entire portfolio of assets, including those placed in the banking and trading books. COVID central scenario: • Reflects the deterioration in the economic outlook over the recent period, and envisages a sharp fall in GDP of 8 percent in 2020, followed by a rebound of 6 percent in 2021. • In this scenario, the contraction in GDP for 2020 is worse than what is projected in the IMF World-Economic-Outlook (WEO) for April. • The COVID central scenario results in a cumulative decline of real GDP relative to the September 2019 WEO projections equivalent to 1.8 standard deviations (6.1 percentage points) over two years. • Unemployment goes up to 6.8 percent in 2020 followed by a gradual recovery reaching 5.6 percent in 2023. • The materialization of credit risk (which is predominantly influenced by GDP growth and the unemployment rate) is the main driver of the losses. That said, the scenario also introduces cost of funding shocks for 2020 based on what has been observed in the markets at this juncture (30 basis points for interbank lending and riskier debt securities and 15 basis points for covered bonds and repos)—because these shocks were considerably less severe than those assumed under the "market shocks" adverse scenario, their impact is limited in the COVID scenarios. • Yield curve shocks for market risk loss calculations are broadly in line with what has happened so far in response to the COVID induced stress. COVID prolonged scenario: • The COVID central scenario is still subject to downside risks.

Domain		Top-down (IMF FSAP team, DN, DFSA)
CREDIT INSTITUTIONS: SOLVENCY RISK		
		• To further acknowledge these looming risks, a second scenario with a more prolonged recession is considered. Instead of a rebound in 2021, the economy continues to contract by 2.1 percent before the recovery ensues in 2022. • The COVID prolonged scenario results in a cumulative decline of real GDP relative to the September 2019 WEO projections equivalent to 4 standard deviations (13.6 percentage points) over two years. • The unemployment rate peaks at 11.8 percent in 2022. • The materialization of credit risk (which is predominantly influenced by GDP growth and the unemployment rate) is the main driver of the losses. That said, the scenario also introduces cost of funding shocks for 2020 based on what has been observed in the markets at this juncture (30 basis points for interbank lending and riskier debt securities and 15 basis points for covered bonds and repos)—because these shocks were considerably less severe than those assumed under the market shocks adverse scenario, their impact is limited in the COVID scenarios. • Yield curve shocks for market risk loss calculations are broadly in line with what has happened so far in response to the COVID induced stress. Market shocks adverse scenario: • The market shocks adverse stress scenario is triggered by a series of global and domestic shocks. It is generated using as input the IMF's Flexible System of Global Models developed and maintained by the Research Department (RES). It is driven by a combination of external and domestic shocks; the domestic effects of these shocks are amplified by existing vulnerabilities. • Escalating global trade tensions and a tightening of global financial conditions are the main drivers which depress business and consumer confidence, generating downturns in advanced and EM economies. • Abrupt decompression of risk asset premia particularly impacts the "high spread economies" in Europe and are reflected in higher money market interest rates, banks' cost of short-term funding, and long-term government bond yields. • Housing prices decline by 18 percent over three years, with an adverse impact on domestic consumption and residential investment.

Domain		Top-down (IMF FSAP team, DN, DFSA)
CREDIT INSTITUTIONS: SOLVENCY RISK		
		• Funding comes under pressure as heavy reliance on wholesale funding by Danish banks and MCIs make them vulnerable to market turmoil. Overall cost of funding increases by 100 basis points, with partial pass-through to lending rates. • The scenario assumes that the exchange rate regime remains credible despite domestic and international stress. • The adverse scenario results in a cumulative decline of real GDP relative to the October 2019 WEO projections equivalent to 2.5 standard deviations (8.6 percentage points) over two years.
	Behavioral Adjustments	• Balance sheet Assumptions: Balance sheets are assumed to be quasi-static—the rate of loan growth and funding growth are tied to nominal GDP growth. • Asset disposal and acquisition is not permitted. • External capital injections are not permitted. • Non-performing loans are not permitted to generate interest income. • Banks are assumed to make dividend pay-outs of 40 percent for periods with positive net income and no pay-outs in case of negative income. • Banks are assumed to pay the same tax rate calibrated as the average of tax rate for the five large banks during the last four quarters. Same calibration exercise is undertaken for the MCIs as well.
	Sensitivity analysis	• Sensitivity analysis evaluates the impact of shocks to single risk factors in a static manner. • Simultaneous default of 3, 5, and 10 largest single exposures with several LGD assumptions. • A significant increase to the RWAs as a result of Basel-III output floors.
4. Regulatory and Market-Based Standards and Parameters	Calibration of risk parameters	• Credit risk – Expected Losses: Based on availability of data, credit risk satellite model projects future impairment rates. Using, Frye-Jacobs LGD function, we split the impairment rate projections into Point-in-time PD and LGD parameters such that PD*LGD = Impairment rate projection. • Credit risk- RWAs: We convert the shocks to the PIT PD parameters to through-the-cycle (TTC) PD parameters for projection of RWAs.

Domain		Top-down (IMF FSAP team, DN, DFSA)
CREDIT INSTITUTIONS: SOLVENCY RISK		
		• Market risk: Yields for sovereign and corporate bonds were determined based on historical statistical relationships with the other variables available in the scenario.
	Regulatory/Accounting and Market-Based Standards	• Capital definition according to the national implementation by DFSA. Data on combined CET1, including the CCB, SIFI, pillar II and CCyB buffers are available from DFSA for 2020 Q1. • RWA behave dynamically according to changes in credit risk parameters.
5. Reporting Format for Results	Output presentation	• Evolution of CET1 capitalization ratios for the consolidated banking groups. • Decomposition of the reduction in CET1 capital ratio in terms of drivers (credit risk, market risk, interest rate risk).

Domain		Assumptions	
		Bottom-Up by Insurance Undertakings	Top-Down by IMF and authorities
INSURANCE SECTOR: SOLVENCY RISK			
1. Institutional perimeter	Institutions included	• 5 life insurers: AP Pension, Danica Pension, PFA Pension, TopDanmark Livsforsikring, Velliv • 6 occupational pension funds: PenSam Liv, PK Farmakonomer, PK Socialrådgivere, PK Sundhedsfaglige, PK Sygeplejersker, Sampension • 5 non-life insurers: Alm. Brand Forsikring, Codan Forsikring, Lærerstandens Brandforsikring, TopDanmark Forsikring, Tryg Forsikring • 1 pension fund: ATP	• 5 life insurers: AP Pension, Danica, PFA Pension, Top Liv, Velliv • 6 occupational pension funds: PenSam, PK Farmakonomer, PK Socialrådgivere, PK Sundhedsfaglige, PK Sygeplejersker, Sampension • 5 non-life insurers: AlmBrand, Codan, Lærerstandens Brandforsikring, TopDanmark, Tryg
	Market share	• Life and occupational pension funds: >70 percent of total balance sheet assets • Non-life: >70 percent of total balance sheet assets	• Life and occupational pension funds: >70 percent of total balance sheet assets • Non-life: >70 percent of total balance sheet assets
	Consolidation	• Solo level	• Solo level
	Data	• Regulatory reporting	• Regulatory reporting
	Reference date	• June 30, 2019	• June 30, 2019
2. Channels of risk propagation	Methodology	• Investment assets: market value changes after price shocks, affecting the solvency position • Sensitivity analysis: effect on available capital and solvency position	• Investment assets: market value changes after price shocks, affecting the solvency position
	Time horizon	• Instantaneous shock • 3-year projection (in the baseline and the adverse scenario)	• Instantaneous shock
3. Tail shocks	Scenario analysis	• Adverse scenario: risk-free interest rates (without volatility adjustment) +/-0 bps (1y DKK), +25 bps (10y DKK); sovereign bond spread +110 bps (Denmark), +40 bps for AAA-rated euro area countries, up to +250 bps for high-yield euro area countries; stock prices -26.5 percent (domestic), -20 percent (other advanced economies), -25 percent (emerging and developing economies);	• Adverse scenario: risk-free interest rates (without volatility adjustment) +/-0 bps (1y DKK), +25 bps (10y DKK); sovereign bond spread +110 bps (Denmark), +40 bps for AAA-rated euro area countries, up to +250 bps for high-yield euro area countries; stock prices -26.5 percent (domestic), -20 percent (other advanced economies), -25 percent (emerging and developing economies);

Domain		Assumptions	
		Bottom-Up by Insurance Undertakings	Bottom-Up by Insurance Undertakings
		property prices -22 percent (domestic residential), -26.4 percent (domestic commercial), -7.7 and -9.2 percent (other countries, residential and commercial, respectively); domestic corporate bond spreads (financials) between +100 bps (AAA) and +300 bps (B and lower); domestic covered bond spreads +80 bps (AAA); foreign corporate bond spreads (financials) between +50 bps (AAA) and +300 bps (B and lower)	property prices -22 percent (domestic residential), -26.4 percent (domestic commercial), -7.7 and -9.2 percent (other countries, residential and commercial, respectively); domestic corporate bond spreads (financials) between +100 bps (AAA) and +300 bps (B and lower); domestic covered bond spreads +80 bps (AAA); foreign corporate bond spreads (financials) between +50 bps (AAA) and +300 bps (B and lower)
	Sensitivity analysis	• Longevity shock (life and pensions only): permanent 25 percent decline in mortality rates • Mortality shock (life and pensions only): permanent 15 increase in mortality rates • Pandemic event (life and pensions only): temporary 35 percent increase in disability/morbidity rates, temporary 10 percent increase in mortality rates • Mass lapse event (life only): 20 percent lapse rate in contracts where the discontinuance of the contract results in a loss for the insurer • Catastrophic events (non-life only): repetition of Windstorm Anatol (December 1999) based on today's exposures • Default of largest banking counterparty	• Lower interest rate term structure: -100 bps parallel shift (for all currencies) • Spread shock to domestic covered bonds: +250 bps
4. Risks and buffers	Risks/factors assessed	• Market risks: interest rates, share prices, property prices, credit spreads • Underwriting risks: longevity, mortality, pandemic event, catastrophic events • Summation of risks, no diversification effects	• Market risks: interest rates, share prices, property prices, credit spreads • Credit risks: default of largest financial counterparty • Summation of risks, no diversification effects
	Buffers	• Product-specific	• Loss-absorption capacity stemming from policyholder participation
	Behavioral adjustments	• Management actions limited to non-discretionary rules in place at the reference date	• None
5. Regulatory standards and parameters	Regulatory/ accounting standards	• Solvency II • National GAAP	• Solvency II • National GAAP
6. Reporting format for results	Output presentation	• Impact on solvency ratios (including and excluding the effect of long-term guarantee measures) • Impact on net income • Contribution of individual shocks • Dispersion measures of solvency ratios and net income • Survey-based reactions and management actions of insurers after stress	• Impact on solvency ratios (including and excluding the effect of long-term guarantee measures) • Contribution of individual shocks • Dispersion measures of solvency ratios and net income

Appendix III. Risk Assessment Matrix

Source of Risk	Overall Level of Concern	
	Relative Likelihood	Expected Impact on Financial Stability if Risk is Realized
1. Sharp rise in risk premia	**High**	An abrupt deterioration in market sentiment (prompted by policy surprises, renewed stresses in emerging markets, concerns about debt levels in euro area countries or, for example, a disorderly Brexit) could trigger risk-off events such as recognition of underpriced risk especially after a prolonged period of low interest rates and stretched asset valuations. A protracted and correlated decline in asset prices would adversely affect the internationally exposed portfolios of insurance companies and pension funds, erode household wealth, and weight on consumption growth. A decline in consumption would set in motion an adverse macrofinancial feedback loop whereby weaker domestic demand and growth bring about further declines in asset prices. These second-round effects are likely to be significant given the high degree of domestic interconnectedness and household indebtedness. At the same time, international investors could retrench from the Danish covered bond market, raising funding costs and creating (re-) financing problems, especially for MCIs.
2. Weaker-than-expected global growth	**High**	A relapse of growth in major advanced economies, including Germany, or a significant slowdown in China could have a sustained negative impact on Danish exports, investment, consumption, and growth. These risks would be exacerbated by rising trade tensions as Denmark is a small open economy with many sectors—including shipping—deeply integrated in global value chains. A disorderly Brexit would further undermine confidence and put pressure on UK-exposed sectors including machinery and agriculture. Corporate-sector losses would be accompanied by rising unemployment, NPLs, and loan loss impairments weighing on bank profitability. An ensuing credit crunch combined with a reduction of consumption by households facing debt servicing strains would amplify the impact of the initial shock.

Source of Risk	Overall Level of Concern	
	Relative Likelihood	Expected Impact on Financial Stability if Risk is Realized
3. Financial shocks originating in the Nordic-Baltic region	**Medium**	Protracted bouts of market volatility, tighter regional financial conditions, or a correction in real estate markets in other Nordic countries would trigger losses for major Danish SIFIs, given their presence in those countries through large MCI subsidiaries. The effects of such shock would be amplified if, due to stress in Finland, the large branch of a Nordic SIFI deleverages by curtailing credit in Denmark. More generally, interlinkages with other Nordic and Baltic countries would amplify the effects of global trade and financial shocks on the Danish economy. Second-round effects would stem from tight regional trade ties and financial interlinkages, including cross-holdings of covered bonds. Although these adverse impacts could be partially mitigated by safe-haven flows, ongoing (regional) ML cases have increased financial system fragility. Likewise, larger-than-anticipated ML-related fines levied by foreign authorities could disrupt the capacity of banking groups to conduct business as usual and a narrower scope of business would adversely affect their profitability.
4. Prolonged downturn in the domestic real estate market	**Medium**	The shock could be triggered by a reassessment of fundamentals whereby a decline in real estate prices would drag down the value of other asset classes, dampening consumption and investment (especially across leveraged households and non-diversified real estate developers), thereby increasing unemployment. The combination of valuation losses, higher NPLs and impairment losses, and credit rationing could set in motion a vicious cycle, whereby tighter financial conditions and depressed economic activity amplify the impact of the initial shock further.

Appendix IV. Banks: Satellite Models and Methodologies for Profit Projections

Credit Loss Projections

A model of LLRs (impairment rates) was estimated for 9 sectors using historical data from 1992 to 2018.[1] The dynamic panel was specified as follows:

$$logit(ImpRate_{t,i}) = \alpha_i + \gamma \times logit(ImpRate_{t-1,i}) + \beta \times M_t + \varepsilon_{i,t}$$

where i and t indicate, respectively, the sector and the time period. The impairment rate (*ImpRate*) is measured as the ratio of impairment charges (flow) to total loans and guarantees.[2] The parameter α_i is the sector-specific fixed effect and M_t is a vector of macroeconomic factors. More specifically, we use both the contemporaneous and the first lag of GDP growth rate, unemployment rate and a short-term deposit rate. Although the slope coefficients vector β is the same for all the sectors, it is important to note that the logit transform on the dependent variable incorporates a non-linearity and implies that each sector responds differently to shocks. The inclusion of the lagged dependent variable incorporates the impact of starting point. For example, a sector entering stress with already high impairment rates such as the agriculture suffers a lot more losses as observed in historical data.

The estimated coefficients, except for the sector-specific intercepts, are presented below:

Explanatory valiable	Coefficent
Impairment rate (logit transform, 1 year lag)	0.193
Unemployment Rate	-0.060
Real GDP growth rate	-0.321
Short-Term deposit rate	-0.050
Unemployment Rate (1 year lag)	0.292
Real GDP growth rate (1 year lag)	-0.094
Short-Term deposit rate (1 year lag)	0.118

Two adjustments were applied to the estimated model before using it to make LLR projections. The first adjustment shifts the sector-specific intercepts to better represent the sample of banks included in the tests. The second refinement relates to the bank level use of lagged dependent variable in the model's implementation.

[1] The 9 sectors used in model estimation are (1) agriculture, (2) Manufacturing industries, (3) Building and construction, (4) Trade, (5) Transportation, (6) Finance and insurance, (7) Real estate (8) Other corporates, (9) Households.

[2] In rare instances, observed flows of impairment charges can be negative—when the economy is strong, certain banks may consider that they have over-provisioned and decide to reduce their existing stock of provisions. Since the logit transformation doesn't exist for negative values, negative observations were floored at a small positive value.

- Intercept adjustment: The model is estimated with aggregate country level sectoral data because it was available from 1992 and covers historical downturns. Similar data was available at the at the bank and industry level granularity but only after 2010. In order to obtain sufficiently macro-sensitive coefficients, we worked with the more aggregated data that covers past downturns. The disadvantage of this choice was that the data and therefore the model are not truly representative of the banks participating in the stress tests. In order to address this shortcoming, we fixed the macro-factor coefficients as estimated from the sectoral level model and calibrated new fixed effect intercepts using the bank and industry level more granular data that starts after 2010. The re-calibration of sector-specific intercepts is conducted following the below formula:

$$\alpha_i = \left(\sum_{t=2011}^{2018} logit(ImpRate_{t,i,j}) - \gamma \times logit(ImpRate_{t-1,i,j}) + \beta \times M_t \right) /8$$

where subscript j denotes the group of banks included in the stress testing exercise and $ImpRate_{t,i,j}$ denotes the realized average impairment rate for these banks.

- Lagged dependent variable at the starting point: In addition to the intercept adjustment, we also use the bank specific starting points for the lagged dependent variable in implementation of the model while making scenario-dependent projections. In other words, to project future impairment rates for a specific bank and industry, we use the last year's impairment rate for that same bank and industry. This treatment further enhances the representativeness of the model for the banks subject to stress testing.

Obtaining Stressed PDs and LGDs:

The satellite model described above produces stressed impairment rate projections but not stressed PD and/or stressed LGD. This would preclude the calculation of stressed NPLs since flow of new NPLs are dependent on the stressed PD. The calculation of NPLs is an important piece of stress testing since they are not supposed to produce interest income. For these reasons, we needed to produce stressed PD and LGD projections from the stressed impairment rate projections. First of all, the impairment rate can be loosely interpreted as PD*LGD, but this gives us only one equation. To solve for two unknowns, we need a second condition. We use the Frye-Jacobs (FJ) LGD function as our second condition. The FJ-LGD function connects the conditional LGD rate (cLGD) to the conditional PD (cPD), as follows:[3]

$$cLGD = \Phi[\Phi^{-1}[cPD] - k]/cPD, \text{ where } k = \Phi^{-1}[PD] - \Phi^{-1}[PD \times LGD]$$

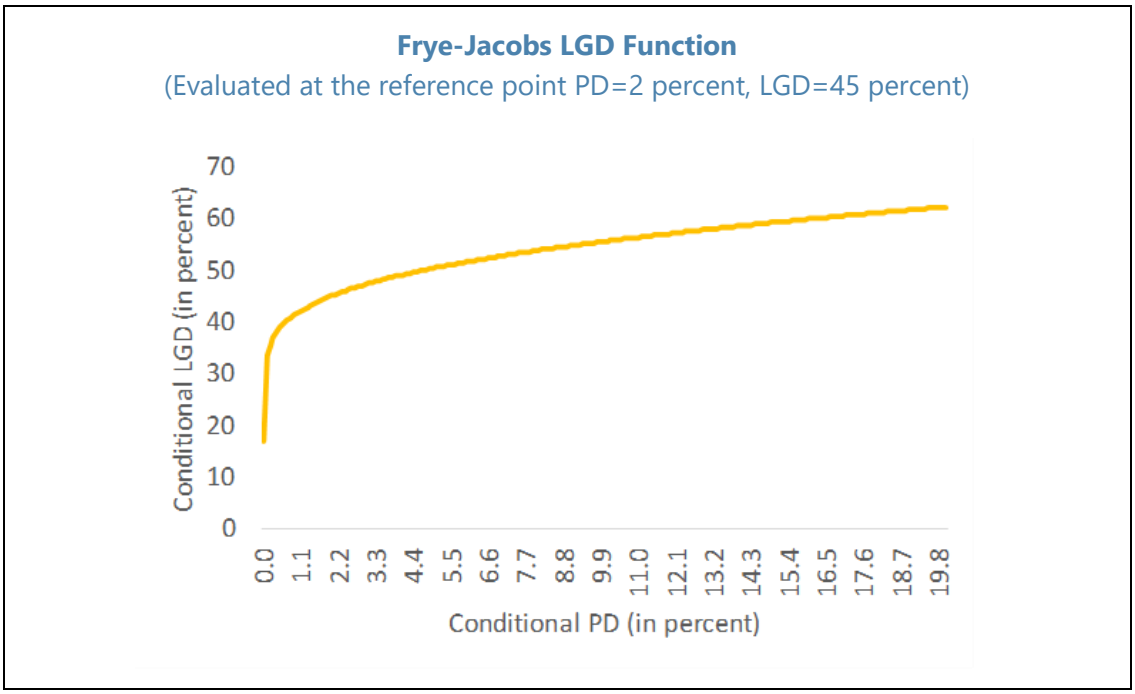
Please note that the cPD and cLGD denotes PD and LGD conditional on the stress scenario whereas the PD and LGD denotes unconditional PD and LGD. For these latter parameters, we use the regulatory through-the-cycle PD and LGDs at the firm and industry level.

[3] Note that the original formula also includes an asset correlation parameter which we set to zero, as recommended by Frye and Jacobs (2012) for stress testing purposes. According to public disclosures of the Federal Reserve system, LGDs in DFAST stress testing exercises are calculated with the FJ formula with a correlation parameter equal to zero.

Solving the two equations with two unknowns, one obtains the following:

$cPD = \Phi[\Phi^{-1}[Imp.rate] + k]$ where $k = \Phi^{-1}[PD] - \Phi^{-1}[PD \times LGD]$ and

$cLGD = ImpRate/cPD$.



Appendix V. Contributions to Changes in Capital—Adverse Scenarios

Let CAR denote the CET1 capital adequacy ratio. Changes over time in the capital adequacy ratio $\mathrm{CAR} = \frac{\mathrm{Capital}}{\mathrm{RWA}}$ can be expressed as follows:

$$\Delta\mathrm{CAR}_{t+1} = \mathrm{CAR}_{t+1} - \mathrm{CAR}_t = \frac{\Delta\mathrm{Capital}_{t+1}}{\mathrm{RWA}_t} - \frac{\Delta\mathrm{RWA}_{t+1}\cdot\mathrm{CAR}_t}{\mathrm{RWA}_{t+1}} - \frac{\Delta\mathrm{Capital}_{t+1}\cdot\Delta\mathrm{RWA}_{t+1}}{\mathrm{RWA}_t\cdot\mathrm{RWA}_{t+1}}.$$

In this expression, the first term on the right indicates the (partial) contribution of changes in capital (numerator) to the change in the CAR ratio. Similarly, the second term is the contribution of changes in RWA (denominator) to the change in the CAR ratio. The third term captures the (joint) contribution of changes in RWA and capital to changes in the CAR ratio. This third term is generally much smaller in size compared to the first two and can be added to the contributions of RWA, capital, or both. For the construction of the decomposition chart, we add the joint effect (third term) to the contribution of changes in RWA (denominator), as follows:

$$\text{Contribution of } \Delta\text{Capital to } \Delta\text{CAR} = \frac{\Delta\mathrm{Capital}_{t+1}}{\mathrm{RWA}_t}$$

$$\text{Contribution of } \Delta\text{RWA to } \Delta\text{CAR} = -\frac{\Delta\mathrm{RWA}_{t+1}\cdot\mathrm{CAR}_t}{\mathrm{RWA}_{t+1}} - \frac{\Delta\mathrm{Capital}_{t+1}\cdot\Delta\mathrm{RWA}_{t+1}}{\mathrm{RWA}_t\cdot\mathrm{RWA}_{t+1}}$$

Assuming no capital injections in the period, the evolution of capital over time can be further decomposed as follows: $\Delta\mathrm{Capital}_{t+1} = \mathrm{Capital}_{t+1} - \mathrm{Capital}_t = \mathrm{Profit}_{t+1} - \mathrm{Dividends}_{t+1}$, where

$\mathrm{Profit}_{t+1} = \text{Net interest income}_{t+1} + \text{Credit losses}_{t+1} + \text{Net gains on securities}_{t+1} + \text{Other items}_{t+1} - \mathrm{Taxes}_{t+1}$ and

Other items_{t+1} include net fee and commission income, dividend income, and other items such as administrative/operational expenses. Note that Profit_{t+1} can be written as follows:

$$\mathrm{Profit}_{t+1} = \text{Pre-impairment profit}_{t+1} + \Delta\text{Net interest income}_{t+1} + \Delta\text{Net gains on securities}_{t+1} + \text{Credit losses}_{t+1} + \Delta\text{Other items}_{t+1} - \mathrm{Taxes}_{t+1},$$

Using these expressions, we can decompose the change in capital as follows:

$$\Delta\text{Capital}_{t+1} = \text{Pre-impairment profit}_{t+1} + \Delta\text{Net interest income}_{t+1} + \Delta\text{Net gains on securities}_{t+1} + \text{Credit losses}_{t+1} + (\Delta\text{Other items}_{t+1} - \text{Taxes}_{t+1} - \text{Dividend}_{t+1}).$$

X=source of change in capital (numerator)	**Contribution of X to changes in CAR**
- Pre-impairment profits ($\text{Pre-impairment profit}_{t+1}$) - Losses or gains due to change in net interest income ($\Delta\text{Net interest income}_{t+1}$) - Losses or gain due to market risk (securities) ($\Delta\text{Net gains on securities}_{t+1}$) - Credit losses ($\text{Credit losses}_{t+1}$) - Taxes and other items ($\Delta\text{Other items}_{t+1} - \text{Taxes}_{t+1} - \text{Dividend}_{t+1}$)	$\frac{X_{t+1}}{\text{RWA}_t}$
Change in RWAs	$= -\frac{\Delta\text{RWA}_{t+1} \cdot \text{CAR}_t}{\text{RWA}_{t+1}} - \frac{\Delta\text{Capital}_{t+1} \cdot \Delta\text{RWA}_{t+1}}{\text{RWA}_t \cdot \text{RWA}_{t+1}}$

Note that for the calculation of RWAs, we use the Basel Advanced Approaches regulatory capital formulas and the following through-the-cycle adjustments were applied to all PDs/LGDs:

$$\Delta PD_{REG} = 0.2\,\Delta PD_{PIT}$$
$$LGD_{REG} = LGD_{Downturn}.$$

Appendix VI. MCIs: Satellite Models and Methodologies for Stress Testing

Credit Loss Projections

A model of LLRs (impairment rates) was estimated for the Danish mortgage sector using historical data from 1980 to 2018. The regression was specified as follows:

$$logit(ImpRate_t) = \alpha_0 + \gamma \times logit(ImpRate_{t-1}) + \beta \times M_t + \varepsilon_{i,t}$$

where *t* indicates the year. The impairment rate (*ImpRate*) is measured as the ratio of impairment charges (flow) to total loans and accumulated losses.[1] The explanatory variable M_t is a vector of macroeconomic factors. More specifically, we use both the contemporaneous and the first lag of GDP growth rate, unemployment rate, short-term interest rate and inflation. The inclusion of the lagged dependent variable incorporates the impact of starting point. For example, an MCI which enters a stress period with a high impairment rate will suffer bigger losses, as observed in the historical data. The estimated coefficients are presented in the following Table:

Variable	Coefficient	p-value
constant	-2.70	0.08
Impairment rate logit transform (first lag)	0.70	0.00
Real GDP growth rate	-36.89	0.00
Real GDP growth rate (first lag)	-14.59	0.03
Unemployment rate	-41.68	0.04
Unemployment rate(first lag)	57.72	0.00
Short-term interest rate	18.23	0.21
Short-term interest rate (first lag)	-8.09	0.01
Inflation	39.43	0.00
Inflation (first lag)	-20.91	0.11
R-square	*0.9*	

In the model implementation, we use the average impairment rate for each MCI, calculated using data for 2017, 2018 and 2019Q3.

Top-up Collateral Calculations

All SDO/SDRO-issuing capital centers of MCIs must continuously adhere to LTV thresholds on a loan-by-loan basis. The LTV threshold varies by loan type. We assume a threshold of 60 percent for Manufacturing/ Office and Business/ Agricultural properties, and 80 percent for all other sectors. If this LTV limit is breached due to a house price shock, MCIs are required to provide top-up collateral

[1] In few instances, observed flows of impairment charges can be negative—when the economy is strong, certain banks may consider that they have over-provisioned and decide to reduce their existing stock of provisions. Since the logit transformation doesn't exist for negative values, negative observations were floored at a small positive value.

to return MCI mortgage portfolios to the permissible limit. We calculate the additional required top-up collateral in the following steps:

Using data on mortgages by LTV buckets in the Harmonized Transparency Templates (HTT) from the Covered Bond Label website, we assign the mortgages of each MCI in 2019Q3, into 80/60 LTV limit.

Next, we distribute the loans equally in 1 unit LTV buckets 0-1, 1-2, 2-3 … 99-100, 100-101, and apply the mid-point of LTV bucket to compute initial (house) values 0.5, 1.5, 2.5,….99.5, 100.5. We apply the house-price shock to house values and compute the new LTV as loan amount divided by shocked house value. We also account for loan growth using the growth rates of credit in the scenario, floored at 0. The top-up collateral amount is calculated using the formula: loan amount – (LTV limit)*shocked house values. We repeat this process for all years from 2020-2024. We assume that all MCIs already hold the required amount of top-up collateral at the starting point (2019Q3). The top-up collateral requirement is determined as a difference between the calculated requirement amount for each year and the initial (starting point) collateral. Finally, we arrive at the additional requirement by adjusting for excess collateral available at the MCIs. We floor the top-up collateral requirement at 0.

Finally, we apply a spread on this additional requirement for each year, and adjust the cost against the NII. For the COVID baseline, for years 2020 through 2024, we apply a spread of 60 bps, 50 bps, 30 bps, 10 bps, and -10 bps, respectively. For the pre-COVID “market shocks” scenario, for years 2020 through 2024, we apply a spread of 270 bps, 240 bps, 230 bps, 15 bps, and 40 bps, respectively.

Appendix VII. Group-Level Consolidation

Projection of RWAs for banking groups

The approach to project group-level RWAs consists of three steps:

First, at the starting point, we maintain the amount of RWAs for the subsidiary as reported and adjust the RWAs for the parent entity so that the sum of RWAs can match the reported group-level RWAs. Note that the parent entity is the bank in Danske and Jyske groups; in contrast, the MCI is the parent entity in the Nykredit Group.

Second, using as input the adjusted RWAs obtained in the previous step, we calculate weights for the parent and the subsidiary:

$$W_{sub} = RWA_{sub}/RWA_{Group}$$

$$W_{parent} = RWA_{parent,adjusted}/RWA_{Group}$$

Third, using the weights obtained in the previous step and the RWA growth rates of individual entities, we calculate growth rates of RWAs for the group as weighted averages:

$$(RWA_{group,t+1}/RWA_{group,t}) = W_{sub} \times (RWA_{sub,t+1}/RWA_{sub,t}) + W_{parent} \times (RWA_{parent,t+1}/RWA_{parent,t})$$

We then apply this sequence of growth rates to the starting group-level RWAs of the group (as reported) to generate the future path of RWAs for the group.

Roll-off Rates for Liquidity Inflows (In percent)

Template: C 66.01.a - Maturity ladder		Time period																	
		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 30 days	Greater than 30 days up to 5 weeks	Greater than 5 weeks up to 2 months	Greater than 2 months up to 3 months	Greater than 3 months up to 4 months	Greater than 4 months up to 5 months	Greater than 5 months up to 6 months	Greater than 6 months up to 9 months	Greater than 9 months up to 12 months
		0020	0030	0040	0050	0060	0070	0080	0090	0100	0110	0120	0130	0140	0150	0160	0170	0180	0190
0389 INFLOWS																			
Monies due from secured lending and capital market driven transactions collateralised by:	0390																		
Level 1 tradable assets	0400																		
Level 1 excluding covered bonds	0410																		
Level 1 central bank	0420	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Level 1 (CQS 1)	0430	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Level 1 (CQS2, CQS3)	0440	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Level 1 (CQS4+)	0450	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Level 1 covered bonds (CQS1)	0460	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Level 2A tradable assets	0470																		
Level 2A corporate bonds (CQS1)	0480	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Level 2A covered bonds (CQS1, CQS2)	0490	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Level 2A public sector (CQS1, CQS2)	0500	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Level 2B tradable assets	0510																		
Level 2B ABS (CQS1)	0520	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Level 2B covered bonds (CQS1-6)	0530	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Level 2B: corporate bonds (CQ1-3)	0540	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Level 2B shares	0550	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Level 2B public sector (CQS 3-5)	0560	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Other tradable assets	0570	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Other assets	0580	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Monies due not reported in 2.1 resulting from loans and advances granted to:	0590																		
Retail customers	0600	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70
Non-financial corporates	0610	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Credit institutions	0620	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Other financial customers	0630	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Central banks	0640																		
Other counterparties	0650	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
FX-swaps maturing	0660																		
Derivatives amount receivables other than those reported in 2.3	0670																		
Paper in own portfolio maturing	0680	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Other inflows	0690	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Total inflows	0700																		
Net funding gap	0710																		
Cumulated net funding gap	0720																		

[1] A run-off rate is defined as the fraction of the liability amount maturing in a given period that is withdrawn by the claim holders. Sight deposits and contingent liabilities (committed credit and liquidity lines) are exceptions, however. Due to the instantaneous maturity of sight deposits, a run-off rate on these deposits is the fraction of the initial outstanding balance that is withdrawn in a given period of time. Credit/liquidity lines can also be withdrawn at any time by clients or other financial institutions once they have been granted by the bank. In the above Table, all run-off rates highlighted in blue are defined with respect to the initial outstanding balance.

[2] A roll-off rate is defined as the fraction of the asset amount maturing in a given period that is converted into a cash inflow by the bank.

Run-off Rates for Liquidity Outflows (In percent)

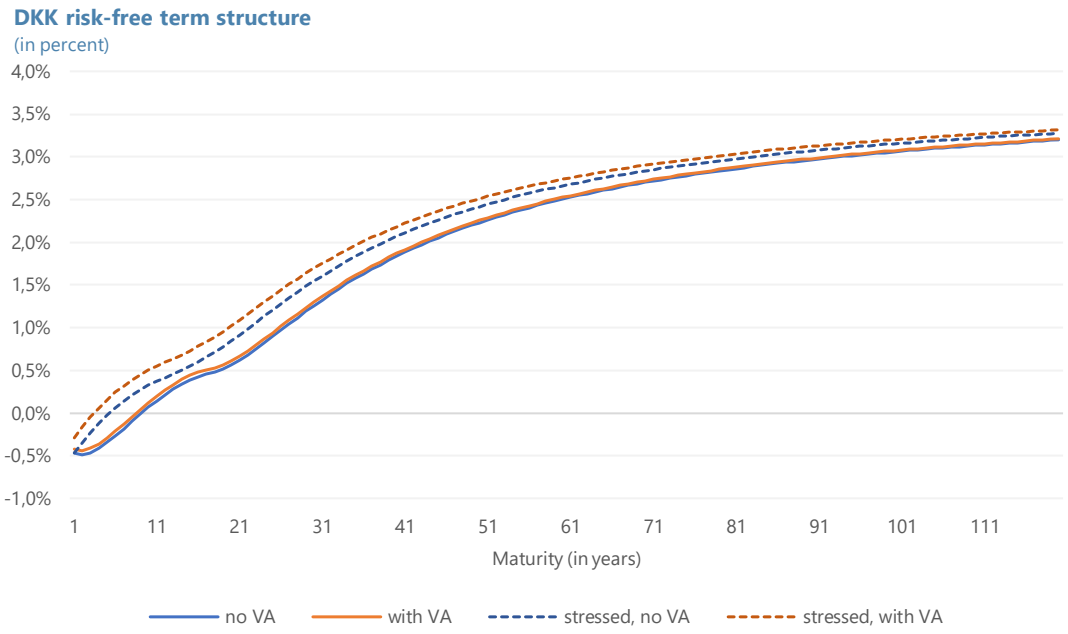
Template: C 66.01.a - Maturity ladder		Time period																		
		Overnight	Greater than overnight up to 2 days	Greater than 2 days up to 3 days	Greater than 3 days up to 4 days	Greater than 4 days up to 5 days	Greater than 5 days up to 6 days	Greater than 6 days up to 7 days	Greater than 7 days up to 2 weeks	Greater than 2 weeks up to 3 weeks	Greater than 3 weeks up to 30 days	Greater than 30 days up to 5 weeks	Greater than 5 weeks up to 2 months	Greater than 2 months up to 3 months	Greater than 3 months up to 4 months	Greater than 4 months up to 5 months	Greater than 5 months up to 6 months	Greater than 6 months up to 9 months	Greater than 9 months up to 12 months
		0020	0030	0040	0050	0060	0070	0080	0090	0100	0110	0120	0130	0140	0150	0160	0170	0180	0190
0005 OUTFLOWS																				
Liabilities resulting from securities issued (if not treated as retail deposits)	0010																			
Unsecured bonds due	0020	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Regulated covered bonds	0030	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Securitisations due	0040	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Other	0050	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Liabilities resulting from secured lending and capital market driven transactions collateralised by:	0060																			
Level 1 tradable assets	0070																			
Level 1 excluding covered bonds	0080																			
Level 1 central bank	0090	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Level 1 (CQS 1)	0100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Level 1 (CQS2, CQS3)	0110	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Level 1 (CQS4+)	0120	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Level 1 covered bonds (CQS1)	0130	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Level 2A tradable assets	0140																			
Level 2A corporate bonds (CQS1)	0150	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
Level 2A covered bonds (CQS1, CQS2)	0160	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
Level 2A public sector (CQS1, CQS2)	0170	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
Level 2B tradable assets	0180																			
Level 2B ABS (CQS1)	0190	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
Level 2B covered bonds (CQS1-6)	0200	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
Level 2B: corporate bonds (CQ1-3)	0210	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
Level 2B shares	0220	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
Level 2B public sector (CQS 3-5)	0230	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
Other tradable assets	0240	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Other assets	0250	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Liabilities not reported in 1.2, resulting from deposits received (excluding deposits received as collateral)	0260																			
Stable retail deposits (sight)		0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	1.0	1.0	0.9	2.2	3.3	2.7	2.7	2.7	-	-	
Stable retail deposits (term)	0270	-	7.0	7.0	7.0	7.0	7.0	7.0	10.0	10.0	10.0	10.0	10.0	10.0	7.0	7.0	7.0	5.0	5.0	
Other retail deposits (sight)		0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.9	2.5	2.5	2.5	6.0	7.0	6.5	6.5	5.5	-	-	
Other retail deposits (term)	0280	-	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	15.0	15.0	15.0	10.0	10.0	10.0	7.0	7.0	
Operational deposits (sight)	0290	0.7	0.7	0.7	0.7	0.7	0.7	0.7	1.5	4.0	4.0	4.0	8.0	10.0	9.0	7.0	6.0	-	-	
Non-operational deposits from credit institutions	0300	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	
Non-operational deposits from other financial customers	0310	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	
Non-operational deposits from central banks	0320	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Non-operational deposits from non-financial corporates (sight)		1.1	1.1	1.1	1.1	1.1	1.1	1.0	1.8	5.5	5.5	5.5	10.0	13.0	10.0	8.5	6.5	-	-	
Non-operational deposits from non-financial corporates (term)	0330	-	50	50	50	50	50	50	50	50	50	40	40	40	30	30	30	20	20	
Non-operational deposits from other counterparties	0340	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	
FX-swaps maturing	0350																			
Derivatives amount payables other than those reported in 1.4	0360																			
Other outflows	0370	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	
1089 CONTINGENCIES																				
Outflows from committed facilities	1090																			
Committed credit facilities	1100																			
Considered as Level 2B by the receiver	1110	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.5	1.5	1.5	2.5	2.5	5.0	-	-	-	-	-	
Other	1120	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.5	1.5	1.5	2.5	2.5	5.0	-	-	-	-	-	
Liquidity facilities	1130	2.1	2.1	2.1	2.1	2.0	2.0	2.0	3.6	4.6	14.0	6.0	18.0	14.0	-	-	-	-	-	
Outflows due to downgrade triggers	1140																			

Liquidity Stress Tests: Haircuts (In percent)

0729 COUNTERBALANCING CAPACITY		Haircuts
Coins and bank notes	0730	-
Withdrawable central bank reserves	0740	-
Level 1 tradable assets	0750	
Level 1 excluding covered bonds	0760	
Level 1 central bank	0770	7
Level 1 (CQS 1)	0780	7
Level 1 (CQS2, CQS3)	0790	7
Level 1 (CQS4+)	0800	7
Level 1 covered bonds (CQS1)	0810	7
Level 2A tradable assets	0820	
Level 2A corporate bonds (CQS1)	0830	20
Level 2A covered bonds (CQS 1, CQS2)	0840	12
Level 2A public sector (CQS1, CQS2)	0850	12
Level 2B tradable assets	0860	
Level 2B ABS (CQS1)	0870	40
Level 2B covered bonds (CQS1-6)	0880	25
Level 2B corporate bonds (CQ1-3)	0890	40
Level 2B shares	0900	70
Level 2B public sector (CQS 3-5)	0910	30
Other tradable assets	0920	
Central government (CQS1)	0930	50
Central government (CQS 2 & 3)	0940	60
Shares	0950	80
Covered bonds	0960	35
ABS	0970	60
Other tradable assets	0980	80
Non tradable assets eligible for central banks	0990	80

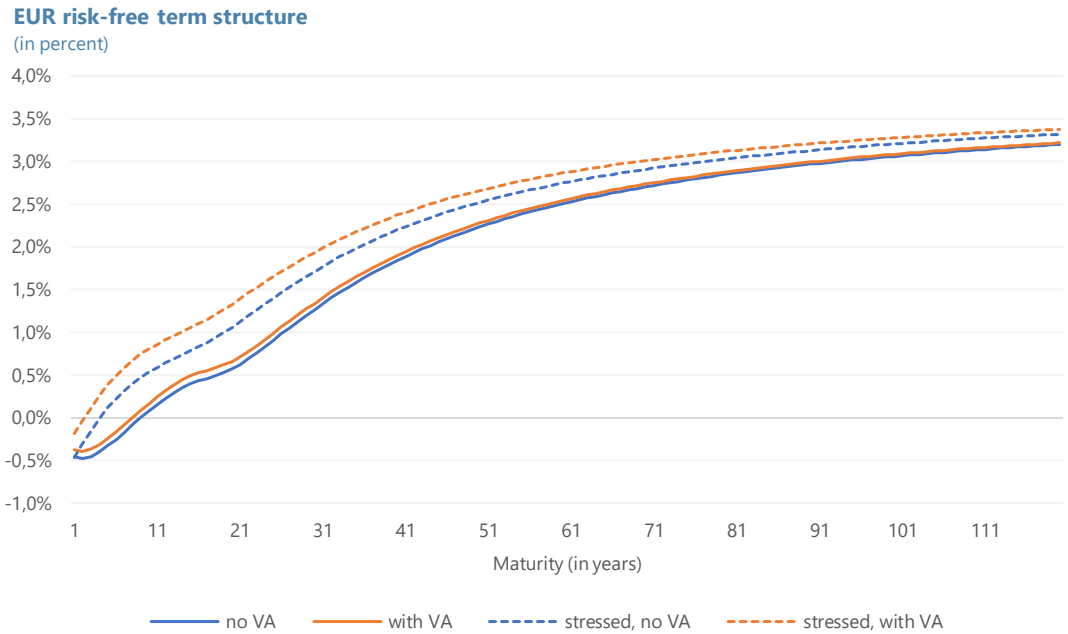
Sources: Authorities; and IMF staff.

Appendix IX. Shocks to the Risk-Free Interest Rate



Notes: According to Solvency II (as of June 2019), the DKK risk-free term structure has its last liquid point at 20 years and converges over 40 years towards an ultimate forward rate of 3.9 percent.

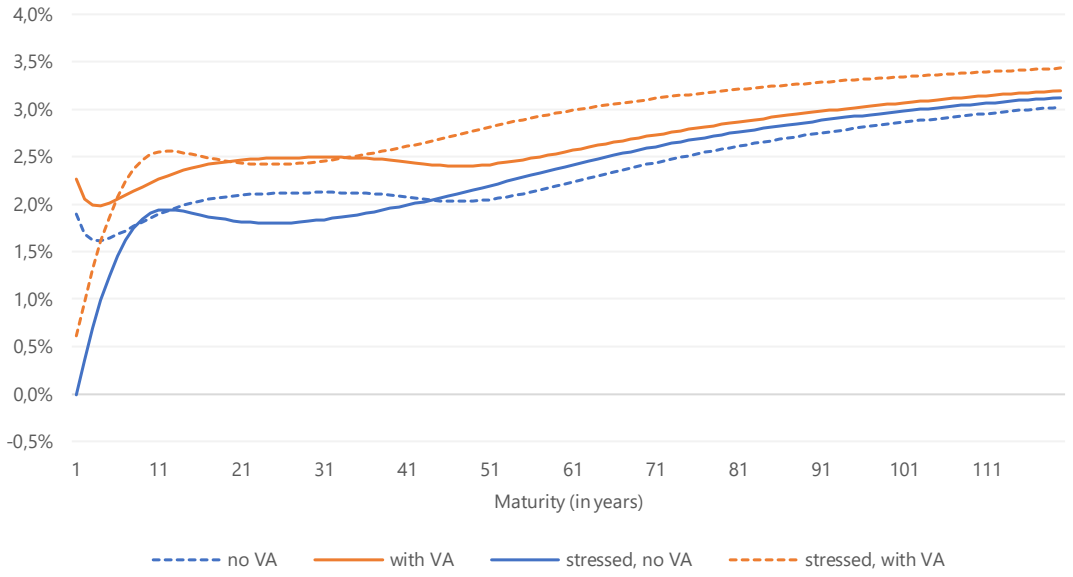
Sources: IMF staff, EIOPA.



Notes: According to Solvency II (as of June 2019), the EUR risk-free term structure has its last liquid point at 20 years and converges over 40 years towards an ultimate forward rate of 3.9 percent.

Sources: IMF staff, EIOPA.

USD risk-free term structure
(in percent)



Notes: According to Solvency II (as of June 2019), the USD risk-free term structure has its last liquid point at 50 years and converges over 40 years towards an ultimate forward rate of 3.9 percent.

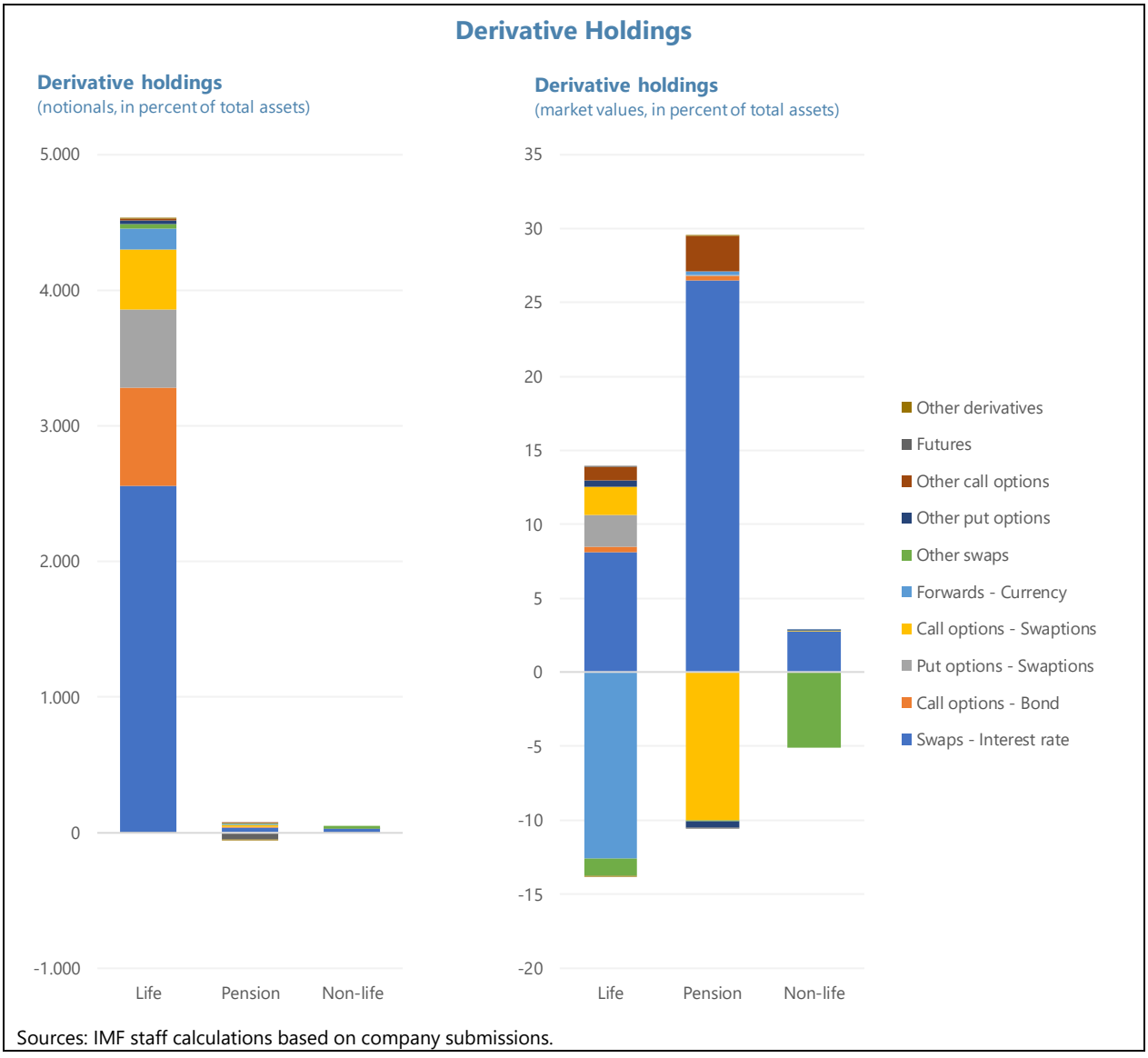
Sources: IMF staff, EIOPA.

GBP risk-free term structure
(in percent)

Notes: According to Solvency II (as of June 2019), the GBP risk-free term structure has its last liquid point at 50 years and converges over 40 years towards an ultimate forward rate of 3.9 percent.

Sources: IMF staff, EIOPA.

Appendix X. Derivative Holdings



Sources: IMF staff calculations based on company submissions.

Appendix XI. Non-financial Corporate Sector

Default Probability Model based on Micro Data

1. Inclusion of macroeconomic variables in corporate default models used by DN. IMF and DN staff used as benchmark NFC default models previously developed by DN. To align these models with the broader objective of stress testing, PDs were modeled as a function of both firm-level variables *and* key macroeconomic variables—GDP growth, interest rates, unemployment, inflation, etc. These variations to earlier versions of the models made them compatible for joint use with macroeconomic scenarios for stress tests, which helped provide clear narratives for simulated NFC defaults.

2. Development of industry-specific PD models. The motivation to estimate the models separately for each industry is based on the idea that macro variables and firm-level variables (e.g. leverage) may have differentiated effects on PDs across industries. Specifically, the IMF-DN team estimated the following logistic regression models for default probability of firm *i*, at time *t*, for industry *j* :

$$\text{logit}\left(\text{PD}^{\,j}_{i,t}\right) = \beta_0 + \beta_1 * \text{Leverage}^{j}_{i,t-1} + \boldsymbol{\beta_2} * \mathbf{Firm\_vars}^{j}_{i,t-1} + \boldsymbol{\beta_3} * \mathbf{Macro\_vars}_{t-1} + \boldsymbol{\beta_4} * \text{Leverage}^{j}_{i,t-1} * \mathbf{Macro\_vars}_{t-1} + \mu^{j}_{i} + \varepsilon^{j}_{i,t}$$

The regressions were estimated separately for the industries shown in the Table below. Note that the breakdown of industries is compatible with the sectoral breakdown of exposures reported by banks, and hence a tight mapping for use in solvency stress tests could be established in future work.

Bank Corporate Sector Exposures by Industry and PD Bracket

	PD interval										
	0 - 0,2 pct. 1.000 kr.	0,2 - 0,5 pct. 1.000 kr.	0,5 - 1 pct. 1.000 kr.	1 - 1,5 pct. 1.000 kr.	1,5 - 2 pct. 1.000 kr.	2 - 3 pct. 1.000 kr.	3 - 5 pct. 1.000 kr.	5 - 10 pct. 1.000 kr.	10 - 20 pct. 1.000 kr.	20 - 100 pct. 1.000 kr.	100 pct. 1.000 kr.
Public sector	PD02	PD05	PD1	PD15	PD2	PD3	PD5	PD10	PD20	PD20100	PD100
Corporates											
Agriculture, hunting, forestry and fishe	PD02	PD05	PD1	PD15	PD2	PD3	PD5	PD10	PD20	PD20100	PD100
Manufacturing industries and extractic	PD02	PD05	PD1	PD15	PD2	PD3	PD5	PD10	PD20	PD20100	PD100
Energy and utilities	PD02	PD05	PD1	PD15	PD2	PD3	PD5	PD10	PD20	PD20100	PD100
Building and construction	PD02	PD05	PD1	PD15	PD2	PD3	PD5	PD10	PD20	PD20100	PD100
Trade	PD02	PD05	PD1	PD15	PD2	PD3	PD5	PD10	PD20	PD20100	PD100
Transport, hotels and restaurants	PD02	PD05	PD1	PD15	PD2	PD3	PD5	PD10	PD20	PD20100	PD100
Information and communication	PD02	PD05	PD1	PD15	PD2	PD3	PD5	PD10	PD20	PD20100	PD100
Finance and insurance	PD02	PD05	PD1	PD15	PD2	PD3	PD5	PD10	PD20	PD20100	PD100
Real estate (property administration)	PD02	PD05	PD1	PD15	PD2	PD3	PD5	PD10	PD20	PD20100	PD100
Other corporates	PD02	PD05	PD1	PD15	PD2	PD3	PD5	PD10	PD20	PD20100	PD100
Corporates, total	PD02	PD05	PD1	PD15	PD2	PD3	PD5	PD10	PD20	PD20100	PD100
Households	PD02	PD05	PD1	PD15	PD2	PD3	PD5	PD10	PD20	PD20100	PD100
Total	PD02	PD05	PD1	PD15	PD2	PD3	PD5	PD10	PD20	PD20100	PD100

The industry-specific PDs were calculated as follows. For each industry *j* and PD bracket ($b_1, b_2, \ldots\ldots, b_{11}$), we calculated a representative PD as a debt-weighted mean of predicted firm-level default probabilities, $\overline{\text{PD}}^{\,j}_{b,t}$. The macroeconomic scenarios were used to compute the stressed PDs.

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