Results of the first dynamic balance sheet stress test in the ARNIE framework

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Stress tests have become an important element of the supervisory review process for banks and an important tool for financial stability analysis. Including balance sheet dynamics substantially improves stress tests by reducing the need for implicit assumptions, thereby making them more realistic and enabling more flexible analyses. After years of work on the dynamic balance sheet stress testing model and its integration into the larger OeNB stress testing infrastructure (ARNIE), this paper presents the first dynamic balance sheet exercise by the OeNB, conducted in parallel with the annual static balance sheet stress testing exercise. The dynamic balance sheet model predicts that, in the baseline scenario, capital ratios stay relatively flat, showing that banks grow their balance sheets instead of hoarding capital. The aggregate CET1 ratio in the baseline scenario increases from 17.6% to 18%, with average annualized credit growth of 3.8%, compared to an increase to 19% in the static exercise. In the adverse scenario, credit growth at the system level slows down to practically zero over the course of the scenario horizon, but it does not turn negative because well-capitalized banks grow their balance sheets, gaining market share from capital-constrained banks that have to engage in deleveraging. The result is that growth of better-capitalized banks effectively compensates for deleveraging pressures from undercapitalized banks. The average annualized credit growth in the adverse scenario is 1.1%, leading to a CET1 ratio that is 0.4 percentage points lower than in the static exercise. This lower CET1 ratio is only true in the aggregate; granular results show a clear difference between undercapitalized banks, which undergo substantial deleveraging, and well-capitalized banks, which continue growing their balance sheets. We discuss these results and present an outlook for the future development of our dynamic balance sheet model.

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In the aftermath of the global financial crisis, banking supervisors around the world, including the European Banking Authority and the US Federal Reserve, started conducting stress testing exercises with an explicit focus on their use as a supervisory tool. In the EU, for example, Article 100 of the Credit Requirements Directive, as amended 2024, mandates competent authorities to carry out, at least annually, supervisory stress tests on institutions they supervise. Despite the efforts to provide unified guidance for the development of stress testing frameworks in line with best practices summarized in the BCBS stress testing principles (BCBS, 2018), no single stress testing approach has emerged, as different objectives lead to conflicting priorities (Drehmann, 2008). Supervisory stress tests typically have a stand-alone perspective at their core, without dynamics, second-order effects and interbank linkages (Borio et al., 2012). Especially in bottom-up settings, where

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banks calculate results, simplified methodologies and strict guidance help enforce conservatism.

The static balance sheet (SBS) assumption implies that banks cannot change their business model in reaction to shocks, and no additional steps are taken by banks to offset the adverse macroeconomic developments. In practice, it means that the size and composition of the balance sheet remains unchanged throughout the exercises' horizon – assets and liabilities maturing over time are replaced with instruments similar to those at the start of the exercise. While such a simplification helps to ensure that individual banks will generate results that are roughly consistent and comparable to one another, it comes with numerous drawbacks. The simplifying approach does not take into account management interventions to respond to the shocks, thus preventing banks from reacting to adverse market conditions, most notably by deleveraging.

To address these weaknesses, supervisory authorities have sought to add dynamic elements to their stress tests for nearly a decade, longer in some cases. According to a survey of 31 authorities and 54 banks conducted by the Basel Committee on Banking Supervision, nearly half of supervisors use an SBS approach, but only one in five banks used this approach for their internal risk management (BCBS, 2017). Furthermore, top-down stress tests conducted by all major supervisory authorities, including the ECB, Fed, SNB, BoE and BoJ, already use some form of dynamic balance sheet (DBS) approach in their stress testing methodologies. This ranges from a simple proportional credit growth in line with projected industry-wide loan and asset growth to more elaborate modeling of optimized portfolio structure and allowing for management actions (Baudino et al., 2018).

At the OeNB, top-down stress tests were initially inspired by early works of Elsinger et al. (2006) on risk assessment in banks. They initially focused on financial stability with an aim to quantify systemic risk rather than to assess individual institutions (Boss et al., 2006). Due to the short observation period of one quarter, the implicit SBS assumption played a minor role. But even the subsequent multiperiod extensions of the approach used by the OeNB that resulted in the development of the Applied Risk, Network and Impact assessment Engine (ARNIE) and incorporated contagion analysis and solvency-liquidity feedback still relied on the SBS assumption (Feldkircher et al., 2013). In line with the aforementioned international efforts to consider more dynamic elements in stress tests and a more general push to make stress tests more macroprudential, while further enhancing the usefulness of stress tests for microprudential purposes, creating a DBS extension for ARNIE has become a priority of stress test development work at the OeNB.

In this paper, we present the first results of this ongoing work. First, we describe the scenario and results of the OeNB's first DBS stress test. Second, we compare the results to those of an SBS calculation given the same underlying scenario. Then we discuss the impact on results and its implications for our analyses. We conclude by providing a brief outlook on our next steps.

1 Scenarios and results

In this section, we present the scenario and the main results of the 2024 OeNB DBS stress testing exercise as well as the results of the SBS exercise. The results were computed using our ARNIE framework (Feldkircher et al., 2013), which has two different configuration options for DBS and SBS stress tests. The stress test covers both significant and less significant institutions at the highest consolidated level. Bank-level data are obtained from the regulatory reporting system. The methodology of our DBS model focuses on credit growth as the banks' main adaptation mechanism. The credit growth model considers macroeconomic conditions as well as bank-level profitability and capitalization/growth constraints. Growth constraints are considered in both directions, i.e. there are limits to both how fast a bank can grow and shrink its credit portfolio in a given amount of time. These limits move dynamically with the evolution of the bank's balance sheet. Due to space constraints, the present article focuses on presenting the results of our first DBS stress test exercise; a separate publication with details on the methodology will follow.

1.1 Scenarios

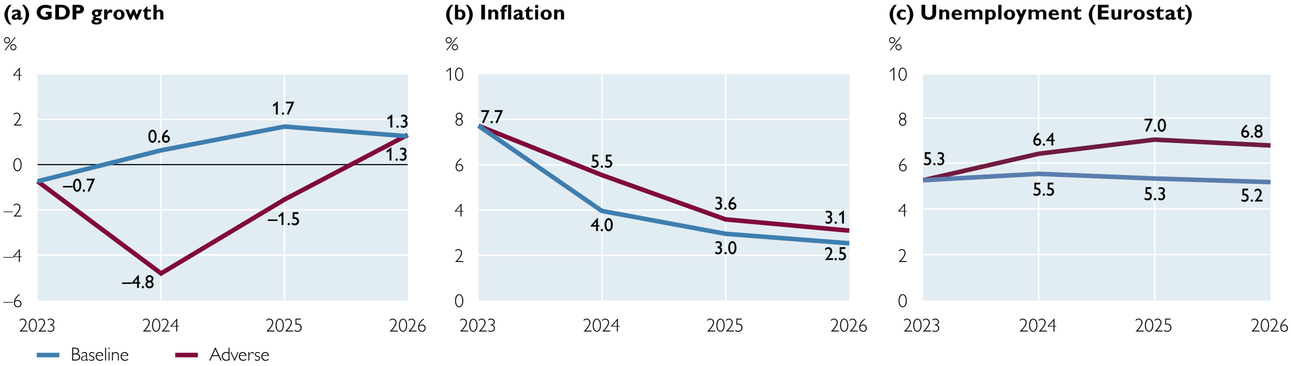
We consider two scenarios, a baseline scenario based on the OeNB's December 2023 Economic Outlook for Austria and an adverse scenario. The scenario horizon covers the period 2024–2026; chart 1 shows the evolution of GDP, inflation and unemployment in both scenarios. The *adverse scenario assumes a severe macroeconomic downturn* marked by a sharp decline in output, increase in unemployment and a slow decline of inflation. The baseline scenario projects a slow recovery of output and inflation. *Cumulative GDP growth* is 3.6% in the baseline scenario and *–5.0% in the adverse scenario.* Inflation drops from 7.7% to 2.5% in 2026 in the baseline scenario and declines to 3.1% in the adverse scenario, staying well above historical averages in both scenarios. Unemployment (Eurostat definition) grows from 5.3% to 6.8% in the adverse scenario and remains relatively flat in the baseline scenario, falling to 5.2%.

1.2 Results

Results for both the DBS and SBS configurations were computed based on the same baseline and adverse scenarios. Chart 2a shows the evolution of the aggregate common equity tier 1 (CET1) ratio for the Austrian banking system in both scenarios for both the DBS and SBS configurations. The aggregate CET1 ratio grows from 17.6% to 18.0% (DBS, +0.4 percentage points) and 19.0% (SBS,

Chart 1

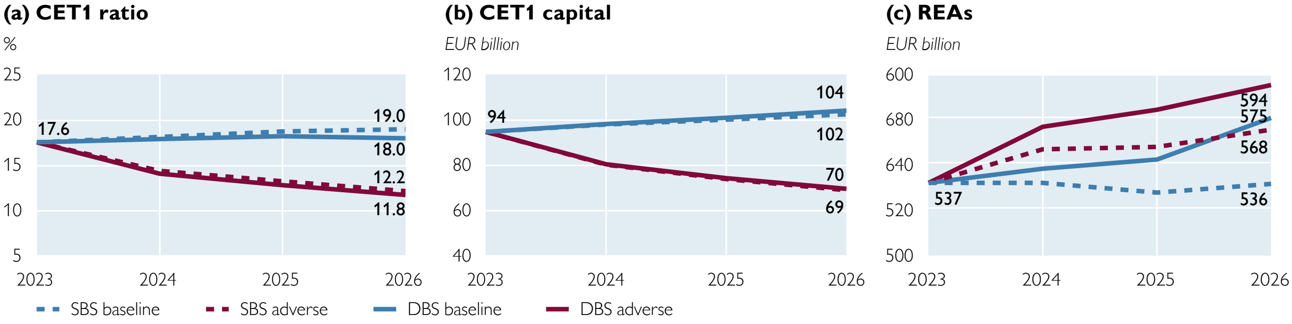
Scenario paths for Austria



Source: OeNB.

Chart 2

Comparison of results between DBS and SBS



Source: OeNB.

+1.4 percentage points) in the baseline scenario. In the adverse scenario, the aggregate *CET1 ratio decreases by 5.8 percentage points to 11.8% in the DBS* configuration and by 5.4 percentage points to 12.2% in the SBS configuration. Charts 2b and 2c show the breakdown of the CET1 and risk exposure amount (REA) components of the CET1 ratio.

Moving from SBS to DBS has a substantially larger impact on REAs than on CET1 capital: In the adverse scenario, REAs are 10.6% higher in 2026 than the starting value in the DBS configuration, compared to an increase of 5.8% in the SBS configuration, a delta of 4.8 percentage points. In the baseline scenario, REAs are practically flat in the SBS configuration at –0.1% compared to +7.0% for DBS, a delta of 7.2 percentage points (numbers do not add up due to rounding). By comparison, the delta for CET1 capital is only 1.7 percentage points in the baseline scenario and 0.6 percentage points in the adverse scenario. A stronger reaction of REAs than CET1 capital to credit growth is to be expected, as REAs directly increase when new loans are granted, whereas capital only grows over time, through the positive P&L contribution of profitable businesses.

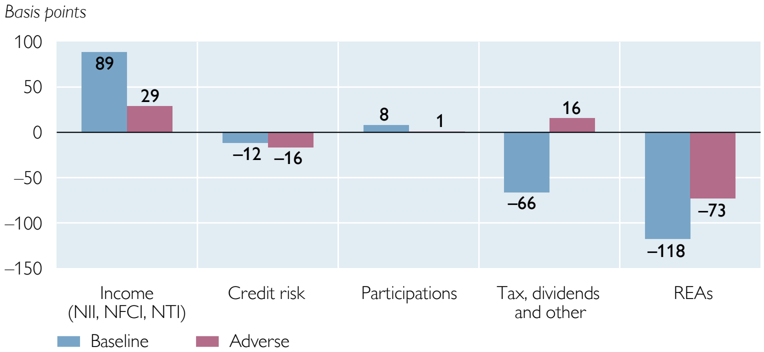
Chart 3 shows a breakdown of various drivers explaining the overall difference in the aggregate CET1 ratio between the DBS and SBS configurations. In line with the above discussion, *REAs are the most important driver of differences between the results of the DBS and SBS exercises:* REA changes drive the aggregate CET1 ratios by 118 basis points lower in the DBS configuration than in the SBS configuration in the baseline scenario, and by 73 basis points lower in the adverse scenario. These changes are partly offset by changes to income components, which – considered in isolation – increase the CET1 ratio in the DBS configuration by 89 basis points in the baseline scenario and by 29 basis points in the adverse scenario, as compared to the SBS configuration. Among those income components, net interest income (NII) is the most important driver. This is not a surprise, given that credit growth directly affects interest income. Taxes, dividends and other effects are another important driver in the baseline scenario, with an impact of –66 basis points. These are primarily driven by higher tax and dividend payments, which are both direct results of the higher income. With regard to credit risk provisions and participation income, the difference between the DBS and SBS configurations is comparatively small.

Chart 4 shows aggregate credit growth in the Austrian banking system for both scenarios. Credit growth is an output of the DBS model and hence only applies in the DBS configuration. Projections for credit growth take into account historical growth rates, macroeconomic influences as well as bank-level profitability and capitalization constraints. *Credit growth* is relatively consistent in the baseline scenario, with an average annualized growth rate of 3.8%, and *drops substantially over time in the adverse scenario,* with an average *growth rate of 1.1%.* These credit growth projections are somewhat high compared to recent credit growth rates due to two main reasons: First, credit growth in Austria has historically been high, which is still reflected in the model. Second, the baseline projection, which dates from 2023, is generally too optimistic compared to actual outcomes in 2024 – for credit growth and other variables as well. The decline in credit growth in the adverse scenario is driven both by macroeconomic variables as well as higher bank losses due to the stress scenario, which limit system-wide growth capacity due to capitalization constraints. Without these capitalization constraints, average annual credit growth would have been 1 percentage point higher in the adverse scenario. In the baseline scenario, capitalization constraints were not binding at the aggregate level but for some banks because shortfalls by capitalization constraints were compensated by other well-capitalized, profitable banks which could benefit by increasing their market shares. The same effect of *well-capitalized, profitable banks growing their market share at the expense of capital-constrained, loss-making banks* was also observed in the adverse scenario.

Table 1 shows average values for selected result drivers in the baseline and adverse scenarios for both configurations as well as the 2023 starting values for comparison. Variables are based on definitions developed explicitly for the stress tests, which may differ from other definitions used in this report. We see that the net interest margin (NIM) decreases in all scenarios compared to 2023. This is not surprising given the very benign environment for banks and is due to the asymmetric response of interest income and expenses to the interest rate increases throughout 2022 and 2023. A lower NIM in both scenarios reflects both a normalization, as interest expenses catch up with higher interest rate levels compared to pre-2022,

Chart 3

Differences in the main drivers – DBS compared to SBS

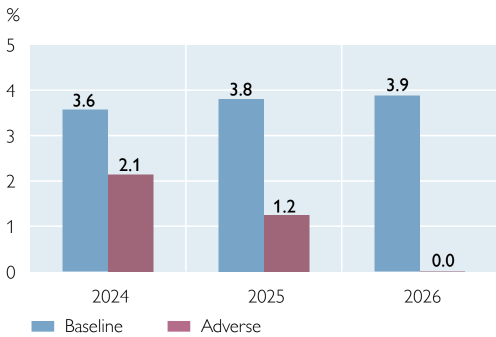


Source: OeNB.

Note: A positive value indicates a positive contribution to the CET1 ratio (measured in basis points) in the dynamic balance sheet (DBS) stress test compared to the static balance sheet (SBS) stress test, and vice versa for negative values.

Chart 4

System credit growth over the stress test horizon



Source: OeNB.

Table 1

Selected results of the static and dynamic balance sheet stress tests

	2023	SBS		DBS	
		Baseline	Adverse	Baseline	Adverse
	%				
Net interest margin	2.15	1.73	1.52	1.70	1.52
Cost of risk	–0.27	–0.40	–1.55	–0.39	–1.54
Cost-to-income ratio	48	61	75	58	73
	EUR billion				
Loan stock	1,307	1,307	1,307	1,406	1,346

Source: Authors' calculations.

and a decline in interest rates. The higher cost of risk in the baseline scenario is driven by an expected uptick in insolvencies, following low default rates in the (post)-COVID era. These changing circumstances are also reflected in higher cost-to-income ratios in both scenarios. Dynamic bank reactions partially offset this development, but only slightly.

2 Discussion and outlook

The addition of the DBS module makes the projections substantially more realistic by removing the restrictive SBS assumption and *allowing for banks to adapt to the evolution of their balance sheets and macroeconomic developments.* This is particularly evident in the results for the baseline scenario, where aggregate CET1 ratios grow only modestly by 0.4 percentage points in the DBS configuration, compared to a substantial increase of 1.4 percentage points in the SBS configuration. This is consistent with *banks making use of profitable opportunities to grow their businesses instead of hoarding capital.* We consider the former to be more realistic and stress that this behavior emerged endogenously from the model and was not an input or a target.

We observe that the decline in credit growth in the adverse scenario is less marked compared to other exercises. We focus on the exercise of Cappeletti et al. (2024) in our comparison because it is the most relevant benchmark in our opinion, being a relatively recent exercise by the European Central Bank covering the euro area banking system with a scenario horizon from 2023 to 2025. They project an annualized aggregate credit growth of –3.4% in the adverse scenario, compared to +1.1% in our results. These differences can be explained by various factors, including:

1. Different scope of the data: Our exercise only covers the Austrian banking market, and the credit growth model has been calibrated on historical data stretching back to 1998. Credit growth in the Austrian banking sector has been substantially positive over the whole 1998–2023 period, leading to generally high estimates. It seems likely that the difference between the Austrian market and the whole euro area, as well as potentially different time frames used in the model calibration will explain part of this observed difference.
2. Different scenarios: The exercise by Cappeletti et al. (2024) is based on data up to 2022 with a scenario horizon from 2023 to 2025, i.e. starting one year before our scenario. Different scenarios may account for some differences but given the overall comparable magnitude of the economic shock in both scenarios, this seems likely a less important contributor.
3. Model differences: The analysis of Cappeletti et al. (2024) is based on the BEAST model by Budnik et al. (2023), while our DBS exercise is based on our own OeNB DBS model, for which a publication will follow later. Compared to the BEAST model, *our model emphasizes the ability of the banking system to compensate for the deleveraging needs of some banks,* through the channel of other

banks growing faster, capitalizing on the opportunity to gain market share. These compensation effects mean that credit growth slows down to effectively zero in the adverse scenario, but it does not turn negative. Combined with slower, but still positive, growth at the beginning of the scenario horizon, this leads to a slightly positive average credit growth rate of 1.1% in the adverse scenario. This positive credit growth is also responsible for the lower aggregate CET1 ratio in the adverse scenario. We stress that this lower CET1 ratio is only true in the aggregate. The granular picture shows a clear differentiation between well-capitalized banks, which grow faster and gain market share, and undercapitalized banks, for which we observe deleveraging at a scale comparable to, or exceeding, the results of the exercise of Cappeletti et al. (2024). These compensating effects seem likely to be the most important driver explaining the differences between our results and those of Cappeletti et al. (2024).

In conclusion, we see that the DBS model provides a richer set of results that make economic sense and that provide additional insights compared to the SBS analysis, especially regarding banks' individual reactions and the resulting behavior of the overall banking system. One development goal of our DBS model was that it should be able to replace the SBS model when called for and not serve as a mere "add-on" exercise. In our view, *dynamic bank reactions make stress tests substantially more realistic and should generally be considered for use,* unless other requirements explicitly call for an SBS approach. For this reason, the DBS model was tightly integrated with the existing ARNIE framework, where it is now one module among many and can be turned on or off (to switch back to an SBS approach) through a simple configuration parameter. This article is the first publication of results using the new DBS model, which we are still actively improving and refining. One important caveat for the current version of the model is that the aforementioned 1 percentage point reduction in credit growth compared to the macroeconomic projection, due to bank capitalization constraints, is not fed back into the macro model. Such a negative credit growth feedback would likely lead to an additional worsening of the adverse macroeconomic scenario, which may in turn drive down future credit growth as banks become even more capital-constrained due to increased losses. We are actively working on including these feedback effects, and a publication of our full DBS model will follow.

References

Basel Committee on Banking Supervision (BCBS). 2017. Supervisory and bank stress testing: range of practices.

Basel Committee on Banking Supervision (BCBS). 2018. Stress testing principles.

Baudino, P., R. Goetschmann, J. Henry, K. Taniguchi and W. Zhu. 2018. Stress-testing banks – a comparative analysis. FSI Insights on policy implementation 12.

Borio, C., M. Drehmann and K. Tsatsaronis. 2012. Stress-testing macro stress testing: does it live up to expectations? BIS Working Papers 369.

Boss, M., G. Krenn, C. Puhr and M. Summer. 2006. Systemic Risk Monitor: A Model for Systemic Risk Analysis and Stress Testing of Banking Systems. In: Financial Stability Report 11. OeNB. 83–95.

Budnik, K. B., J. Groß, G. Vagliano, I. Dimitrov, M. Lampe, J. Panos, S. Velasco, L. Boucherie and M. Jancokova. 2023. BEAST: A model for the assessment of system-wide risks and macroprudential policies. ECB Working Paper Series 2855.

Cappeletti, G., I. Dimitrov, C. Le Grand, L. Naruševičius, A. Nunes, J. Podlogar, N. Röhm and L. Ter Steege. 2024. 2023 macroprudential stress test of the euro area banking system. ECB Occasional Paper Series 347.

Drehmann, M. 2008. Stress tests: Objectives, challenges and modelling choices. In: Riksbank Economic Review 2/2008. 60–92.

Elsinger, H., A. Lehar and M. Summer. 2006. Risk Assessment for Banking Systems. In: Management Science. 52(9). 1301–1314.

Feldkircher, M., G. Fenz, R. Ferstl, G. Krenn, B. Neudorfer, C. Puhr, T. Reininger, S. W. Schmitz, M. Schneider, C. Siebenbrunner, M. Sigmund and R. Spitzer. 2013. ARNIE in Action: The 2013 FSAP Stress Tests for the Austrian Banking System. In: Financial Stability Report 26. OeNB. 100–118.