Working Paper W-1/22

Bank Solvency Stress Testing at Central Bank of Bosnia and Herzegovina

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Abstract

After conducting a stress test for the first time in 2007, the Central Bank of Bosnia and Herzegovina has been developing its framework for stress tests on an ongoing basis. The top-down solvency stress tests conducted by the CBBH are performed at a quarterly frequency with results published once a year in the annual Financial Stability Report. Given the fact that the CBBH is a pioneer in this particular field of BH economic and financial analysis, the need for a working paper which would provide a detailed overview of stress testing in BH emerged. The working paper begins with describing the evolution of the stress test framework from its early-stage model, which had the characteristics of a simple sensitivity analysis, to the present-day top-down solvency stress testing that has been implemented in 2019. Furthermore, the paper highlights the updated methodology for projections of key banks' balance sheet items, model-based calibration of scenarios, underlying satellite credit risk models compatible with the new provisioning standard IFRS 9, and integrated interbank contagion module. The paper describes how the stress test results are presented and their importance in assessing the systemic risk in the banking sector as well as in the conduct of banks supervision in terms of estimating potential bank recapitalization needs. In the paper we also show how the stress test projections using the new framework have improved compared to the previous approach even in the unstable environment triggered by the COVID-19 pandemic. Finally, the paper points out the main areas where further improvement could be made including better projection of credit risk and banks' net profits as well as incorporating the impact of market risk.

Keywords: stress testing; Central Bank of Bosnia and Herzegovina; financial stability; credit risk; capital adequacy

JEL classification: E44, E58, G21, G28

Contents

1. Introduction

Since at least the Global Financial Crisis back in 2008, the stress tests have become an established tool to assess the resilience of both individual banks and the total banking sector. Primarily, they were used to identify capital shortfalls in the banking sector under potential severe but plausible shocks, but later they have evolved into a multi-functional supervisory tool for financial sector surveillance to assess banks' risk profiles. In general, the stress tests are forward-looking exercises that aim to evaluate the impact of adverse macroeconomic developments on banks' balance sheets.

Solvency stress tests, which could be performed either as a top-down or a bottom-up exercise, assess the impact of severe but plausible developments, typically captured in an economic scenario, on the overall capital position of an institution (typically a bank) or the whole (banking sector). This analytical tool is able to project the institution's capital resources and requirements, highlighting the institution's vulnerabilities and assessing its capacity to absorb losses and the impact on its solvency position (EBA 2018). Top-down stress tests are typically performed by a central bank or a supervisory authority using its own stress testing framework and data available in-house, while bottom-up stress tests are performed by individual banks using their internal stress testing models under common scenarios and assumptions provided to banks by supervisory authorities (BIS 2017). A top-down stress test is typically based on macroeconomic scenario designed by the central bank and uses relatively aggregated data for individual banks available at the authority, with less detailed information than in the case of the bottom-up stress test. It enables a uniform and comparative assessment of the impact of a given stress scenario across institutions. Bottom-up stress tests, which are carried out by institutions using their own internally developed models, is based on the institution's own data and potentially high level of data granularity, with possible use of external data for some additional information. It produces detailed results on the potential impact of exposure concentrations, institution linkages, and loss rates (EBA 2018).

A more comprehensive approach to performing solvency stress tests used by EBA is to perform a coordinated exercise in which the same macroeconomic scenarios (baseline and adverse) are used to perform both bottom-up stress test as well as top-down stress tests. Bottom-up stress test is performed with the goal to assess the capital requirements of individual banks and the entire banking sector. Top-down stress tests is performed using the same scenarios, and the obtained results are used as a benchmark for comparing the results

obtained in bottom-up stress tests. Such a coordinated stress testing exercise was also conducted in Bosnia and Herzegovina (BH) within the IMF's FSAP mission in 2014.

In accordance with the task of contributing to the preservation of financial stability in the country, the Central Bank of Bosnia and Herzegovina (CBBH) carries out a top-down macro solvency stress test for the banking sector of BH since 2007. Although the fundamental goal of conducting stress tests is to preserve financial stability, this framework is also used for micro-prudential purposes, and is a good starting point for creating a broader macroprudential framework that is still under development in BH. Over the past ten years or so stress testing framework has been continuously developing from the simple sensitivity analysis to a comprehensive tool that can be run at quarterly basis, accommodates one baseline and two adverse scenarios calibrated jointly by the CBBH's Chief Economist Office and the Financial Stability Department (FSD) and prepares projections of key bank variables for up to next three years. Current framework fully reflects the recent changes in the regulatory framework in BH, such as implementation of new capital adequacy regime based on Basel III (EU CRR/CRD) and the expected credit loss provisioning of IFRS 9. It is important to underline that with every improvement, the stress test methodology within the CBBH strives to be one step more aligned with the EBA guidelines on stress testing, in areas in which such compatibility is possible given the specifics of the BH banking sector. Following the EBA guidelines, the CBBH has positioned the scenario analyses as core part of the stress test program, incorporated most of EBA emphasized risks, and created mechanisms for translating risk factors into relevant risk parameters. The CBBH stress test model is specifically designed, in line with the EBA guidelines but tuned with the complexity of BH banking sector in terms of level of detail. Finally, the CBBH stress test model also tends to be aligned with the bottom-up EBA guidelines, in order to support bottom-up stress test carried out by the supervisory banking agencies in BH.

Stress tests carried out by CBBH indicate banking system vulnerabilities and their results should be interpreted with caution, as they strongly depend on the calibration of the scenarios used as well as on the methodology and assumptions used (Henry and Kok 2013). They are just one instrument in the financial sector surveillance and before being used as input into any financial sector policies and regulatory measures, they should be complemented by additional analyses and indicators as indicated in the BIS stress testing principles (BIS 2017).

This paper provides a comprehensive overview of the current approach used for top-down solvency stress tests at the CBBH. It describes all important stages of the stress test exercise

(data collection, methodology and assumptions, satellite models for credit risk, calibration of macroeconomic scenarios, derivation and interpretation of final results and their publication). In the paper, we also present how the stress test framework has evolved since 2007 amid the developments of the banking sector over the same period, which is also covered. Furthermore, we analyze whether predictions of key banks' balance sheet variables under the new approach have improved compared to the previous approach. In conclusion, we point to issues that may require additional improvements over the next years and describe next steps planned in development of the banking sector stress test framework.

2. Main characteristics and trends in the BH banking sector

Financial sector of the BH is dominated by moderately concentrated banking sector. At the end of 2020, the banking sector accounted for 89% of financial system assets, equivalent to 96% of GDP. Since 2007, the year when CBBH started to conduct stress test, the share of banking sector assets in total assets of financial sector has increased by 9 percentage points. Trend of consolidation of banking sector has continued until the end of 2016 and the number of banks significantly reduced. At the end of 2007, the BH banking sector accounted for 32 banks, compared with 23 banks at the end of 2020. Banking sector consists mostly of foreign-owned banks (15 banks accounting for 83% of total banking sector assets), of which 8 belongs to the 4 foreign groups, 7 banks are domestic privately-owned (14.5% of total assets), and one bank is state-owned (2.9% of total assets). Four largest banks represent about 50% of the total banking sector assets.

Supervisory framework of financial sector in BH is established at the entity level. Accordingly, the BH banking sector is supervised by the two entity bodies i.e. two agencies for bank supervision. The Banking Agency of the Federation of Bosnia and Herzegovina (FBA) supervises the banks with headquarters in the Federation of Bosnia and Herzegovina (15 banks), while the Banking Agency of Republika Srpska (BARS) supervises the banks with headquarters in the Republika Srpska (8 banks). The CBBH as a state-level institution does not have a direct supervisory or regulatory function but is charged with the task of coordinating the activities of the two Agencies including information exchange among all three institutions.

The main banking sector indicators are presented in Table 1.

Table 1: Main banking sector indicators

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021Q3
Key macroeconomic indicators															
GDP growth (real % yoy)	5.9	5.4	-3.0	0.9	1.0	-1.0	2.5	1.2	3.1	3.2	3.2	3.7	2.8	-3.2	7.5
Inflation (% yoy)	1.5	7.4	-0.4	2.1	3.7	2.1	-0.1	-0.9	-1.0	-1.1	1.2	1.4	0.6	-1.0	0.9
Capital adequacy															
Regulatory capital to risk-weighted assets	17.1	16.2	16.1	16.2	17.1	17.0	17.8	16.3	14.9	15.8	15.7	17.5	18.0	19.2	19.2
Asset quality															
Nonperforming loans to total gross loans	3.0	3.1	5.9	11.4	11.8	13.5	15.1	14.2	13.7	11.8	10.0	8.8	7.4	6.1	5.5
NPL net of provisions to Tier 1 capital	n.a.	n.a.	25.5	42.0	25.9	30.0	31.0	27.9	26.9	18.5	14.4	12.1	9.9	7.8	6.6
Earnings and profitability															
ROAA	0.8	0.4	0.1	-0.6	0.7	0.7	-0.1	0.8	0.3	1.1	1.5	1.3	1.4	0.8	1.5
ROAE	8.6	4.2	0.8	-5.5	5.8	5.1	-0.5	5.4	2.0	7.3	10.2	9.6	10.4	6.0	11.5
Net interest income to gross income	59.7	60.6	61.5	60.1	63.9	63.7	62.3	61.6	62.0	60.4	58.3	58.8	56.8	56.0	53.4
Noninterest expenses to gross income	85.1	90.6	97.4	109.0	86.5	87.4	101.2	85.7	94.5	80.7	73.3	74.0	71.0	83.0	67.8
Liquidity															
Liquid assets to total assets	37.7	30.0	30.9	29.0	27.2	25.4	26.4	26.8	26.5	27.2	28.4	29.7	29.6	29.1	29.0
Liquid assets to short-term liabilities	61.3	51.8	53.0	49.7	46.7	44.1	46.2	46.1	44.0	44.1	44.3	44.7	45.5	42.7	41.5
Deposits / loans	103.1	81.8	85.6	86.3	84.9	84.4	87.2	92.4	96.9	101.7	105.1	109.6	112.7	120.7	78.3
Sensitivity to market risk															
Net open position in foreign exchange to Tier 1 capital	5.9	6.2	1.7	4.4	16.0	5.3	6.7	10.2	9.0	1.7	-0.2	2.2	3.5	4.4	8.2
Foreign- currency denominated loans to total loans	74.1	73.3	73.9	70.0	66.9	67.2	68.8	68.0	67.1	62.6	60.1	56.7	53.9	53.9	51.8
Foreign- currency denominated liabilities to total liabilities	65.1	69.5	69.2	67.0	66.2	65.2	63.8	62.7	60.3	57.4	55.1	53.3	50.7	48.1	45.5
Loans and interest rates															
Nominal loan growth	30.9	21.1	-3.9	3.3	5.0	3.9	3.4	1.1	3.5	2.3	7.2	7.1	7.0	0.3	5.1
Average loan interest rates	7.9	7.8	8.3	8.1	7.7	7.7	7.5	7.1	6.6	6.0	5.3	4.7	4.4	4.2	4.4
Household loans to GDP	n.a.	26.0	25.4	24.9	25.5	25.8	26.1	26.9	27.0	26.8	27.2	27.5	28.1	28.8	n.a.
Non-financial priavate enterprises to GDP	n.a.	29.0	29.1	30.0	30.3	32.2	32.6	31.2	30.5	29.5	30.3	30.4	30.5	31.8	n.a.

Sources: CBBH, Banking Agency of FBiH and Banking Ageny of RS

Over the past 15 years, the BH economy went through a typical business cycle, with an upturn up to 2008 in the run-up to the Global Financial Crisis, a recession between 2009-2012, and a recovery between 2013 and the coronavirus crisis of 2020 (Table 1). Over the whole period though, the inflation stayed very low (except 2008) or even negative, reflecting the country's monetary regime based on currency board with a fixed exchange rate to euro, thus mostly imported inflation depending on trends in the oil and food prices. The recession experience during the Global Financial Crisis negatively affected the performance of financial sector as well. Aggressive lending and inadequate lending policies of few banks in the system in the period between 2002-2007 resulted in a significant increase in NPLs in 2009-2010, with elevated levels as measured by the NPL ratio up to 2015 outbreak which posed a greatest risk to preserving stability of banking sector in that period. The high share of non-performing loans in these banks affected the asset quality of the entire sector and, consequently led to large credit losses which affected the profitability of the sector. Nevertheless, banking sector showed resilience even in the period of highest level of credit risk maintaining high liquidity and solvency, with the level of capital adequacy ratio remaining significantly above the regulatory minimum of 12%. In order to reveal the true level of credit risk and strengthen the capital position of banks, a process of asset quality review (AQR) was performed in 2014-2016. Banks undertook a number of measures to improve the asset quality such as tightening credit standards, restructuring of existing claims to enhance the borrower’s chances to service their existing debt, and transferring a portion of their portfolios to separate non-bank legal entities. Structural changes and consolidation of several small domestically-owned banks led to the improvement of the banking sector financial soundness indicators and strengthened the overall resilience of the whole sector. In addition, banking regulatory and supervisory framework in BH was in the process of harmonization with relevant EU regulations and directives in this period. Between 2016 and 2019, until the outbreak of the coronavirus crisis, the banking sector was assessed as stable, with all the key indicators continuously improving.

The coronavirus pandemic, itself causing a significant decline of economic activity in 2020 due to lockdowns and a drop in international trade and tourism, were only partly affecting the BH banking sector. The measures undertaken by the Banking Agencies including moratorium for loan repayments mitigated the impact of the adverse economic developments on credit quality in banks’ portfolios and their liquidity, but a lower demand for loans and tightening of banks' lending standards resulted in zero credit growth and a drop in profitability. Asset quality indicators improved in 2020 and 2021 indicating that credit risk to which the banking

sector was exposed from the beginning of the pandemic has not been materializing. According to the last available information from Banking Agencies, only around 4% of the total loan amount on the system level in mid-2021 was subject to some of the measures adopted by the Agencies compared to 11.5% of the total loan amount at the end of 2020. After a significant decrease in net profit in 2020, profitability began to recover in 2021, reaching almost the pre-pandemic values.

3. Evolution of the stress testing framework at the CBBH

In accordance with the task of contributing to the preservation of financial stability in the country, the CBBH started to conduct top-down stress tests for the banking sector in 2007. The first CBBH conducted stress test was based on the 2006 IMF FSAP mission stress test methodology and it had the characteristics of a sensitivity analysis. It included two scenarios to test the banking sector's resilience to credit shock and cross-border funding shock with results published in the CBBH 2007 Financial Stability Report (FSR).

Following the IMF technical assistance mission in April 2009, a new stress test methodology has been introduced. The new methodology was used only once, in stress test exercise based on data for the end of 2008 and stress test results were published in FSR 2008. In this stress test mild and extreme scenario were introduced for the first time. The scenarios have been made as a combination of individual shocks. Both scenarios were based on migration in classification of claims caused by the increase of costs of short-term financing and were differed by intensity of shock. In addition, foreign exchange risk and liquidity risk were included only in the extreme scenario.

The third generation of the CBBH stress tests was introduced during the second half of 2009, after a regional stress test exercise organized by the IMF in collaboration with the World Bank. A number of improvements were made: first of all, from the second quarter of 2010, the stress test for the banking sector of BH have been performing on a quarterly basis. Second, typically two scenarios (one baseline and one adverse) were calibrated for the next two calendar years. Acknowledging the fact that the credit risk dominates in the banking system of BH, the main shock was an impact of the adverse macroeconomic environment onto non-performing loans, resulting in an increase of provisions and decline in capital adequacy. The key determinant behind the credit risk materialization were the GDP growth and changes in interest rates driven by rising country risk. Stress testing using this framework was implemented until the end of 2018.

In addition to using stress tests to assess resilience of the banking sector as a whole, stress tests have also become an increasingly important tool in the supervisory framework. The process of running stress tests for supervisory purposes has been formalized at the institutional level in 2013 by adopting the "Guidelines for the Development of Stress Tests and the Use of Prudential Instruments in the CBBH, FBA and BARS" between the CBBH and the entity Banking Agencies. The guidelines defined the obligations and responsibilities of all institutions involved in the stress testing process. The guidelines also defined relations between macroprudential monitoring, supervisory surveillance and the risk management, which includes risk mitigation process.

Given the changes in the regulatory framework for banks in BH during 2017-2019, including the implementation of the Basel III supervisory framework and of the new International Financial Reporting Standard (IFRS) 9 on expected credit loss provisioning, it was necessary to modify the stress testing approach once again. As a part of the USAID's Financial Sector Reform Project (FINRA), a new tool for solvency stress testing was developed in 2019, fully reflecting the changes in the regulatory framework. The stress test framework is fully on par with top-down solvency stress testing frameworks used by central banks in Europe, which are aligned with the EBA guidelines on stress testing, while reflecting the CBBH specifics, data availability, and regulation. The new stress test is based on three macroeconomic scenarios (one baseline and two adverse scenarios) and the time horizon has been extended from two to three years. The approach is using explicit satellite models to link macro-financial variables with credit risk indicators, especially credit quality migration rates. The framework also includes an explicit projection of banks' pre-provision income and an optional market risk module for local government bond revaluations. The interbank contagion module – developed in parallel as a part of the FINRA technical assistance mission in 2018 – was later also integrated in this stress test framework. At the same time, the quarterly frequency of running stress tests has been kept.

Banking Agencies started to develop their own supervisory stress tests in a bottom-up format and organized the first stress testing exercise in 2019. Calibration of both baseline and adverse scenarios for the purpose of these bottom-up stress tests were done in cooperation with the CBBH, with scenarios largely in line with those used for the top-down stress tests. Both the CBBH and the Banking Agencies are committed to continue cooperation in this area in the future with the intention to use the same scenarios in both top-down and bottom-up exercises

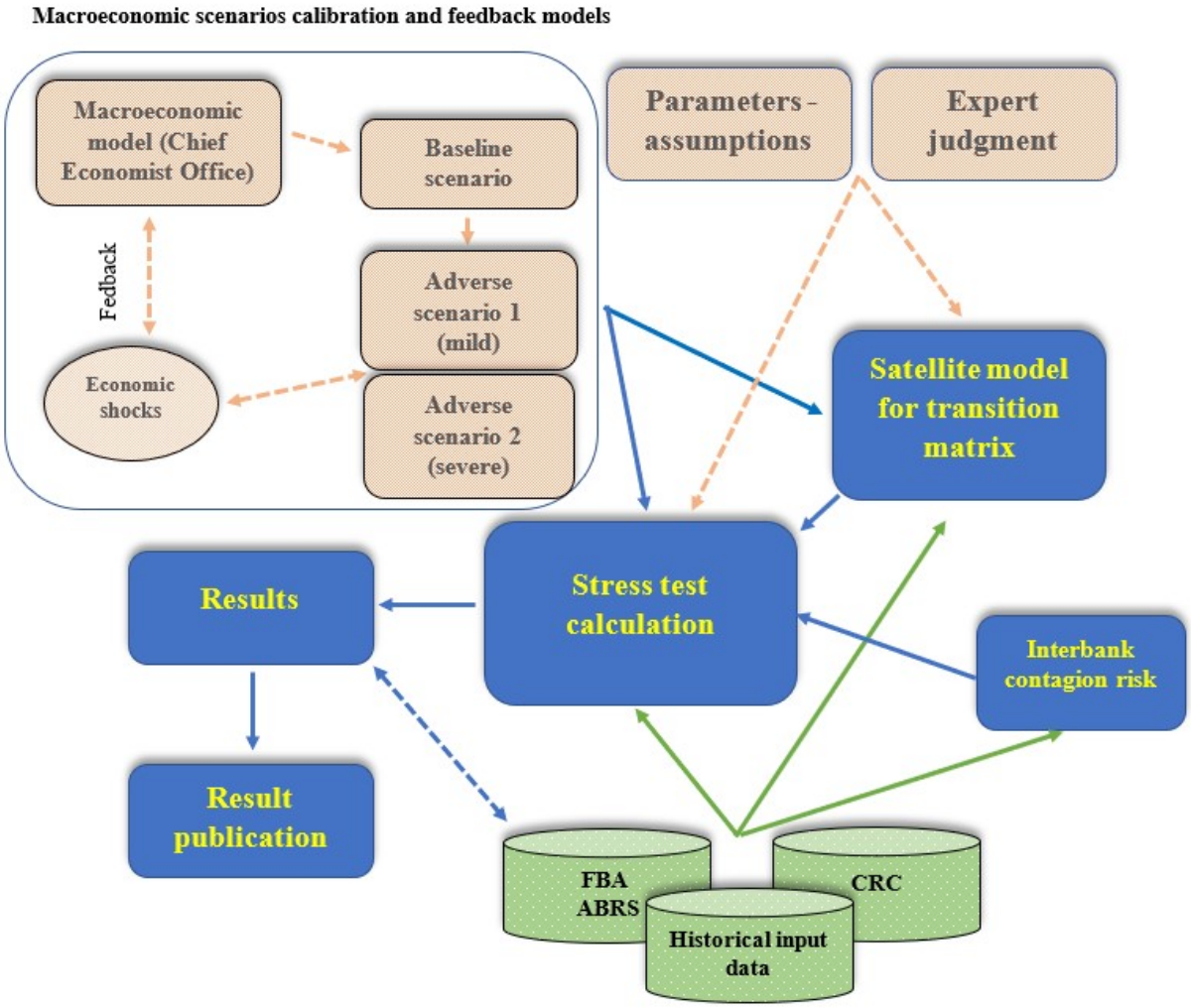
so that the results could be compared and possible differences used to improve both types of stress tests.

While the baseline scenario for the CBBH has typically been based on the IMF World Economic Outlook projection, since the third quarter of 2020, the baseline scenario has been calibrated using the most recent macroeconomic projections for real GDP growth, inflation, house prices, and credit growth from the new CBBH macroeconomic model, which was developed in the CBBH Chief Economist Office in the first half of 2020. The model was constructed to capture the key relationships among the main macroeconomic sectors and can be used to analyze the implications of various shocks, construct alternative scenarios, and produce reliable forecasts of economic activity in BH (Čolaković et al. 2021). Given that the model includes specific elements of BH economy, the stress test framework has improved compared to the previous one in which the IMF WEO projections were used. The Chief Economist Office projections are delivered two times a year, in May and November, and the baseline scenario for the top-down stress test is based on the most recent projection available. The latest improvement in the scenario design was done in 2021, when the macroeconomic model developed in the Chief Economist Office started to be used also for calibrating the adverse scenarios with the purpose of improving their economic consistency.

4. Current stress testing framework

The stress testing framework is a complex structure consisting of various mutually linked components (Chart 1). Green and beige elements in Chart 1 represent inputs – macroeconomic scenarios calibrated outside the stress testing tool and setting of key assumptions and parameters on one hand, and bank-level data received either from the Banking Agencies or from the CBBH Credit Register on the other hand. Blue elements in Chart 1 represent the individual modules in the stress testing tool – the satellite models for credit risk, calculation of the impact of the shocks on banks' balance sheet and profit and loss items, and the interbank contagion module. The tool has a number of possible visualization of the results (various charts and tables).

Chart 1: The design of the dynamic stress test exercise



4.1.Stress test dataset

The starting point for any stress test is the collection of relevant data. There are three main sources of data which are used here: first, the CBBH receives quarterly banking data from the Banking Agencies for all banks, consisting mainly of balance sheet items, profit and loss (P/L) account items, risk-weighted assets, and regulatory capital, among others. The stress test tool needs the key assets such as cash, government securities, and loans, whereby the loans and associated loan loss provisions are reported by IFRS 9 credit risk stages (S1, S2, S3 classification) and categorized by economic sectors (industries for corporations such as agriculture, manufacturing, construction; purpose for households – consumer loans, housing loans etc.).

The regulatory capital data includes total regulatory capital (Tier 1 and Tier 2) along with CET 1 capital. Risk-weighted assets are also included along with a simplified P/L account for the last period. Key ratios needed for the projections, such as interest-bearing assets, Tier 1, Tier 2 and capital adequacy ratio (CAR), net interest margin, etc. are automatically calculated by the tool. It is also important to point out that the Banking Agencies submit to the CBBH notices on every methodological change that took place in the way of reporting certain categories.

Along with Agency's, two other sources of data are crucial for the implementation of the stress test. The first one is the Central Credit Registry of Business Entities and Natural Persons in Bosnia and Herzegovina, established and maintained in CBBH, provides the data for calculating credit migration rates. The data are in line with the IFRS 9 which was introduced in BH in 2020, as a way of interpreting the true economic value of a bank's primary product – loans – and better account for the level of credit risk in the banks. The tool is using all migration rates for household and corporate sector as input: three "deterioration" rates S1 → S2, S1 → S3 and S2 → S3, as well as three recovery rates: S2 → S1, S3 → S1 and S3 → S2. In addition, repayment rates for loans in S1 and S2, and write-off rates from S3 are calculated and used as input.

The final source of data are historical macro-financial data for BH such as GDP growth, inflation, interest rates etc. For every run of stress tests, these need to be updated to capture the starting point (the state of the economy) before the macroeconomic projections from the scenarios are added.

4.2. Scenario design

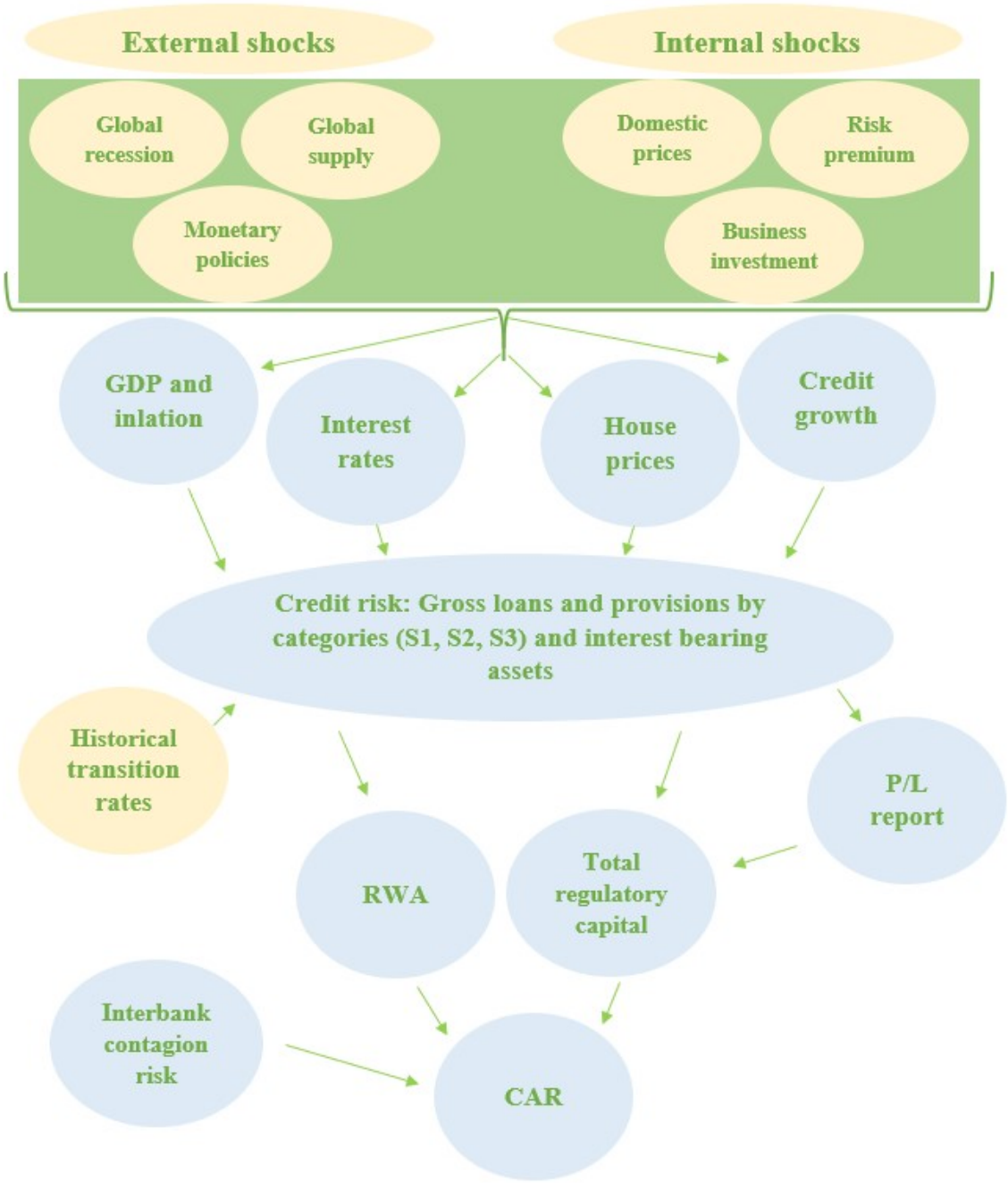
Calibrating macroeconomic scenarios represents a crucial block of the current stress tests. Three scenarios are prepared - a baseline and two adverse scenarios differing in the strength of the assumed shocks - for the next three calendar years. The baseline scenario is based on the most recent macroeconomic projections of the CBBH Chief Economist Office, the ECB and OECD projections for the European financial markets (long-term and short-term interest rates), and additional assumptions of the CBBH FSD including loan repayment and write-off rates related to the movements of relevant indicators in the BH economy, based on historical trends that are continuously monitored. Unlike the baseline scenario, the purpose of the adverse scenario is to test the resilience of the banking sector to severe but plausible shocks stemming from the macroeconomic developments, which, if materializing, could cause

significant damage to the stability of the banking system. Therefore, not only a scenario has to be severe in terms of the development of the main macro-financial variables, but it has also to be regarded as likely to materialize in respect to the consistency of the relationship of each macro-financial input variables with their current trend (EBA 2018). Ideally, complete macroeconomic models should be used as a tool that enables the development of economically consistent scenarios in which different shocks and reactions are meaningfully aggregated.

For the purpose of improving consistency of adverse scenarios used in the top-down stress test, the FSD recently started using the macroeconomic model of the CBBH Chief Economist Office for the adverse scenario calibration. FSD staff firstly identifies main upcoming risks for the macro economy and financial sector of BH in the near future and translates them into specific shocks which is one of the commonly used approaches in stress test scenario design (Baudino et al. 2018). It is to be noted that the stress scenario does not represent the CBBH's forecast or opinion about upcoming developments, but rather an exploration of the factors that could develop in a way unfavorable to the banks' balance sheets and business plans. It is necessary to define the following three inputs for each shock so that the model can assess the reactions of endogenous variables: 1) type of shock (which shock or which variable we shock), 2) duration of shock (reaction length will be endogenously determined by model mechanisms, but the duration of the shock must be predefined), 3) the strength of the shock (usually in % of baseline or share in GDP, etc.).

Possible shocks that can be simulated using the model could be foreign or domestic shocks including for example decline in GDP of main trading partners, consumer/producer confidence shock, oil prices shock, exchange rates, domestic or foreign interest rates, tax changes, changes in government spending, increased risk premium etc. When the shocks are specified, model estimates impulse responses of all endogenous variables to each of the shocks separately. Such reactions are then summed (due to model linearity) into one common reaction which is ultimately added to the baseline forecast to obtain an alternative scenario projection for the required set of variables including GDP growth, inflation, credit growth, interest rates and housing prices (see Chart 2).

Chart 2: Basic stress test framework in CBBH



4.3. Credit risk modeling

The stress testing tool explicitly projects transition rates (TRs) between IFRS 9 credit quality stages (S1, S2 and S3) in each of the projection years. Moreover, the tool is fully compatible with the IFRS 9 provisioning in which the loan loss allowance is calculated as expected credit loss for a 1-year horizon (S1 loans) or lifetime horizon (S2 and S3 loans, respectively, whereby a simplified approach for S3 is adopted).

The first step is the projection of the distribution of loans across the three IFRS 9 stages for all end-years of the projection horizon in each scenario, bank, and sector. This is done using an estimated transition matrix, whereby the projected TRs capturing the deterioration in quality (S1 → S2, S1 → S3, S2 → S3) are derived by satellite models while the recovery rates (S2 → S1, S3 → S1, S3 → S2) are relying on expert-based assumptions reflecting the last observed values and historical averages. Bank-specific initial TRs are used as a starting point. To arrive at the final distribution of the stock of loans for each bank, the projected migration matrix is complemented by assumptions about repayment rates for loans in S1 and S2, and write-off rates for S3 loans as well as assumptions about the assumed credit growth.

Satellite models were estimated using historical annual TRs for the corporate and household sectors obtained from the Central Credit Registry and selected macroeconomic variables (GDP growth, interest rates). The TRs were available from 2008 for both households and corporates. Given a reasonable length of most time series (10 years+) and coverage of a full financial cycle (run-up to the crisis 2007-2008, crisis period 2009-2013, recovery 2014-2017), the estimated links between TRs and macroeconomic variables are significant and suitable to be used in solvency stress tests. Final projections of transition rates over the projection horizon can be smoothed by different combination of weights of the model forecasts and the latest observations for each TR separately. Also, the satellite models allow for a possibility of add-ons to accommodate expert-based adjustment due to additional information. Even when the stress testing tools works with individual economic sectors, using sector-specific initial distribution of loans into S1, S2 and S3 stages, the estimated aggregate TRs for corporations are applied onto all corporate sectors and the TRs for households onto all household loan segments.

For the end-year stock of loans in individual sectors and IFRS 9 stages, the provisioning rates are calculated using the expected credit loss concept in line with the IFRS 9 rules. Thus, for S1 loans in each sector, the provisioning rate is equal to the product of the scenario-specific probability of default (PD), estimated as the TR (1-3), and the Loss Given Default (LGD), calibrated as a sum of the initial NPL coverage ratio (i.e. coverage of S3 loans by provisions in the same sector) and a scenario-specific expert-based add-on. For S2 loans, the tools includes a simulation module that generates the lifetime expected credit loss using the path of PD – here as the TR(2-3), as we are in stage 2 – LGD, interest rate, typical amortization schedule (to capture the time-varying exposure), and average maturity of the loans in the sector. Depending on initial parameter values and the scenario, the final lifetime loss rate

quite realistically captures the levels of S2 provisions observed at individual banks. Finally, the provisions for S3 loans are equal to the assumed LGD, i.e. the starting level of the NPL coverage (i.e. observed provisioning rate for S3 loans) adjusted by an expert-based add-on.

4.4. Interbank contagion module

In general, the interbank market plays an important role in the financial system by enabling the banks to manage short-term liquidity. However, it can also become a channel of contagion through which solvency or liquidity problems in one bank are transmitted to other bank or banks. The effect of interbank contagion risk, which is based on a network analysis of systemic risk spillovers in the BH banking sector, have also been incorporated in the new stress testing framework.

The main source of data for the interbank contagion is the information provided by two Banking Agencies on the quarterly basis (see Chart 1) on interbank exposures. The interbank market in BH is small and limited and therefore only few banks hold deposits at other banks (often the interbank exposure is to banks within the same banking group), but depending on the exposure size, there might be contagion effects.

The contagion module is relying on a concept of riskiness of the counterparty: each bank assigns a PD to the counterparty based on the counterparty's capital adequacy ratio (CAR) as follows: PD = 100% for negative CAR; PD = 75% for CAR between 0% and 8%; PD = 50% for CAR between 8% and 10%; PD = 25% for CAR between 10% and 12%; PD = 0% for CAR greater than 12%. This structure operationalizes the assumption that if a bank has its CAR above the regulatory minimum of 12%, the risk is virtually zero, but once the capital adequacy goes below the minimum – for example in times of adverse economic developments – the risk increases disproportionately. Each bank is assessing the riskiness of its counterparties and creates additional provisions equal to the expected loss from interbank exposures PD×LGD×EAD, where the EAD is the net interbank exposure (interbank deposits data) and the LGD is assumed to be 100% as interbank exposures are mostly unsecured.

If a bank's CAR declines under the regulatory minimum and its PD increases, for example as a result of the impact of macroeconomic stress on the banks' credit portfolios in an adverse scenario, all banks having interbank exposure vis-à-vis such bank would need to create additional provisions. However, for some of them, the additional provisions could bring their own CAR under the minimum, causing problems to yet other banks etc. The calculation continues in several rounds until the "domino effect" of interbank contagion ends which

means until the rise in PD induced in one bank or group of banks does not lead to a rise in the PD of other banks. Having in mind that interbank market is quite limited in BH banking sector, typically there is no significant effect of the interbank contagion, i.e. a reported reduction in the capital ratio of any bank after the first round of calculation normally does not bring down another bank.

It is important to point out that the interbank contagion module is integrated in the stress testing framework, but only in the adverse scenarios as no interbank contagion is assumed for baseline scenario. The effects of this risk are assessed at the end of the third year of the stress test (i.e. the CARs from the third year are used to calculate the initial PDs). The final impact of the interbank contagion goes back to the capital adequacy and this ratio after interbank contagion is concluding the results of the stress test (see Chart 2).

4.5. Projections of P/L account items, regulatory capital and capital adequacy

Depending on the input data, scenario parameters, and several other assumptions, the stress test model projects the bank-specific key P/L account items net interest income, other operating income and expenses, and impairments. As a result, gross and net profit after tax are calculated.

The projection of the net interest income for each bank is using the projected changes in net interest margin (calculated as initial banks-specific margin and expert-based reduction, especially for adverse scenarios, reflecting an increase in funding costs) and the evolution of risk bearing assets. Net interest margin is calculated as the net interest income divided by interest-bearing assets. These are projected endogenously in the tool, themselves depending on the assumed credit growth and the migration from performing (S1 and S2) to non-performing (S3) loans (see Chart 2), as S3 loans are not bearing any interest income. It is possible to specify whether the net interest margin of the last period or an average of last three years should be used as the starting point, depending on whether the last period was somehow specific (and not representative enough) compared to previous years or not.

Operating income and expenses for each bank can be kept at the same level as in the last year (or at an average of two or three last years), or percentage change can be assumed as a specific parameter in any of the scenarios for entire time horizon of the stress test. Typically, baseline scenario would use the last year's level of operating income, or in case economic activity grows significantly, some increase in proportion to nominal GDP growth, while for

adverse scenarios, haircuts of a few percentage points would be applied. Operating expenses are kept at the constant level across the stress test horizon.

Impairment (credit losses) is calculated separately for legal entities and households, taking into account the change in the stock of provisions adjusted for write-offs, and sovereign exposures, with impairments calculated in line with the IFRS 9 using an increase in provisioning due to deterioration of the credit rating and thus the implied PD.

The tool also includes a market risk module that calculates losses due to revaluation of securities held by banks. However, given that most securities are held to maturity and the revaluation is typically very small, this feature is typically not used. Government bonds held are instead subject to sovereign credit risk loss allowance in line with IFRS 9. Given the currency board structure in BH, i.e. a hard peg of the currency to euro, no FX risk is assumed and tested.

The final P/L is then explicitly calculated from the above-mentioned items, whereby the tool includes a possibility for bank-specific dividend payouts. Dividend payouts are useful to consider if banks pay out dividends regularly, as without it the capital adequacy ratio would significantly increase in the baseline scenario. Typically, it is assumed that banks pay out 50% of their net profits. In accordance with the applicable regulations, dividends are allowed if the CAR for an individual bank is higher than 14.5%. The final P/L result, adjusted for potential dividend payout, is then kept as retained earnings, influencing the banks' regulatory capital.

Regulatory capital in all alternatives (Total, Tier 1, and CET1) is projected using the starting level, additions (retained earnings, if any), and reductions (net losses from P/L). The Tier 2 is not assumed to be changed. Given the tool also includes an interbank contagion module, the calculation of the total capital adequacy ratios is done twice: once after credit, market and income shocks, with the resulting CARs used as inputs for the interbank contagion exercise, and once again, after the interbank contagion is run, assumed to happen at the end of the horizon, which adjusts both capital (losses directly booked against it on interbank exposures) and RWA (assuming a 100% risk weight on interbank exposures).

Risk-weighted assets are projected in a simplified way by using the net exposures (calculated from the credit portfolios after provisions over the horizon) and the initial bank-specific average risk weight. This is a relatively good approximation as all banks in BH use the standardized approach to credit risk capital requirements, where risk-weights for individual types of exposures typically do not change over time.

The basic stress test results are expressed in terms of capitalization (capital adequacy) of the banking system as a whole and also of individual banks. The final result of the stress test also provide information on:

a) how many banks (and which) would within the three year time horizon record a fall below the CAR regulatory minimum of 12%;

b) what is the capital shortfall for each bank (recapitalization needs in order to reach the minimum capital regulatory requirement of 12% CAR) and

c) what is the aggregate capital shortfall for the whole system in % of nominal GDP.

The final results are presented in terms of a "contribution" chart, with the change between the starting and the final level of capital adequacy being explained by the key contributing factors (net interest income, credit losses, net operating income, dividend payouts, taxes, interbank contagion, and changes in risk-weighted assets). These charts can be set for the banking sector as a whole or for the individual bank. As seen in the illustrative charts below from the Financial Stability Report 2020 for the two adverse scenarios, the decline in the capital adequacy ratio in the three-year period was mostly affected by credit losses due to the increase of provisions for non-performing loans.

Chart 1. Contribution of individual items on capital adequacy ratio, Adverse 1, 2020 Q4

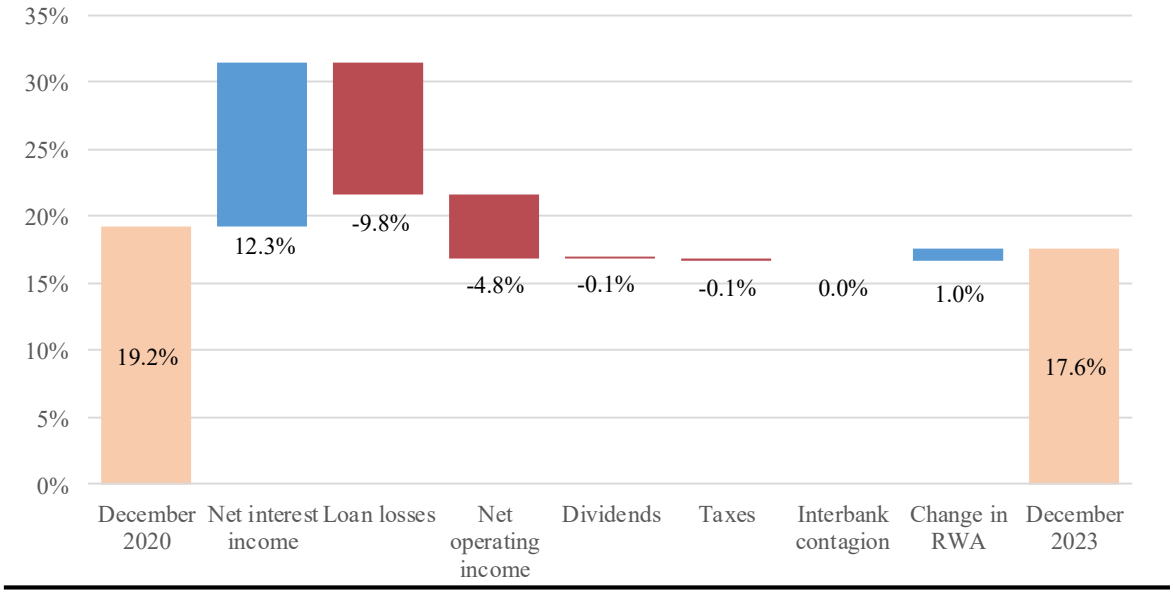
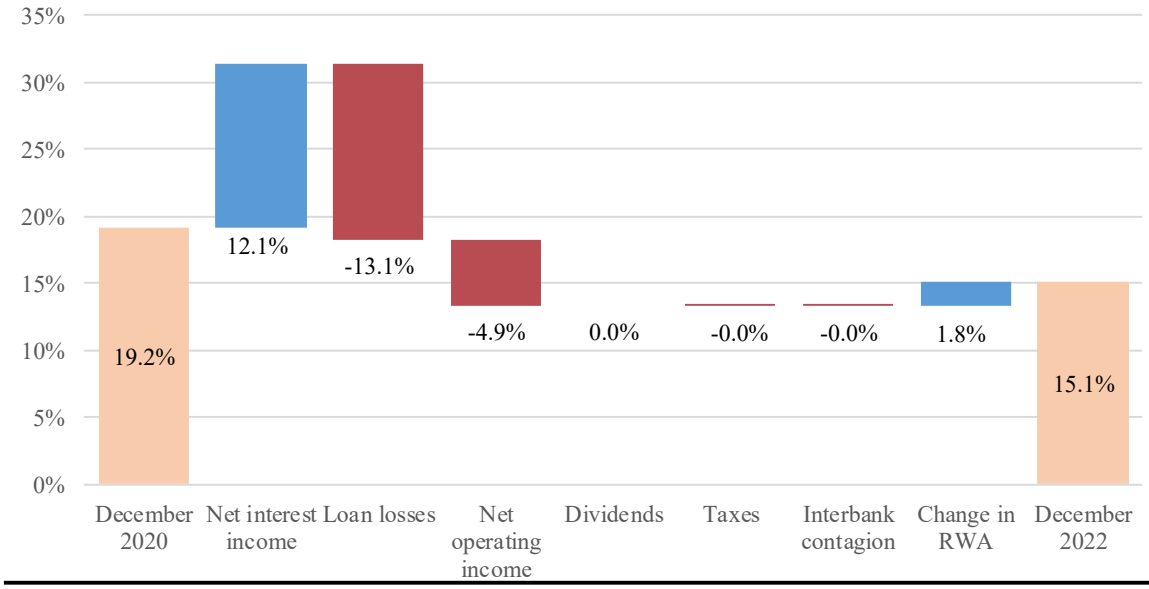


Chart 2. Contribution of individual items on capital adequacy ratio, Adverse 2, 2020 Q4



4.6. Publication and communication of the stress test results

Stress test results are used for two main purposes. Primary goal of conducting stress test is to assess the resilience of the financial sector to severe but plausible shocks, which forms and important component of systemic risk surveillance aimed at preserving financial stability. When analyzing the results of top-down stress tests, it should be noted that the focus of stress tests is to test the resilience of the entire banking sector to potential shocks and not to determine the recapitalization needs of individual banks. Since stress test are based on plausible but highly unlikely assumptions or events, it is natural that these events may produce negative effects on entire financial system. Failing to meet minimum regulatory capital requirements in solvency stress test does not necessarily mean that a specific bank faces with problems in their operations but indicates the a bank is more vulnerable to assumed shocks and could not keep their operations unhindered in case such events materialize. Another important aspect of using stress tests is for supervisory purposes. Banking supervisors use stress tests as an additional tool for assessment of risks in individual institutions. Additionally, discussing the stress test results with banks contributes to improving the banks' risk management practices and to a better understanding of the risks and threats arising from the macroeconomic developments, including to raise awareness of the potential systemic effects of their individual activities and policies. Nevertheless it should be noted that the stress test results are not the only and sufficient instrument based on which supervisors can determine recapitalization needs of individual banks. The results for

individual banks in top-down stress test are obtained using common assumptions applied for the entire banking sector, not sufficiently taking into account the specifics of individual banks. Given this fact, it is possible that the risks in some banks can be either overestimated or underestimated. As already mentioned, a better approach to top-down stress test results is to use them as a benchmark for bottom-up stress test results performed by individual institutions which better take in the account all the necessary specifics.

In order to strengthen financial stability and enhance confidence in the banks, CBBH have established several channels for communication of the stress results. First, the CBBH FSD prepares an internal quarterly Report on stress test results that includes a detailed explanation of the scenarios and the stress test results by individual banks as well as banking sector as a whole. The CBBH shares this Report as well as the stress test file with both Banking Agencies and the IMF, given the ongoing IMF programs and the involvement of the IMF in financial sector policies. Second, the CBBH FSD also prepares the Report on stress test results aggregated on banking sector level and shares it with the Banking Agencies and the other members of Standing Committee for the Financial Stability of BH (three Ministries of Finance, at state and entity level, and the Deposit Insurance Agency) as well as with the European Commission. Finally, the year-end stress test aggregated results (stress tests based on Q4 data) are an integral part of the annual public FSR and as such have been distributed to a wide-range of readers in the country and abroad.

Box: Model-based scenario design for 2022-2024

With the end of 2021, the FSD and the Chief Economist Office of the CBBH have calibrated three macroeconomic scenarios (one baseline and two adverse) for the stress test exercise using the official macro-economic projection model. The model took into the account a wide range of economic variables and indicators (both domestic and foreign) and produced projections for the 2022-2024 period.

As for the baseline scenario, the macro-projections were aligned with the official macro forecast of the CBBH published in November 2021. The official projections were extended by one year, with the technical assumption of unchanged growth rates from 2023 in the last year of the simulation horizon. The adverse scenarios incorporated numerous hypothetical shocks which could emerge on the global and domestic economic and financial landscape. The nature of hypothetical shocks for both adverse scenarios are identical, but their magnitude differs - a

slightly milder economic contraction is assumed in Adverse 1 compared to Adverse 2 scenario where the recession is much stronger with no signs of a rebound during the observed period. Global risks, which we have assumed, are (i) a global recession (in particular in the EU as our most important trade partner), (ii) a global upswing in consumer prices (oil, food, etc.), and (iii) a foreign monetary policy rate shock which could elevate Euribor rates.

At the same time, the main internal shocks include the increase in domestic consumer prices (increase of energy prices which could result in chain reaction of other CPI components), elevated risk premium (rise of interest rates), and a drop in business investment (decline in both public and private investment amid declining FDI inflows). External shocks reflected in global recession and inflation are on the forefront of the negative impact in adverse scenarios. These two hypothetical shocks would consequently drag the BH economy into a recession territory, primarily by reduced export of goods and private consumption.

Because the COVID-19 pandemic has led to significant global disturbances in supply chain over the past quarters, in our adverse scenarios we expect that such disturbances will deepen even further, hurting the BH trade performance on both sides of the trade balance but more strongly on the export side. Along with the impact on the trade balance, global supply disorder is also expected to drive up the commodity prices (primarily oil and energy prices).

In Adverse 1, we assume that the increase in oil and other commodities prices, which began in 2021, will continue through 2022 and only in mid-2023 a gradual weakening of inflationary pressures is assumed. In Adverse 2, we expect additional price pressure even in the last year of the projected period. Thus, in order for the scenarios to be consistent, a gradual increase in interest rates of most important central banks (primarily the ECB) is assumed in both adverse scenarios, as a result of the described inflationary pressures. In Adverse 1, increase in interest rates is expected to be somewhat milder compared to one expected in Adverse 2. Tightening of conventional monetary measures will spill-over onto the money market rates in Europe, which will increase disproportionately due to an assumed increase in risk premium amid the adverse economic development. The increases in the euro area reference interest rates along with the growth of risk premium in BH will influence lending conditions in BH and push domestic interest rates up, which would additionally dumper the GDP performance, already hurt by the previously mentioned aggregate supply shocks. Rising interest rates in retail segment would further narrow private consumption, while in such economic conditions, we also cannot expect positive push from the side of corporate lending and investments.

The impact of the above-mentioned shocks on the key macroeconomic variables (GDP, inflation, interest rates and house price growth) are presented in the table below. Finally, it should be noted that with every run of the stress test, such hypothetical shocks can be varied up or down depending on the economic environment.

Basic stress test assumptions

in %

	Baseline scenario			Adverse scenario 1			Adverse scenario 2		
	2022	2023	2024	2022	2023	2024	2022	2023	2024
Real GDP growth	3.9%	2.1%	2.1%	-1.1%	-0.2%	0.2%	-2.1%	-2.5%	-2.4%
Inflation	2.1%	1.4%	1.4%	3.5%	3.8%	1.9%	4.2%	4.9%	5.7%
Credit growth - NFC*	1.5%	2.0%	2.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Credit growth - HH*	4.6%	4.5%	4.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Interest rates - NFC	3.8%	3.9%	4.1%	4.1%	4.6%	5.0%	4.2%	5.0%	5.6%
Interest rates - HH	5.5%	5.7%	5.8%	5.8%	6.3%	6.7%	6.0%	6.7%	7.2%
House price growth	1.6%	1.8%	1.8%	-2.7%	-4.8%	-4.6%	-3.6%	-7.9%	-11.3%

* In both adverse scenarios, it is assumed that there will be no credit growth, ie that the level of total loans to nonfinancial private companies and households will not change during the stress test horizon compared to the level at the end of 2021. Credit growth assumption in adverse scenarios is not model based.

5. Assessment of the projection accuracy

To verify whether the new stress testing framework represents an improvement over the previous approach in terms of being able to project well the banking sector indicators, we have compared the accuracy of projections for 2019 and 2020 under the new approach with the accuracy of projection for 2011 to 2018 under the old approach. We used only the baseline scenario projections and since alternative scenarios are unlikely events which in most occasional have not occurred and thus their predictions is impossible to assess in terms of accuracy.

To assess the accuracy of projections, we took baseline predictions of capital adequacy, non-performing loan (NPL) ratio, net profits, and credit losses for the nearest year-end from all quarterly stress tests conducted between Q4 2010 to Q4 2020 and compared them with the outturns. For example, the stress tests of Q4 2014, Q1 2015, Q2 2015 and Q3 2015 all give predictions for end-2015 (Q4 2015), while stress tests of Q4 2015 give the prediction for the next year-end (Q4 2016). Thus, there are always 4 predictions for each year-end, and these are compared with the outturn (the observed value).

The predictions from Q4 2010 to Q3 2018 are made using the old approach while predictions from Q4 2018 to Q4 2020 are made using the new approach.[1] The accuracy is measured by the mean absolute error (MAE) defined as:

$$\frac{1}{n}\sum_{t=1}^{n}|P_t - A_t|$$

where P_t denotes the value of the nearest year-end projection of a selected variable from the stress test conducted in quarter *t*, while A_t denotes the actual value of the variable at the nearest year-end after quarter *t*.[2] We have calculated the MAE of key variables for the period between Q4 2010 and Q3 2018 (old approach) and for the period Q4 2018 until Q4 2020 (new approach) for the purpose of comparison between the two different stress testing approaches, but we also calculate the MAEs for various subperiods and show the individual projections and outturns in charts.

The most important output variable of the stress tests is the estimate of the capital adequacy (CAR). Here, following Gersl and Seidler (2010), we also report the MAE for the case in which we would have known the path of the macroeconomic variables (i.e. instead of using the baseline macro projection, the observed developments now known were used). The prediction errors of CAR can namely be divided in two components: first, potential prediction error due to inaccuracy in the prediction of main macroeconomic variables, and second, an error caused by the assumptions and sub-models used in the stress test framework.

Table 2 shows that the accuracy of the CAR projections has improved with the new framework. The MAE for CAR for the period 2011-2018 was 1.16 ppts, while for 2018-2020, after the implementation of the new stress test framework, it has declined to 0.78 ppts. After calculating the MAE of CAR, using the actual (ex post) values of macroeconomic variables in the baseline scenarios, we concluded that only a small portion of the error is caused by the error in the macroeconomic forecasts as the MAE statistics with the known macro decreased only modestly and not even in all observed periods (Table 2). Thus, the macro predictions are relatively accurate, with most of the projection errors being due to the stress testing models and assumptions.

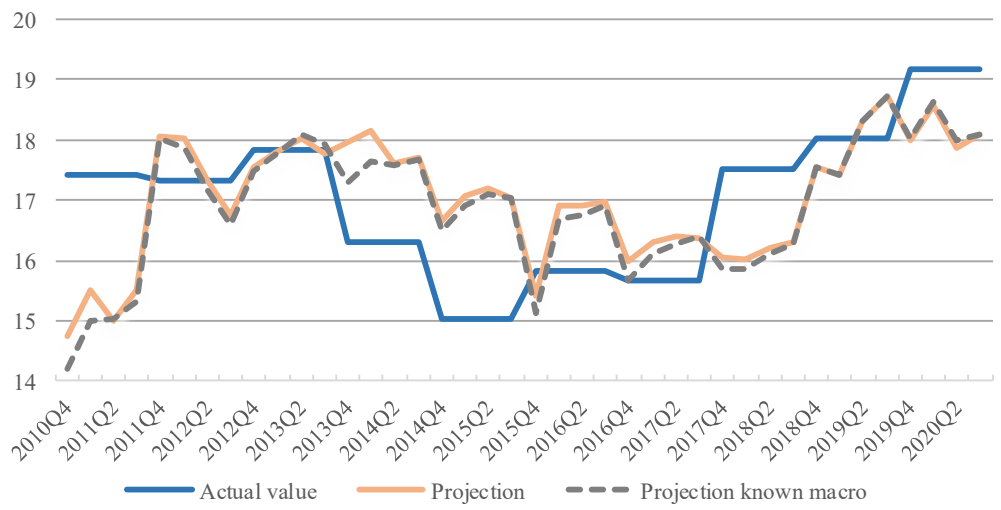
[1] The Q4 2010 prediction means that initial bank data used in stress tests were as of Q4 2010.
[2] We have also used the Root Mean Square Error (RSME) as an alternative but the results are essentially the same, so we report only the MAE.

Table 2: Mean average error of the capital adequacy ratio (CAR) projections

Period	2018-2020	2011-2018	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015	2015-2016	2016-2017	2017-2018	2018-2019	2019-2020
MAE	0.78	1.16	2.24	0.51	0.14	1.55	1.95	0.94	0.59	1.38	0.52	1.05
MAE-known macro	0.75	1.15	2.54	0.52	0.19	1.25	1.85	0.90	0.44	1.50	0.52	0.99

While in general it is good to strive for as accurate projections as possible, errors of less than one percentage points are acceptable especially if the projections are on average underestimating the observed CAR (i.e. negative errors prevail). As Gersl and Seidler (2010) emphasize, the stress test framework should be calibrated conservatively, i.e. should on average somewhat overestimate risks and losses. When assessing baseline projections, accurate or slightly lower than ex-post observed values should be the norm. Chart 3 shows that this has happened with the new framework, as under the old one, especially between 2013 and 2017, the projections were too optimistic.

Chart 3: CAR end-year projections compared to the actual value (in percent)



Note: The orange line represents the projections for the nearest year-end from the stress tests conducted with the initial data at the quarter as captured by the horizontal axis. The blue line shows the actual value of the nearest year-end corresponding to the projection, and the gray dashed line indicates projected value using the actual (ex post) values of macroeconomic variables.

Second closely monitored indicator projected by the stress test is the NPL ratio. Table 3 shows that also here, the MAE is significantly lower in the period 2018-2020 after the implementation of the new stress testing framework (0.85 ppts) compared to the period 2011-2018 (1.70 ppts). If we eliminate the influence of error in the macroeconomic forecasts, using the actual (ex post) values of macroeconomic variables, we can conclude that the greatest

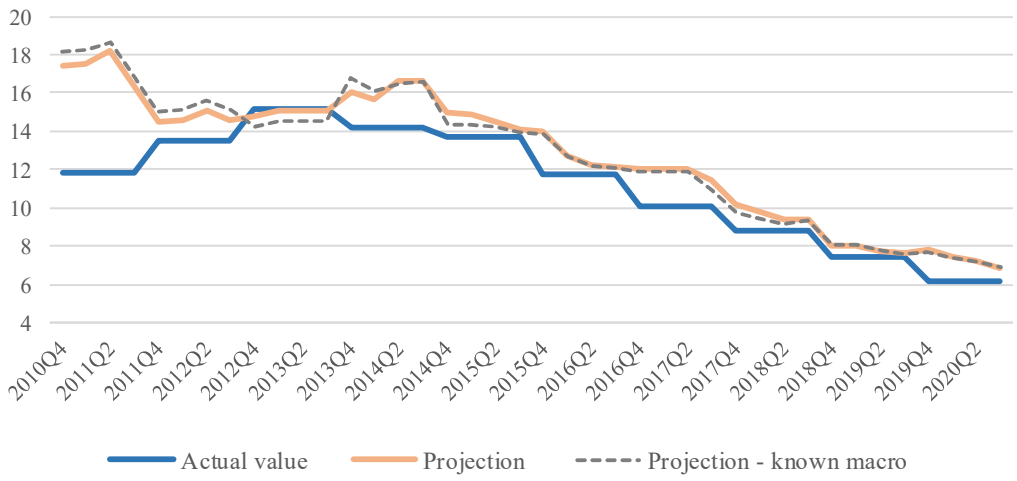
portion of the error is caused by models and assumptions used in the stress test, and the accuracy of the NPL projections has improved with the new stress test framework.

Table 3: Mean average error of the non-performing loan (NPL) ratio projections

Period	2018-2020	2011-2018	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015	2015-2016	2016-2017	2017-2018	2018-2019	2019-2020
MAE	0.85	1.70	5.59	1.21	0.10	2.09	0.89	0.99	1.82	0.91	0.46	1.24
MAE-known macro	0.81	1.81	6.15	1.76	0.66	2.32	0.48	0.92	1.59	0.64	0.46	1.15

A comparison of the predictions and the actual NPL ratio for the banking system reveals that the predicted values have been typically overestimated under both the old and the new approach, but they are more accurate under the new one (Chart 4). The prediction error of the NPL ratios in the period from 2010 to 2011 is an outlier since the regulatory treatment of the NPLs in the lowest category (loss loans) was changed in that time and these loans – while being accounted for only in off-balance until 2010 - became a part of banks' balance sheet since 2011, increasing the total amount of NPLs.

Chart 4: NPL ratio end-year projections compared to the actual value (in percent)



Note: The orange line represents the projections for the nearest year-end from the stress tests conducted with the initial data at the quarter as captured by the horizontal axis. The blue line shows the actual value of the nearest year-end corresponding to the projection, and the gray dashed line indicates projected value using the actual (ex post) values of macroeconomic variables.

Finally, we assess the accuracy of projections for two important P/L variables, namely the net profit (as this is the main source of banks' capital via retained earnings) and credit losses (impairments). For simplicity, we only show the charts comparing the predictions and the actual values. Also, here, visually, the net profit projections have become more accurate, especially for 2019, although they are slightly overestimating the actual profitability (Chart

5). The only year in which the net profit were significantly underestimated was the year 2020, which happened in many countries. Given the decline in GDP due to the Covid-19 crisis, the stress tests have projected large credit losses (Chart 6), but the actual impairments were muted due to the regulatory measures such as moratoria on debt repayments etc. Apart of 2020, though, the projections of credit losses became more accurate with the new framework and are now conservative (higher predicted credit losses that actual values).

Chart 5: End-year projections of net profit compared to the actual value (BAM million)

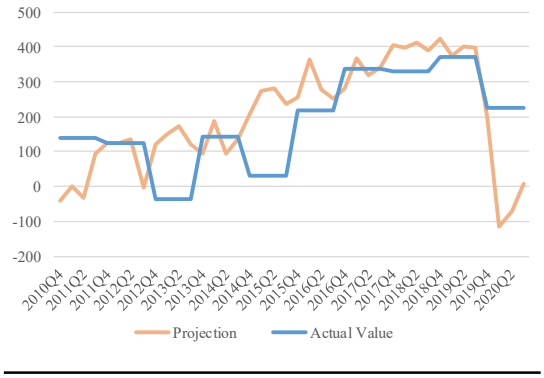
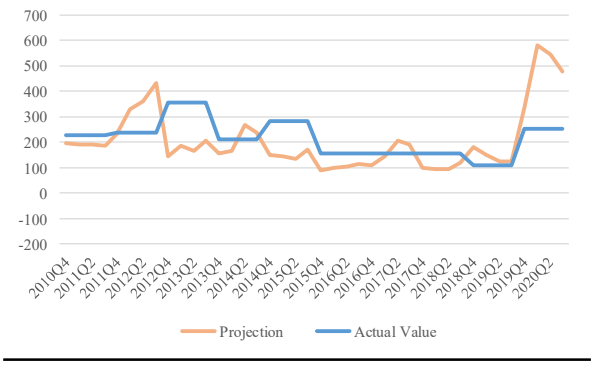


Chart 6: End-year projections of credit losses compared to the actual value (BAM million)



Note: The orange line represents the projections for the nearest year-end from the stress tests conducted with the initial data at the quarter as captured by the horizontal axis. The blue line shows the actual value of the nearest year-end corresponding to the projection.

When assessing the main stress test results, we have to bear in mind that 100% accuracy in projecting the main banking sector indicators cannot be expected from the stress test exercise as such predictions exceed the scope of the top-down stress testing framework and goal of the exercise itself. The stress test projections should capture the main trends within the banking sector performance under various circumstances and be broadly accurate, ideally with a conservative margin. In line with such defined goals, the stress tests conducted at the CBBH FSD have played this role quite well, despite the above-mentioned deviations from actual values. This stands especially true for the period after the implementation of new stress framework which brought numerous improvements in methodology of assessing the impact of materialization of various risks for the banking sector.

The new framework was implemented just before the economic crisis triggered by the COVID-19 pandemic, which is an unprecedented economic shock in the modern history, creating an environment of uncertainty manifested in unstable projections susceptible to constant revisions. Despite such unstable environment, the top-down stress tests managed to display reasonable predictions, even with a lower mean absolute error for selected key

banking indicators compared to the periods before the crisis. Nevertheless, our exercise indicates that there are areas of improvements that should be performed in the nearest future.

6. Conclusion

The Central Bank of Bosnia and Herzegovina has been carrying out top-down solvency stress tests for the banking sector of BH since 2007. The stress testing framework has been continuously developing and significant progress has been made. The current stress testing tool was developed in 2018-2019 and fully reflects the changes in the regulatory framework, especially the implementation of the new provisioning standard IFRS 9. The main focus of the stress testing framework remains to be credit risk, but income risk, interbank contagion, and a market risk module for government bond revaluations are also incorporated.

This paper reviewed the new stress testing framework, including the data sources used, scenario design, credit risk modeling, and interpretation of the results. As the stress test results are typically expressed in terms of the capitalisation of the banking system, we show how the individual factors such as credit losses, pre-provision income, dividend payouts or changes in risk-weighted assets contribute to the evolution of capital adequacy in various scenarios. Credit losses typically give the most significant negative contribution to the capital adequacy ratio under stressed conditions.

We also assessed the accuracy of predictions of both the new and the previous stress testing framework. While the accuracy has in general improved with the implementation of the new models and assumptions, a better projection of credit risk and banks' net profits are desirable. The ongoing cooperation between the Chief Economist Office and FSD within the CBBH should also result in better macroeconomic projections as well as improvements in adverse scenario calibration.

One area that has remained underdeveloped in the current stress tests is the impact of market risk. Calculating the impact of potential bond portfolio revaluations due to adverse market developments should be in focus of further stress test development given the fact that debt instruments represent a significant share in total assets of almost all banks and can trigger significant changes in the profit/loss structure.

Finally, cooperation between the CBBH FSD and the Banking Agencies in calibrating common scenarios for both the top-down and the bottom-up stress tests should be continued in the following years. Top-down and bottom-up stress test results should be compared and differences discussed between the CBBH and Banking Agencies and used to improve both

frameworks. All above mentioned improvements should further strengthen the reliability of the final results, fulfilling the main aim of the exercise to better understand the financial position and risks of the banking sector.

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