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Climate Risk and Financial Stability: Insights from the CNB Climate Stress Test

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Abstract

This paper presents the latest climate stress test conducted by the Czech National Bank and demonstrates how climate risk narratives can be translated into a standard top-down stress testing framework tailored to a small open economy. The analysis focuses on the Czech banking sector to assess banks' capital positions under an adverse climate scenario, using supervisory data as of mid-2024. An important feature of the framework is the introduction of a carbon competitiveness overlay, designed to capture cross-country differences in the effects of carbon pricing arising from differences in emissions intensity, energy mix and industrial structure, reflecting the Czech Republic's position within the EU decarbonisation process. The adverse scenario is characterised by a delayed and abrupt transition to a low-carbon economy. Climate dimensions are incorporated through sectoral emissions intensity and a deterioration in carbon competitiveness. The framework captures the main transmission channels of climate risk, incorporating both transition and physical risks, with transition risk playing a dominant role in the adverse scenario design. A sharp increase in carbon prices generates significant negative shock and leads to persistent macroeconomic losses. The results indicate that, supported by its strong initial capital position, the Czech banking sector remains resilient even under a sudden and severe materialisation of climate risk, maintaining aggregate capital adequacy despite a substantial drawdown of releasable capital buffers. The paper also highlights the importance of accounting for cross-country heterogeneity, indirect transmission channels and modelling uncertainty in climate stress tests.

JEL Codes: E58, G21, G32, Q54.

Keywords: Carbon competitiveness, climate risk, climate stress testing, financial stability, transition risk.

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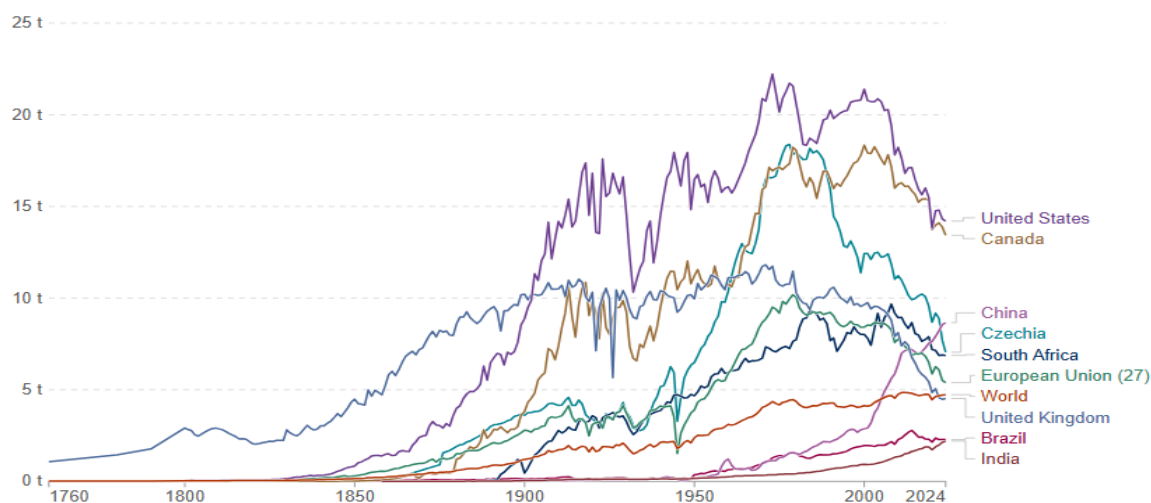
1. Introduction

Although the attention of policymakers is increasingly divided among multiple global challenges, many countries remain committed to addressing climate change. As physical risk materialises through increasingly severe climate hazards, including more frequent natural disasters, and as economies face the challenges associated with the transition towards lower greenhouse gas (GHG) emissions, climate change continues to pose a significant global challenge. Addressing this challenge requires not only building resilience to physical risk but also managing transition risk arising from economic, regulatory, and technological uncertainties associated with the shift to a low-carbon economy. These risks operate over different time horizons (Carney, 2015) and involve important trade-offs. Given its shorter and more policy-driven materialisation horizon, transition risk may represent a more immediate concern for financial stability. Transition risk is largely driven by regulatory instruments, most notably carbon pricing mechanisms¹ and complementary climate policies,² which affect sectors unevenly and generate heterogeneous cost pressures across the economy.

The low-carbon transition implies structural adjustments across the economy. To understand the scale of this adjustment, it is useful to consider the historical foundations. The fossil fuel-based economic model emerged with the onset of the Industrial Revolution, when coal and later oil became the dominant sources of energy. For more than 200 years, these fuels have underpinned economic growth and technological progress, while many economies have become increasingly dependent on them. The historical trajectory of emissions clearly reflects this dependence. Figure 1 illustrates per capita CO₂ emissions for selected economies from 1760 to 2024, showing the close historical association between industrial development and rising carbon output. While industrialized countries such as the United States and the United Kingdom have experienced high per capita emissions for over a century, emerging economies including China and India have seen a steep increase only in recent decades. This demonstrates that countries enter the global low-carbon transition from markedly different starting points, shaping both the risks they face and the opportunities available to them.

¹ The EU Emissions Trading System Directive (Directive 2003/87/EC).

² For example, the Renewable Energy Directive (Directive (EU) 2023/2413) or the Energy Efficiency Directive (Directive (EU) 2023/1791).

Figure 1: CO2 Emissions Per Capita (1760 – 2024)

Source: Global Carbon Budget (2025)

From this historical perspective, efforts to limit the pace and severity of climate change, primarily through decarbonisation, present a profound structural challenge, particularly given a much shorter period over which the transition is expected to take place. The largest share of global GHG emissions arises from the energy sector,³ which remains heavily reliant on fossil fuels. However, decarbonisation also requires changes in industry, transport, construction, and services. Firms must adapt to changing regulatory conditions, carbon pricing mechanisms and technological standards. Their ability to reallocate capital, restructure production processes, and adopt low-carbon technologies will shape both their competitiveness and the macroeconomic costs of the transition. This adjustment process will extend beyond firms, as households respond to changing prices and incentives by modifying consumption patterns, energy use, and transport choices.

In this context, the financial sector plays a dual role. Banks are directly exposed to climate risk through their lending and investment portfolios, while at the same time influencing the allocation of capital and thus the speed of decarbonisation. Climate shocks can lead to asset repricing, higher defaults, and increased volatility in financial markets. However, due to the fundamental uncertainty surrounding the timing and scale of climate policy and technological change (Chenet, 2021), it is not possible to define a single predictable development path. Although climate change itself is a long-term phenomenon, physical and transition risks may materialise over different time horizons. The combination of long-term uncertainty and different materialisation horizons makes climate risks particularly challenging to assess. Against this background, stress testing provides a suitable analytical framework. Rather than predicting “What will happen?”, climate stress tests explore “What could happen?” under different severe but plausible scenarios.

³ For the Czech Republic, the share of the energy sector, i.e. sector D under the NACE sectoral classification, in overall emissions stood at almost 33 % in 2023.

Despite substantial methodological progress, several limitations remain in existing climate stress-testing exercises. Climate shocks are often assessed in relative isolation from broader macro-financial stress, while transition scenarios tend to focus primarily on carbon pricing and corporate credit risk. This may understate both the interaction between climate and conventional macro-financial shocks and the broader set of channels through which the transition affects the economy. Moreover, evidence remains comparatively limited for small open economies.

This paper documents the most recent Czech National Bank (CNB) climate stress test and uses it as a case study to demonstrate how climate risk, and transition risk in particular, can be translated into a macro stress-testing framework tailored to a small open economy. The exercise, the results of which were originally published in the CNB's Autumn 2024 Financial Stability Report (CNB, 2024a), uses bank-level supervisory data as of 30 June 2024 as its starting point. The framework embeds climate shocks within a broader adverse macro-financial scenario and incorporates multiple transition channels. An important feature is the introduction of a carbon competitiveness overlay, which captures differences in the competitiveness that economies may experience under a common carbon pricing regime due to their production structure, energy mix and emissions intensity.

The climate stress test applies the established macroprudential stress-testing framework (CNB, 2022) to an adverse scenario characterised by a delayed and abrupt transition to a low-carbon economy, consistent with the EU's Fit-for-55 target for 2030. A sharp increase in carbon prices, coupled with a deterioration in the carbon competitiveness of the domestic economy, results in a prolonged macroeconomic contraction that feeds through banks' balance sheets. The results show that transition-related shocks can generate substantial credit losses and increase risk weights, resulting in significant capital depletion. Despite these losses, the Czech banking sector remains resilient at the aggregate level, supported by strong initial conditions as of mid-2024 and relatively limited exposures to the most emissions-intensive sectors, while retaining sufficient capacity to continue providing credit to the real economy.

The remainder of the paper is structured as follows. Section 2 reviews the literature on climate stress testing. Section 3 describes the methodology with a focus on broader macro effects and transmission channels of climate risks. Section 4 presents the scenario design, with emphasis on the competitiveness channel in the context of EU decarbonisation trends and the position of the Czech Republic relative to other Member States. Section 5 presents the results of the climate stress test, and Section 6 concludes.

2. Literature Review

Climate financial risks have become an important topic in macroprudential oversight and financial stability analysis. Over the past decade, both academics and policymakers have increasingly focused on quantifying transition and physical risks, exploring their interaction with macroeconomic outcomes, and assessing their implications for banks, firms, and the broader financial system. Climate stress testing has become one of the principal analytical tools for these purposes, helping institutions identify vulnerabilities under different climate scenarios.

International bodies have repeatedly called for the integration of climate risks into stress testing frameworks (Gros et al., 2016; Carney, 2019; Bailey, 2020; BIS, 2020; Lagarde, 2021). As aptly noted by Guth et al. (2021), *“the quantification of climate risks – even if fraught with uncertainty – can support decision-makers in assessing the magnitude and urgency of these risks for the banking sector, as well as the potential impact of policy measures.”* Similarly, the Bank of England’s (BoE) Climate Biennial Exploratory Scenario (BoE, 2022) emphasised the role of stress testing as a forward-looking tool to assess financial system resilience under adverse climate conditions.

The use of climate stress testing has expanded rapidly. Based on a survey conducted by the Financial Stability Board (FSB) and the Network for Greening the Financial System (NGFS), at least 35 climate stress-testing exercises had been conducted across 23 jurisdictions by 2022 (see also Reinders et al., 2023a and Baudino et al., 2021), for overviews of climate stress tests conducted to date). This expansion has been accompanied by substantial heterogeneity in design, time horizons, and methodological approaches. As in conventional stress testing, climate stress tests are conducted using either a bottom-up approach (Allen et al., 2020; Alogoskoufis et al., 2021; BoE, 2022) using banks’ own assessments of climate risks, or a top-down approach (Emambakhsh et al., 2023; Guth et al., 2021; Gross et al., 2025), which relies on macro-level estimates.⁴ While bottom-up approaches provide insight into how individual institutions perceive climate risks and how they may respond to their materialisation, top-down approaches offer greater consistency across institutions while imposing a lower reporting burden on banks.

To capture the long-term nature of climate risks, climate stress tests often employ longer scenario horizons than those used in conventional stress-testing. Some studies employ scenarios extending to 2050, in line with the time frame of the NGFS climate pathways (e.g. Frankovic et al., 2023; Alogoskoufis et al., 2021; Allen et al., 2020), whereas others focus on shorter horizons of between three and seven years (e.g. Guth et al., 2021; Vermeulen et al., 2018; ESAs and ECB, 2024; Gross et al., 2025). Long-term scenarios are well suited to capture the gradual effects of climate change and structural decarbonisation. However, their application requires assumptions regarding technological development, firms’ and households’ adaptation, changes in production structures, banks’ portfolio reallocation, and balance-sheet dynamics. Shorter horizons, by contrast, allow the analysis to focus on the near-term materialisation of climate risks, including abrupt transition shocks as well as acute physical shocks. They require fewer assumptions about technological change and portfolio reallocation, while maintaining a closer link to banks’ current exposures and conventional prudential stress-testing frameworks.

⁴ Some banks and regulatory authorities have deployed frameworks combining bottom-up and top-down approaches.

Beyond the choice of scenario horizon, climate stress-testing methodologies also differ substantially in the granularity of the underlying data and modelling framework. Since the early top-down exercise conducted by De Nederlandsche Bank in 2018 (Vermeulen et al., 2018), methodologies have evolved substantially (see, for example, ESRB, 2021; Acharya et al., 2023; or Reinders et al., 2023a for overviews of methods). Early tests primarily relied on sector-level data to estimate risk parameters based on the sectoral emissions intensity. More recent approaches incorporate firm-level data, enabling a more accurate reflection of heterogeneity in GHG emissions and in corresponding exposures in banks' portfolios. As Reinders et al. (2023a) summarise, “[t]aking a more micro approach at sector, firm, or asset level allows for more precise allocation of risks to financial institutions based on their sectoral and spatial asset exposures, which helps to identify those institutions that are most at risk.” Highly granular modelling frameworks using firm-level data have been developed by Allen et al. (2020) for France, Emambakhsh et al. (2023) for the Eurozone, and Gross et al. (2025) for Germany. Granular data have also been employed for household exposures: Reinders et al. (2023b), for example, use loan-level data covering a substantial share of Dutch residential mortgages and differentiate exposures by dwelling type, LTV and remaining maturity when assessing their vulnerability to climate-transition shocks.

Greater granularity, however, comes at the cost of substantially higher data requirements and is often constrained by data availability and quality. More importantly, the appropriate level of granularity depends on the purpose of the exercise. As argued by Baudino et al. (2021), relatively low levels of data granularity may be sufficient for a top-down macroprudential assessment aimed at identifying the main vulnerabilities of the financial system, for which sector classifications and average sectoral carbon intensities can provide an appropriate starting point. Greater firm- or asset-level granularity becomes more important when the objective is instead to identify banks' exposures to the most emissions-intensive firms or activities.

Despite these methodological differences, the literature converges on several common findings.

First, the effects of climate shocks are markedly heterogeneous, both across and within sectors. Using firm-level PDs from Bundesbank's credit register and firm-level balance sheet indicators,⁵ Gross et al. (2025) show that transition pressures can increase average probabilities of default for non-financial firms by up to 40% relative to baseline levels, with effects concentrated among emissions-intensive firms. Sectoral approaches, conducted, for example, by OeNB (Guth et al., 2021) or ECB (2022), similarly demonstrate that disorderly transitions disproportionately affect emissions-intensive industries, translating into material declines in banks' capital ratios.

Second, a delayed and disorderly transition is associated with more severe financial impacts than an orderly and gradual pathway. Guth et al. (2021) show that, for the Austrian banking sector, insolvency rates increase by around 0.6 percentage points under an orderly transition but by approximately 2.5 percentage points under a disorderly one. Similar conclusions are drawn for the euro area by Emambakhsh et al. (2023) and European Systemic Risk Board (ESRB) (2021), who find that earlier and more orderly transition paths are associated with lower medium-term financial risks.

⁵ Indicators such as return on assets, liquidity ratio, leverage, interest expenses or equity ratio obtained from the Bundesbank database of annual financial statements.

Despite substantial methodological progress, several limitations remain in the climate stress tests conducted to date. First, climate shocks are frequently assessed in isolation from the broader cyclical and structural macro-financial stresses that shape banks' credit losses, market valuations, and capital positions, limiting the ability of existing climate stress tests to capture potential amplification effects when these risks materialise jointly. This interaction is particularly relevant because the joint materialisation of these shocks may magnify financial losses (Grippa and Mann, 2020; Baudino et al. 2021; ESAs and ECB, 2024). Second, many transition-risk exercises focus primarily on increases in carbon prices and their effects on corporate credit risk, while other transmission channels – including changes in the consumption of fossil fuels, shifts towards renewable energy, changes in demand associated with the transition from internal-combustion-engine vehicles to electric vehicles, and confidence shocks related to transition uncertainty – have received less systematic attention. Third, evidence remains comparatively limited for small open economies in Central and Eastern Europe, where trade openness, industrial structure, energy intensity, and foreign ownership of the banking sector may shape the transmission of transition shocks.

Against this background, this paper develops an exploratory short-term scenario (following Aikman, 2026), in which climate shocks interact with broader cyclical and structural macro-financial stress. The framework embeds a short-term disorderly scenario that combines transition and physical risk within a broader macro-financial stress test and assesses their joint impact on banks' credit portfolios, market-risk exposures and banks' capital positions. Rather than modelling the transition solely through an increase in carbon prices, the scenario incorporates several mutually reinforcing structural shocks: a decline in fossil-energy consumption, an increase in the share of renewable energy, a shift in demand from internal-combustion-engine vehicles towards electric vehicles, an adverse consumer and investor confidence shock. Physical risk is incorporated through macroeconomic effects of more frequent and severe climate events. Finally, the paper introduces the concept of carbon competitiveness to capture the asymmetric effects of climate policies across economies with different production structures, energy mixes, and emissions intensities.

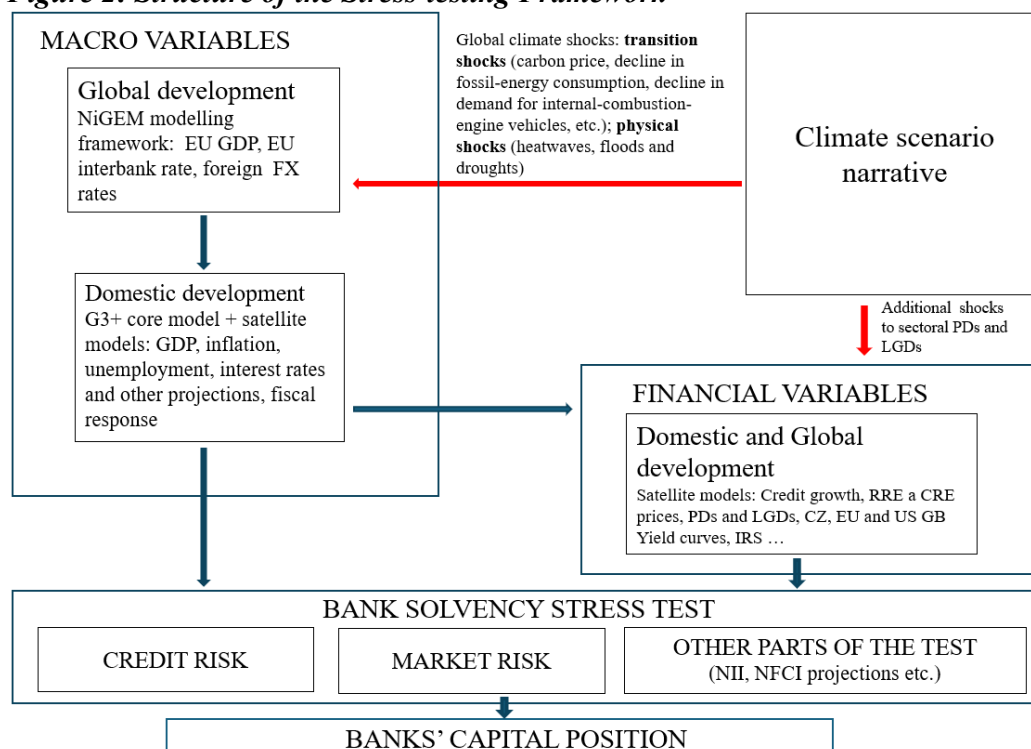
The paper makes four contributions to the literature. First, it integrates climate and conventional macro-financial risks within a single stress-testing framework. Second, it captures a broader range of mutually reinforcing transition and physical risk channels and evaluates their combined effects on credit risk, market risk, and the aggregate capital position of the banking sector. Third, it extends the scenario design to account for carbon competitiveness, reflecting the additional macro-financial pressures that transition policies may impose on emissions-intensive economies that lag behind their trading partners in the decarbonisation process. While cross-country and cross-sectoral differences in the effects of carbon pricing have been examined in the broader literature (e.g. Ward et al., 2019; Berthold et al., 2024), their implications remain largely underexplored in climate stress testing. Fourth, the paper provides evidence for the Czech banking sector and, more broadly, for the relatively underexplored group of small open economies in Central and Eastern Europe, with notable exceptions including Kalman et al. (2023) and Várgedö (2022).

3. Modelling Framework

The CNB climate stress test was conducted as part of the regular top-down solvency stress-testing for the Autumn 2024 Financial Stability Report (CNB, 2024a)⁶ and covers all domestic banks and non-EU foreign banks operating under CNB supervision.⁷ The stress test follows a dynamic balance-sheet approach⁸ and evaluates banks' capital positions under a baseline and an adverse climate scenario.

The stress-testing framework consists of three interconnected layers (Figure 2). First, a macroeconomic block produces scenario paths for key macroeconomic variables. Second, a financial block comprising a set of satellite models⁹ translates macroeconomic developments into key financial variables, particularly bank risk parameters such as PDs and LGDs. Third, a set of bank-level stress-testing modules projects both the numerator of the capital adequacy ratio, i.e. regulatory capital, and its denominator, i.e. the total risk exposure amount (TREA). The stress test estimates each bank's capital position under both scenarios and, on that basis, evaluates the overall resilience of the Czech banking sector.

Figure 2: Structure of the Stress-testing Framework



Note: Red arrows describe climate shocks. Blue arrows describe where outputs from a model are used further.

⁶ For the purposes of this exercise, the climate scenario was treated as the main adverse scenario.

⁷ The results of the CNB climate stress test were published in the Financial Stability Report, Autumn 2024. For a detailed description of the stress testing methodology see CNB (2022).

⁸ CNB's dynamic balance sheet approach does not model each institution's balance sheet dynamics separately based on its specific banking model. Instead, it applies uniform assumptions for credit growth and the corresponding deposit growth to all banks within scope. Likewise, the dynamic balance sheet approach does not account for possible portfolio reallocations in response to the materialisation of climate risks.

⁹ A more detailed exposition of individual satellite models can be found in Panoš and Polák (2019), Polák and Panoš (2019), Kučera and Szabo (2019), Siuda (2020), Plašil (2021), Časta (2022).

3.1 Embedding of Climate Risks into Macroeconomic Variables

The stress-testing framework incorporates both transition and physical climate risks, with transition risk playing a dominant role in the design of the adverse scenario. At the global level, the NGFS scenario provides the initial climate shocks and their macroeconomic effects. These global developments then enter the NiGEM model,¹⁰ while the resulting foreign shocks are transferred to the domestic economy through the CNB's core forecasting model, g3+, and satellite models (Brázdik et al., 2020), which generate paths for output, unemployment, inflation, interest rates and other macroeconomic variables. To account for structural features of the Czech economy, the scenario narrative is extended to include a carbon competitiveness channel, as described below.

Within the NGFS scenario, physical risk is incorporated through climate damage functions linking projected effects of global warming to macroeconomic outcomes. These functions capture the aggregate economic consequences of more frequent and severe physical hazards through several channels. Floods and wildfires primarily damage the capital stock, heat stress reduces labour productivity, while droughts adversely affect agricultural output. Through these channels, physical risks reduce aggregate economic activity.

Given its macroprudential perspective, the stress-testing framework focuses on system-wide risks rather than on the direct consequences of individual natural disasters. While isolated physical events, such as a single flood or drought, may have substantial regional impacts, systemic effects arise primarily from the cumulative effects of climate damage and their transmission through international trade, commodity markets, and global supply chains. For example, climate disruptions to agricultural production may increase international food prices, generating additional supply-side inflationary pressures across economies. Such effects are captured at the aggregate level in the NGFS scenario and subsequently transmitted through the macroeconomic modelling framework described above.

Transition risk, by contrast, is primarily policy-driven. Pollution represents a textbook example of market failure, as the social costs of emissions are not fully reflected in market prices (Pigou, [1920] 2017). Climate policy relies on carbon taxes, emissions trading systems (ETS) and other regulatory instruments to internalise the social costs of emissions. A key challenge in climate stress testing is to capture the effects of policy-driven shocks that evolve over time and affect economic sectors unevenly (Hebbink et al., 2018). In the EU, carbon pricing, implemented primarily through the EU ETS, constitutes a key regulatory driver of transition risk.¹¹

Accordingly, the transition shock in the adverse scenario reflects a delayed and abrupt tightening of climate policy that results in a sharp increase in the carbon price. Rising allowance prices directly increase production and energy costs in energy-intensive industries and indirectly affect other sectors through higher energy prices and supply-chain cost pass-through. In a small open economy

¹⁰ The NiGEM model represents a widely-used global structural macroeconomic model that is able to capture international spillovers from global shocks.

¹¹ Chen et al. (2025), based on a meta-analysis of more than 70 studies, find that emission trading schemes, particularly the EU ETS and the China ETS, have generally stimulated technological investment, albeit with moderate aggregate effects and substantial sectoral variation.

within the EU single market, these effects may be amplified by exposure to international trade and the structure of domestic production. Higher input costs can weaken price competitiveness, particularly in emissions-intensive manufacturing sectors, where international competition may constrain firms' ability to pass higher costs through to output prices. This motivates the inclusion of an additional carbon competitiveness channel in the adverse scenario.

Carbon competitiveness reflects the fact that the same carbon price increase may affect economies differently depending on their energy mix, industrial structure and emissions intensity (Ward et al., 2019; Tu and Wu, 2021; Berthold et al., 2024; Le Moigne et al., 2024; Teixeira, 2025). Economies with higher emissions intensity and stronger dependence on fossil energy face a larger competitiveness shock, which can translate into weaker exports and investment and more persistent output losses. Firms that are slow to decarbonise risk declining competitiveness within global value chains, particularly as growing investor scrutiny and emissions disclosure requirements (including Scope 1, 2, and 3 emissions) increase the visibility of carbon footprints. Delayed decarbonisation can therefore lead to lost business opportunities and reduce firms' attractiveness to investors and trading partners, making carbon competitiveness a structural determinant of export performance and investment dynamics.

While the NGFS scenarios capture the aggregate macroeconomic consequences of climate policy, they do not fully account for differences in the competitiveness effects that economies may experience under similar carbon price developments due to their structural characteristics. Therefore the scenario narrative incorporates a deterioration in the Czech economy's carbon competitiveness. Following the increase in carbon prices specified in the NGFS scenario, additional expert-judgement-based shocks are applied through the CNB's core forecasting model, g3+, and associated satellite models to increase the persistence of adverse domestic demand and foreign trade shocks. Their magnitude and persistence reflect the Czech economy's relatively high emissions intensity, energy mix and industrial structure, and the associated greater exposure to carbon price shocks. Rather than estimating the precise effect of carbon competitiveness, this approach is intended to capture its potential contribution to a deeper and more persistent macroeconomic adjustment under a delayed transition.

3.2 Embedding of Climate Risks into Financial Variables

Climate risk affects banks primarily through traditional risk channels such as credit risk, market risk, net interest income and operational risk, while the importance of each channel depends on both the nature of the shock and structural features of the financial system (BIS, 2021). Given the Czech bank-based financial system and the predominance of lending to households and non-financial corporations, credit risk is the primary solvency transmission channel, followed by market risk, while other channels are less significant.

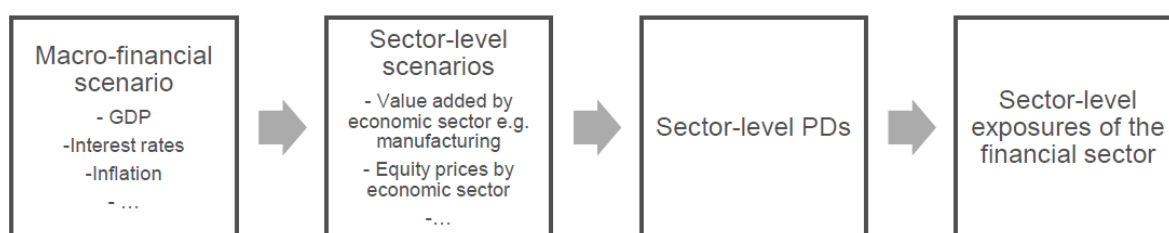
3.2.1 Credit Risk Channel

Credit risk feeds into bank solvency through changes in the probability of default (PD) and the loss given default (LGD). Higher PDs and LGDs increase expected credit loss and loss allowances, reducing profitability and hence the numerator of the capital ratio. For banks using the IRB approach, deteriorating risk parameters also increase risk weights and risk-weighted exposures, and hence raise the denominator of the capital ratio.

The materialisation of physical and transition risks can adversely affect credit risk parameters through several channels. On the physical risk side, climate events can directly damage the properties of households and firms, weaken their balance sheets and repayment capacity and thus increase the probability of default. At the same time, physical damage to properties pledged as collateral may reduce collateral values and increase LGD.

On the transition-risk side, rising carbon prices put pressure on the profitability of firms in emissions-intensive industries. Profitability may decline directly through higher compliance and input costs and indirectly as suppliers pass through part of their increased costs. Conversely, attempts by firms to transfer these costs to customers could trigger adverse demand responses, further eroding revenues. The resulting decline in profitability weakens firms' debt-servicing capacity and translates into higher PDs (see Figure 3). This transmission mechanism – operating through sectoral cost increases and turnover effects – can be operationalised using an empirical framework such as an input-output model, which captures intersectoral linkages and cost pass-through effects, as applied, for example, by OeNB (Guth et al., 2021) or the ECB (2022). Alternatively, as highlighted in the literature review, increasing attention is being given to more granular approaches that estimate PD trajectories on a firm-by-firm basis (see, for example, Gross et al., 2025).

Figure 3: Sector-level Approach to Credit Risk in Climate Stress Tests



Source: ESRB (2021)

Within the CNB framework, sector-level PDs are produced by a satellite model based on input-output structure (Siuda, 2020). Unlike conventional static input-output models with fixed production coefficients, the model allows the input-output coefficient matrix to respond to economic shocks. Macroeconomic shocks are propagated to individual sectors via performance indicators (e.g. gross value added, gross operating surplus), and sector-specific default rates are estimated using a LASSO estimator. In this setup, the carbon price shock affects PDs primarily through the macroeconomic scenario: EU-wide carbon prices are modelled in NiGEM (Kotlář et al., 2023), transmitted to the Czech economy via g3+ and satellite models, and PDs respond to scenario trajectories of macroeconomic variables (most notably unemployment).

To reflect the heightened transition risk faced by the most emissions-intensive sectors, a targeted PD overlay is applied to the five most emissions-intensive industries.¹² The overlay is designed as

¹² These sectors together represent around 77 % of the overall GHG emissions.

a transparent sensitivity adjustment rather than as a separately estimated structural parameter. The adverse-scenario PD of the most emissions-intensive sector, energy production, is increased by 100% to capture its exceptionally high exposure to transition risk, over and above the effect implied by the PD satellite model. PDs of four additional sectors (agriculture, mining and quarrying, water supply, and transportation) are scaled proportionally to their emissions intensity relative to energy production (see Table 1). This approach follows the logic of transition-risk stress testing, where the direct impact of a carbon price shock is commonly differentiated across sectors according to their emission intensity (Várgedő, 2022; ECB, 2026).

Table 1: Development of PDs in Emissions-intensive Industries in Alternative Scenarios (in %)

Sector	Historical value (2023)	Baseline	Adverse - no climate add-on	Adverse - with climate add-on	Maximum PD over the scenario horizon
A: Agriculture, forestry and fishing	1.7	1.7	2.6	3.2	3.9
B: Mining and quarrying	0.02	0.3	1.0	1.5	2.9
D: Electricity, gas, steam and air conditioning supply	0.6	0.4	1.2	2.4	2.7
E: Water supply; sewerage, waste management activities ¹³	0.7	1.1	2.9	3.9	4.7
H: Transportation and storage	0.5	1.5	4.5	4.9	6.8

Note: The table presents average (except the last column which represents yearly maxima) PD values across scenarios for the five most emissions-intensive industries for which the climate add-on was incorporated

Source: CNB

We acknowledge that this approach is simplified relative to the more granular climate stress-testing frameworks used in the literature. It does not explicitly model the propagation of carbon pricing through production networks and intersectoral input–output linkages. This reflects both data limitations and substantial modelling complexity. A possible extension would be to allow carbon prices to enter the sectoral input–output model directly, enabling a more granular and internally consistent assessment of transition risks across sectors and their propagation through the economy.

As regards the second key credit risk parameter, LGD dynamics are driven primarily by the macro-financial conditions embedded in the scenario rather than by climate risk per se. In the adverse scenario, the main source of LGD stress is the pronounced decline in residential property prices driven by a deterioration in consumer and investment sentiment. Property prices decrease on average by 5.3% over the final four years of the scenario, which significantly reduces collateral

¹³ Sectoral PD paths reflect the full historical dynamics and macroeconomic sensitivity of each sector, rather than only their latest observed values. Although the water-supply and energy sectors recorded similar PDs in 2023, default rates in the water-supply sector were historically higher and more responsive to macroeconomic shocks. Its model-implied PD therefore increases more strongly under the adverse scenario and remains above the energy-sector PD after the climate add-on is applied.

values. In response to this development and to higher default rates, LGD for mortgage loans doubles over the scenario horizon. LGDs for consumer credit, calibrated as a scaled version of mortgage LGD, also rise significantly. For loans to non-financial corporations, modelled under the standard approach, LGD increases by more than 50 percentage points. This reflects both weaker collateral valuations and the typically higher loss severity associated with corporate defaults under adverse macroeconomic conditions. Transition risk could further affect LGDs through additional declines in collateral recovery rates that are not captured in the current framework. In particular, assets used as collateral in emissions-intensive sectors may experience an additional loss in value if they become economically obsolete or require substantial investment to comply with tighter climate policies (so called stranded assets). Energy-efficiency requirements may similarly affect the value and recovery costs of real-estate collateral. Accounting for these channels could therefore result in higher LGDs and amplify the estimated credit losses, particularly for exposures to emissions-intensive sectors.

3.2.2 Market Risk Channel

Market risk acts as a secondary, albeit significantly weaker, transmission channel in the Czech banking sector, reflecting the relatively small size of trading portfolios and the high share of securities classified as held-to-maturity.¹⁴ Market losses materialise through valuation changes in securities portfolios measured at fair value through profit and loss (FVPL) and fair value through other comprehensive income (FVOCI).

Transition risk is expected to affect market valuations through the repricing of carbon-intensive assets, particularly in energy-intensive sectors. On the fixed-income side, transition shocks may widen corporate credit spreads, reflecting higher default risk and risk premia for firms exposed to rising carbon prices and regulatory uncertainty. On the equity side, deteriorating market sentiment towards emissions-intensive firms may depress share prices. Both channels can generate valuation losses in banks' securities portfolios.

In stress-testing frameworks, market risk is modelled through the revaluation of banks' securities portfolios, based on scenario-consistent paths of key financial variables, including risk-free yield curves, government and corporate bond yields. Sovereign and corporate credit spreads reflect the combined effects of prolonged economic slowdown, accommodative monetary policy and heightened risk premia associated with a delayed and disorderly climate transition. In addition, increased macroeconomic uncertainty and weaker fiscal positions may further contribute to higher sovereign risk premia, which feed into government bond valuations (see Appendix Figure B1). This is consistent with recent empirical evidence showing that climate risk can interact with sovereign debt dynamics and is increasingly priced into sovereign bond yields. While this evidence is largely based on cross-country analyses and may not fully translate to all country-specific details, countries with higher emissions intensity tend to face higher borrowing costs, with these effects being more pronounced in emerging and developing economies (Anyfantaki et al., 2025).

To capture heterogeneous exposure to transition risk across industries, the stress test applies industry-specific transition vulnerability factors (TVFs) based on NACE sectoral classifications

¹⁴ Financial assets held in the trading book account for only about 5% of total assets, while financial assets measured at amortised cost, where credit risk is the predominant risk, represent more than 85%.

following Vermeulen et al. (2018). TVFs translate sectoral emissions intensity into additional shocks to equity prices and corporate credit spreads, on top of the macro-financial shocks embedded in the adverse scenario.¹⁵ Appendix A presents the sectoral distribution of TVFs used in the climate stress test. This approach provides a transparent and tractable way to reflect sectoral repricing effects without requiring firm-level ESG data.¹⁶

4. Scenario

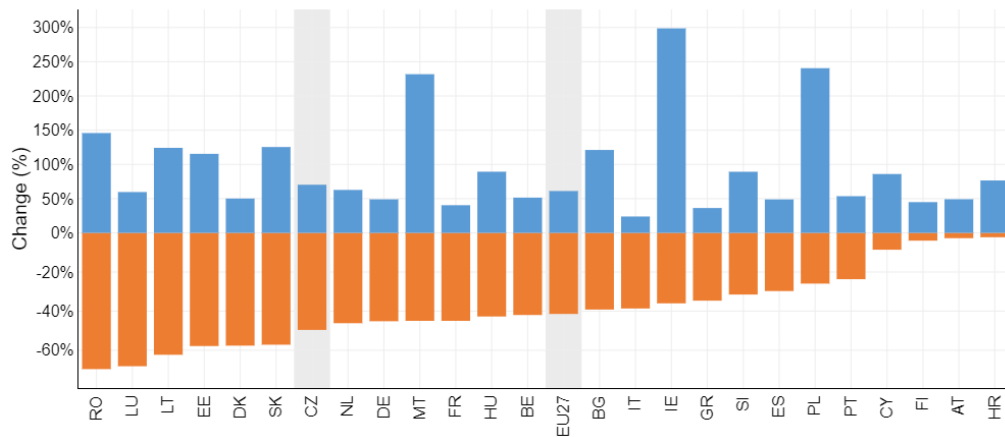
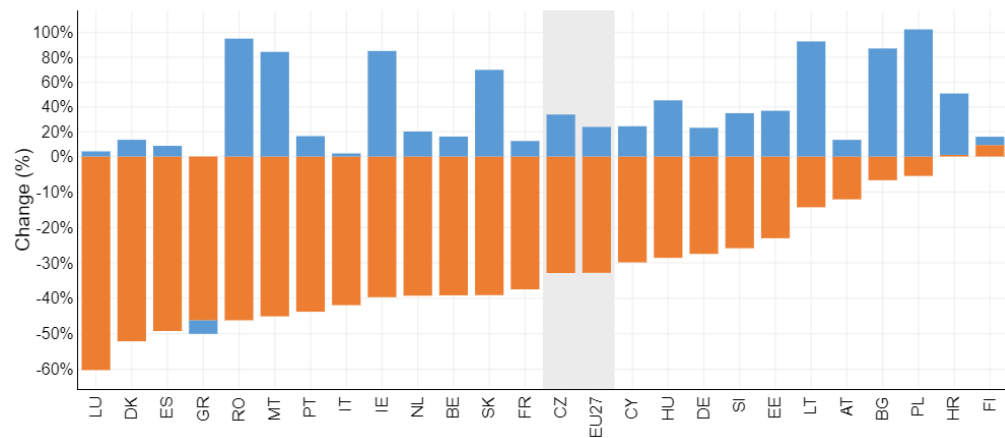
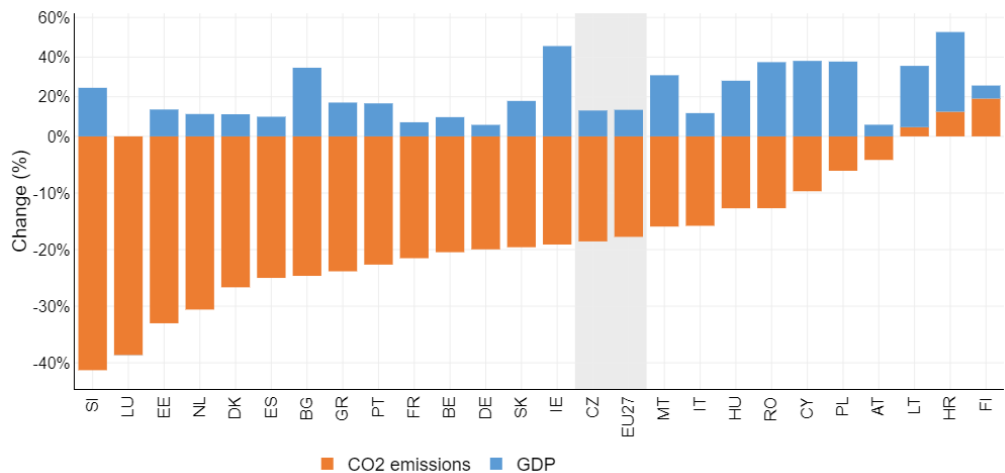
4.1 Narrative

The adverse scenario follows a delayed and abrupt transition. After a period of insufficient climate action, during which emissions remain elevated and dependence on fossil fuels persists, a rapid and disorderly policy tightening takes place. The transition involves a sharp increase in carbon prices, accelerated deployment of low-carbon technologies and substantial market repricing, ultimately triggering a deep recession.

At the domestic level, the transmission of these shocks reflects the structural characteristics of the Czech economy. From a long-run perspective, the Czech Republic has achieved substantial emissions reductions. Relative to 1990 levels, per-capita emissions declined by around 50% by 2023, reflecting post-transition structural change and industrial modernisation (Figure 4A). However, more recent benchmarks suggest a more moderate pace of decarbonisation. Since the launch of the EU ETS in 2005, emissions declined by roughly 33%, broadly in line with the EU average (Figure 4B). Compared with frontrunner economies, the Czech economy faces structural constraints associated with coal dependence and a relatively high share of emissions-intensive industrial production.

¹⁵ As noted by Vermeulen et al. (2018), “The transition vulnerability factors are similar to the betas in capital asset pricing model (CAPM) in the sense that they determine a stock specific return given a certain excess market return. However, whereas the betas in CAPM capture a relationship between a stock and its market risk, the transition vulnerability factors in this stress test capture a relationship between a stock and its energy transition risk.”

¹⁶ Empirical evidence from green bond markets shows that investors often accept lower yields for green bonds compared with matched conventional bonds, generating a green premium (greenium). While generally small, the magnitude of the greenium varies across regions, bond types, and issuers, and is influenced by factors such as liquidity, demand, credit quality, and the credibility of the issuer (Pietsch and Salakhova, 2022).

Figure 4 (A – C): GHG Emissions Reduction by EU Countries**Figure 4A: 2023 Relative to 1990****Figure 4B: 2023 Relative to 2005****Figure 4C: 2023 Relative to 2015**

Note: Data for Sweden are excluded because per-capita emissions were already very low in 1990; as a result, small absolute changes translate into large relative changes, which would distort the interpretation of the chart.

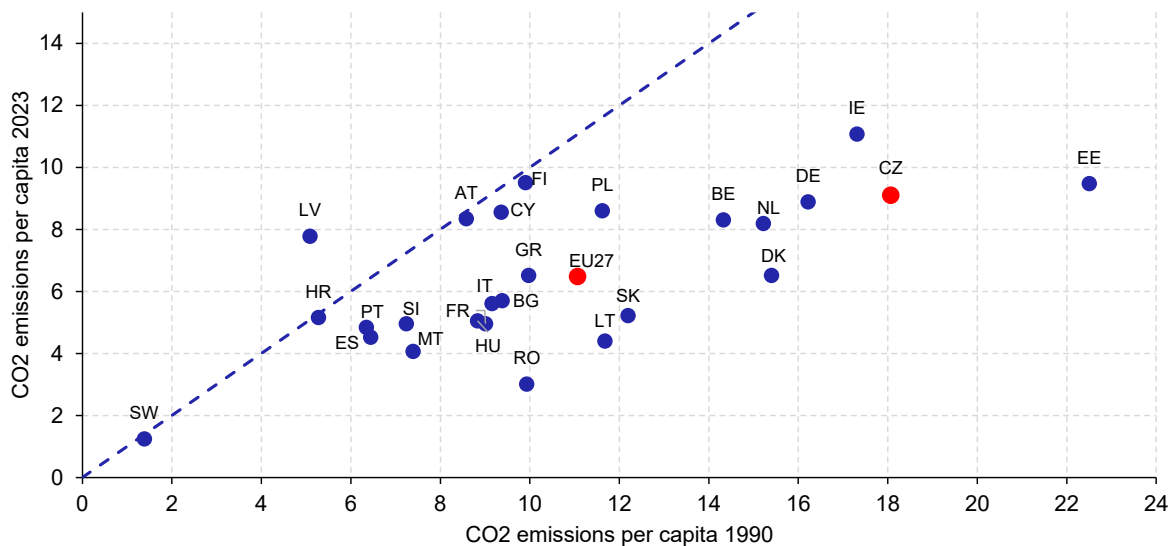
Source: Global Carbon Budget (2025); Eurostat (2026)

Despite the recent acceleration in emissions reductions – particularly in 2023 amid high-energy prices and renewable expansion (European Commission, 2024) – the Czech Republic remains

among the most emissions-intensive EU economies. In 2023, emissions reached 9.1 tonnes CO₂e per capita, compared with the EU average of 6.5 tonnes CO₂e (Figure 5). The concentration of emissions in energy and heavy industry, together with continued coal reliance, increases the economy's exposure to carbon price shocks.

These structural characteristics imply that a sharp increase in carbon prices may translate into a larger competitiveness shock and more persistent macroeconomic losses than in less carbon-intensive economies. However, emissions intensity should be interpreted with caution as an indicator of transition risk exposure. Industrial economies tend to appear more emissions-intensive than service-based ones, while the latter may also face transition risks indirectly through international trade and higher import prices.

Figure 5: Process of Decarbonisation in EU Countries



Source: Eurostat (2026)

Consistent with a delayed and abrupt transition narrative, the CNB adverse scenario builds on the NGFS (2023) Delayed Transition Scenario complemented by the carbon competitiveness overlay. Following a period of insufficient adaptation, the carbon price increases by \$10 per tonne of CO₂ each quarter during the first two years, followed by a one-off jump of \$150 per tonne in the third year. While severe relative to historical carbon prices, shocks of comparable magnitude have been considered in the literature (Guth et al., 2021; Best et al., 2026). The increase in carbon prices reduces fossil fuel consumption and industrial production, while the shift in demand from combustion-engine vehicles towards electric vehicles remains gradual. For the Czech Republic, the transition shock is additionally propagated through higher energy and carbon costs, weaker export performance (Figure 6D), and lower investment. The carbon competitiveness overlay captures the greater persistence of these adverse macroeconomic effects associated with the Czech economy's emissions intensity, energy mix and industrial structure.

Unlike conventional cyclical stress tests with a 3–5 year horizon, this scenario concentrates climate shocks over the 2024 Q3 – 2030 Q4 horizon.¹⁷ The exercise is exploratory in nature and assesses vulnerabilities under a severe but plausible climate transition rather than predicting the most likely macroeconomic path. Transition risks interact with other structural and geopolitical pressures, generating a prolonged recession, weakening consumption and investment sentiment, and sustaining elevated credit losses.

4.2 The Macroeconomic Block

Output in the euro area contracts due to declining demand and rising transition costs, generating a negative output gap (Figure 6). Weaker demand lowers inflation and leads to a substantial decline in interest rates relative to the baseline.

Figure 6 (A-D): Key International Macroeconomic Variables in Scenarios

Figure 6A: Eurozone GDP growth
(in %; Year-on-Year)

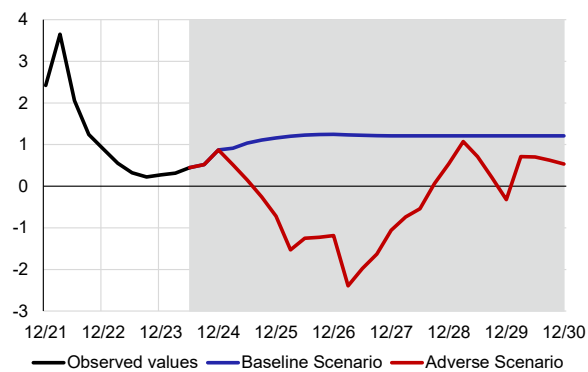


Figure 6B: 3M EURIBOR
(in %)

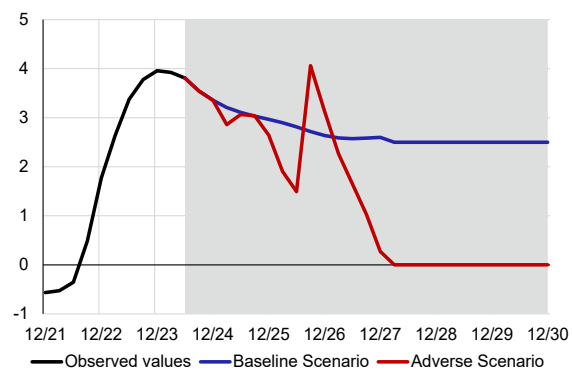


Figure 6C: Foreign demand
(in %; Year-on-Year)

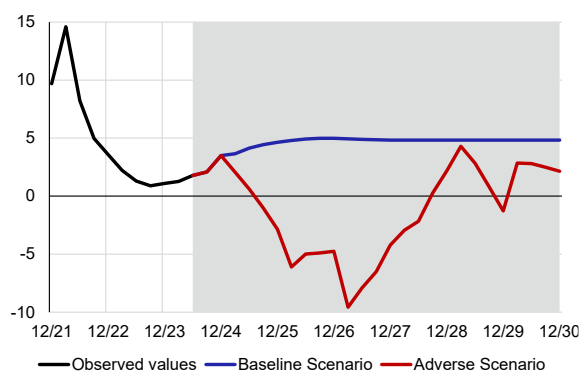
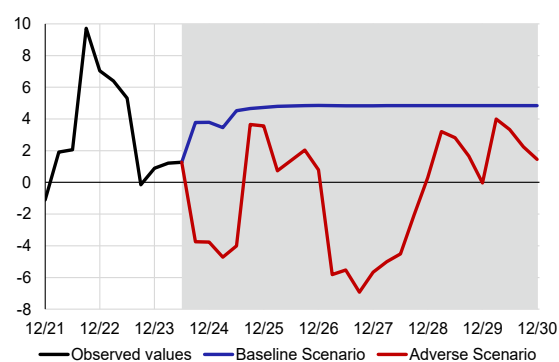


Figure 6D: Czech real export growth
(in %; Year-on-Year)



Source: CNB

¹⁷ The initial quarter (2024 Q3) is determined by the timing of the Autumn Financial Stability Report, for which the stress test was prepared.

The resulting domestic macroeconomic path reflects both the transmission of global shocks and the additional domestic effects associated with slower decarbonisation and reduced carbon competitiveness. The recession is highly persistent (Figure 7A), with GDP declining over an extended period. Unemployment rises sharply, peaking at around 13%, while inflation falls close to zero after a temporary carbon-price-driven spike. Monetary policy becomes strongly accommodative, with short-term rates declining to near-zero levels (Figure 7D). The adverse scenario thus represents a substantial negative shock to the domestic economy. By contrast, the baseline scenario follows the official CNB economic forecast for the first two years and is subsequently simulated for stress-testing purposes. It does not include any climate shocks.

Figure 7 (A-D): Main Domestic Macroeconomic Variables in Scenarios

Figure 7A: Real GDP growth
(%; quarterly data)

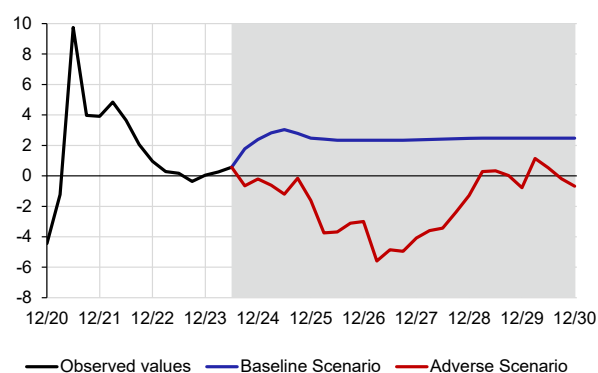


Figure 7B: Unemployment rate
(%)

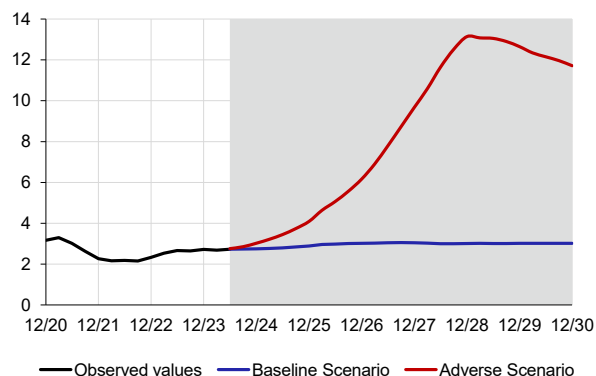


Figure 7C: Inflation
(%)

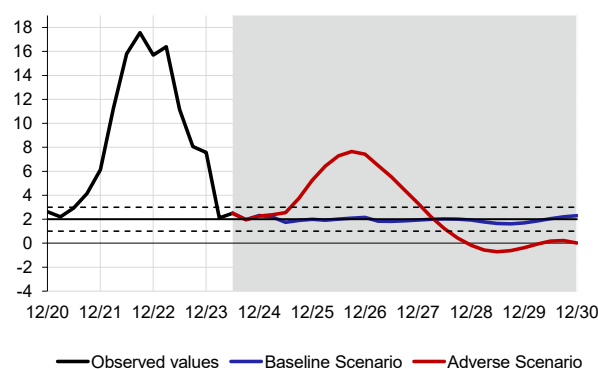
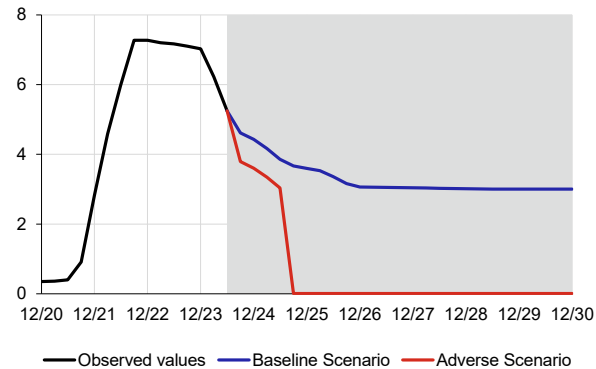


Figure 7D: 3M PRIBOR
(%)



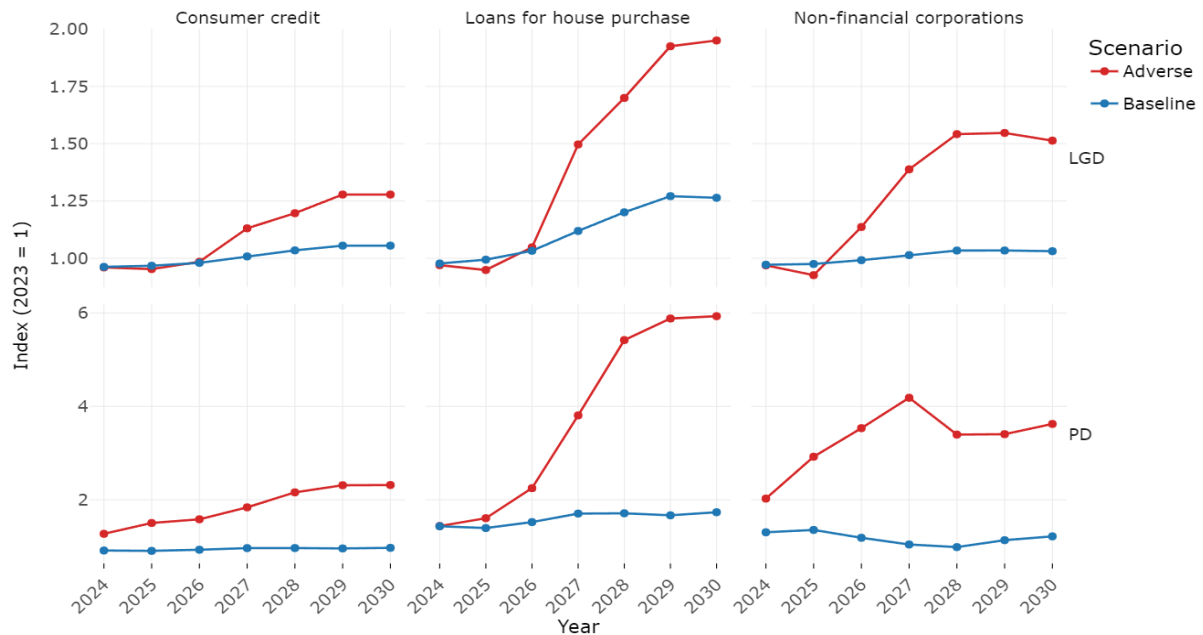
Source: CNB

4.3 The Financial Block

Under the adverse scenario, credit risk deteriorates markedly. Higher unemployment and declining collateral values lead to a pronounced increase in both PDs and LGDs across loan portfolios, translating into higher expected credit losses and risk-weighted assets.

Figure 8 illustrates the projected trajectories of PDs and LGDs expressed as multipliers relative to their last observed levels in 2023. Risk parameters for mortgage loans exhibit the largest relative increase, primarily driven by the sharp rise in unemployment (Figure 7B) and, in the case of LGDs, by declining residential property prices. In absolute terms, mortgage PDs peak at approximately 3.7%, while consumer credit PDs reach around 7.5%. Mortgage LGDs increase to about 28%, and LGDs for loans to non-financial corporations and consumer credit exceed 50%, reflecting both weaker repayment capacity and deteriorating collateral conditions.

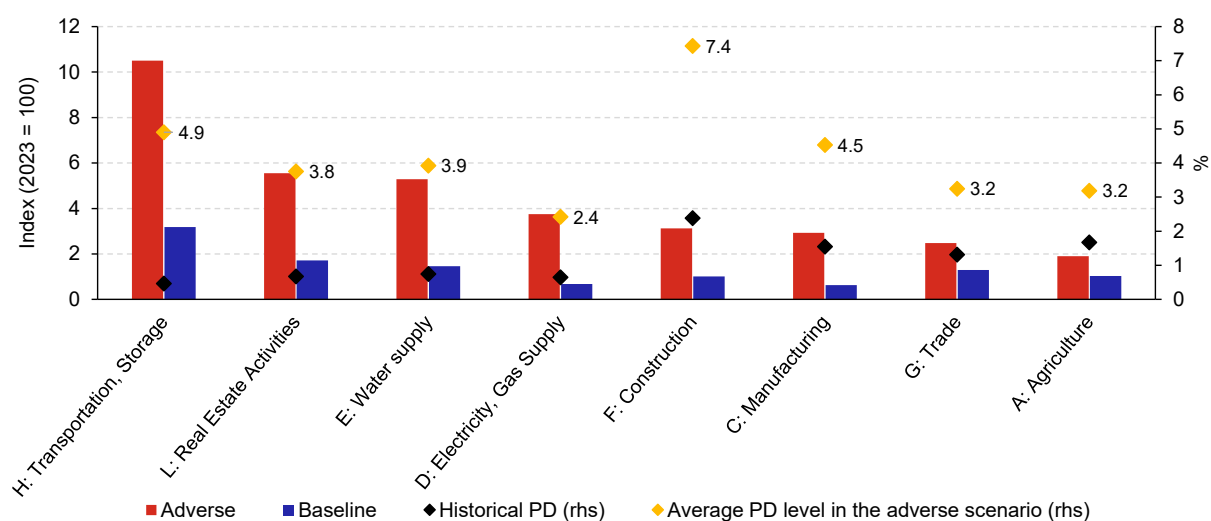
Figure 8: Estimated PDs and LGDs in Scenarios Relative to the Starting Point



Note: The figure depicts the projected trajectory of LGD and PD expressed as multipliers with respect to the starting point, which is the last historical value (i.e., 2023).

Source: CNB

Among non-financial corporate sectors (Figure 9), Transportation and Storage shows the strongest relative increase in credit risk, with the estimated PDs rising by more than tenfold over the scenario horizon. This reflects the sector's sensitivity to the prolonged macroeconomic downturn, compounded by the additional climate-related PD adjustment applied to emissions-intensive sectors. More broadly, sectors with initially low PD levels tend to display larger proportional increases under stress.

Figure 9: Estimated PDs Across Economic Sectors

Note: The figure depicts projected PDs across selected sectors (representing over 85 % of total non-financial corporate banking exposures and 94 % of total emissions). Values are expressed as multipliers with respect to the starting point, which is the last historical value (i.e., 2023).

Source: CNB

5. Results

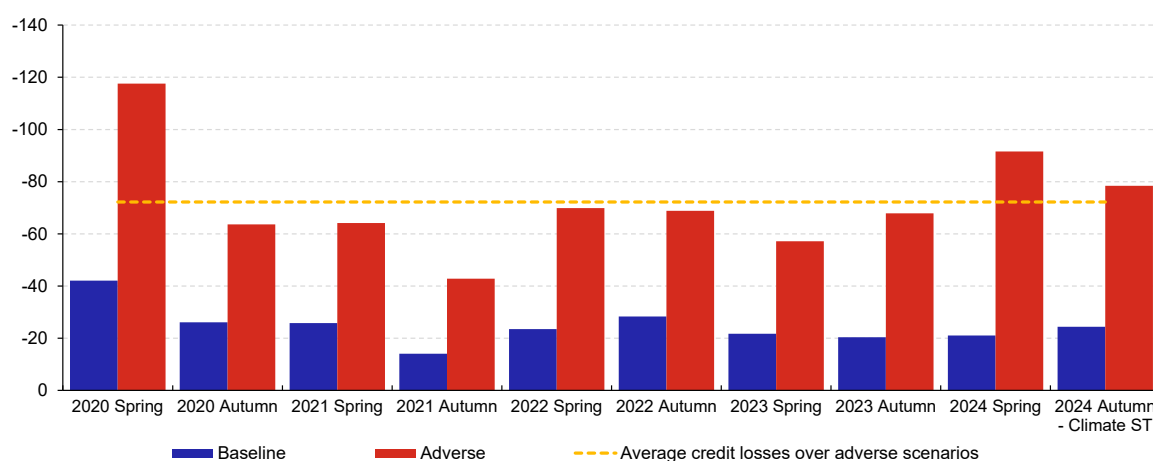
This section assesses the resilience of the Czech banking sector to the adverse climate scenario. While the exercise is subject to considerable uncertainty, the results suggest that, given its initial position, the banking sector maintains aggregate capital adequacy, albeit with a material drawdown of releasable capital buffers. We first examine the impact of the climate scenario on credit losses and risk-weighted assets, and then turn to profitability and the capital position. The section concludes with a discussion of the key drivers of resilience and the main sources of uncertainty.

The deterioration in risk parameters translates into a substantial increase in expected credit losses. Under the adverse scenario, average annual expected credit losses exceed CZK 78 billion (Figure 10), equivalent to around 1.4 % of client loans and more than three times the average level under the baseline scenario. Over the seven-year stress test horizon, cumulative credit losses thus reach approximately CZK 550 billion, equivalent to 10.2% of average client loans and 4.9% of average total assets. Compared with previous CNB stress-testing exercises (Figure 10), projected losses rank among the most severe outcomes, with only two adverse scenarios over the past five years producing higher annual credit losses.

Compared with other European climate stress-tests, the CNB projection points to a relatively severe credit-risk impact. This reflects the broader design of the exercise, which combines transition and physical risks with a prolonged macroeconomic contraction and generates losses in both corporate and retail portfolios. The OeNB carbon-price stress test for Austria reports five-year credit-risk losses of 0.8% of total exposure under an orderly transition and 1.8% under a disorderly transition (Guth et al., 2021). Emambakhsh et al. (2023), in the ECB economy-wide climate stress test, report annual expected losses in 2030 of around 0.7–0.9% of total loan exposures for the median euro area

significant institution, rising to 2.1% for the 90th percentile under the late-push scenario. The Fit-for-55 climate scenario analysis reports cumulative credit losses over 2023–2030 of 6.9% of in-scope exposures in the baseline,¹⁸ 7.7% in the transition-risk scenario, and 11.3% in the scenario combining transition risk with a severe macro-financial shock (ESAs and ECB, 2024). Against these benchmarks, the CNB result – average annual credit losses of 1.4% of client loans and cumulative losses of 10.2% of average client loans – should be interpreted mainly as the outcome of a broad adverse scenario in which climate shocks interact with macroeconomic amplification, rather than as a standalone estimate of climate-risk losses.

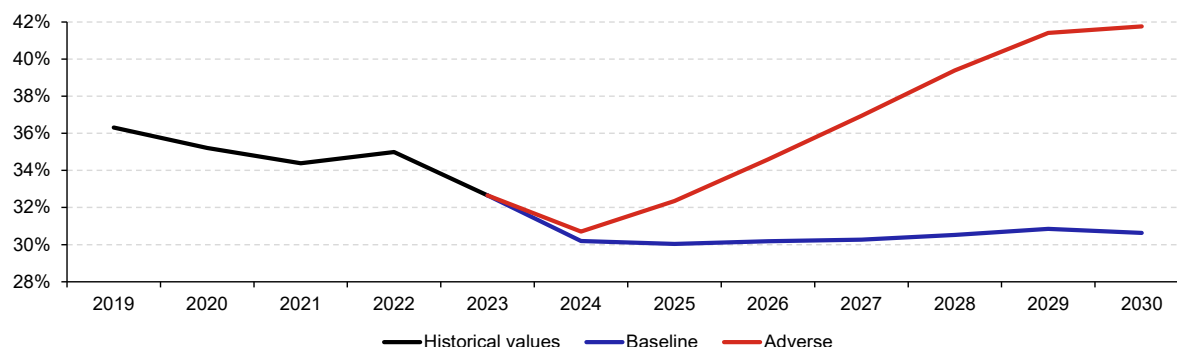
Figure 10: Average Annual Credit Losses in Scenarios (in CZK Billions)



Source: CNB

In parallel, the deterioration in credit risk parameters leads to a significant increase in risk weights, amplifying the capital impact beyond the direct effect of provisioning losses. Over the scenario horizon, average risk weights rise by more than 9 percentage points and exceed baseline levels by approximately 6.5 percentage points (Figure 11). The largest relative increase occurs in the mortgage loans portfolio, where average risk weights rise by approximately 65%, from around 23% to 37%. In contrast, the largest absolute increase occurs in loans to non-financial corporations, for which risk weights increase by more than 27 percentage points, reaching nearly 93%. This substantial increase in risk-weighted assets further depresses capital ratios.

¹⁸ Working under a static balance-sheet framework, in-scope exposures remain stable over the scenario horizon, while in the CNB climate stress test they grow by almost 29%.

Figure 11: Development of Average Risk Weights in Scenarios

Note: The figure presents average risk weights, expressed as the ratio of total risk-weighted assets (TREA) to total assets. Recognizing that certain asset categories are excluded from the risk-weighting framework, the chart can be interpreted as illustrating the balance sheet's overall risk-weighted asset density.

Source: CNB

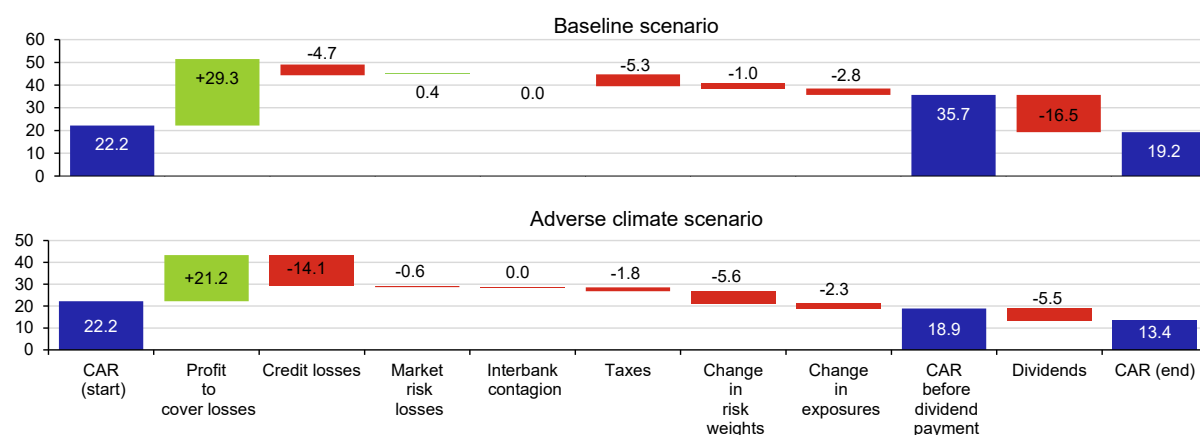
In contrast to credit risk, market risk has a relatively limited impact, owing to the small share of trading book exposures in banks' balance sheets. The widening of credit spreads due to the implementation of transition vulnerability factors, together with declining asset prices, generates market losses on assets measured at both fair value through profit or loss and fair value through other comprehensive income. On average, these losses amount to CZK 1.1 billion per year.

Elevated credit and market losses, increased risk weights, and near-zero interest rates exert substantial pressure on the banking sector over the entire scenario horizon. Although the sector remains profitable in aggregate, return on assets (RoA) falls markedly below the baseline, as lower interest rates reduce interest income and pre-impairment income provides a smaller cushion against credit and market losses (Figure 12). The combined impact of elevated losses, higher risk weights, tax expenses and balance sheet expansion reduces the aggregate capital ratio by more than 3 percentage points, to 18.9%. Under the assumption that banks distribute the maximum available capital surplus through dividend distributions, amounting to CZK 330.5 billion, the capital ratio declines further to 13.4%, representing an overall decrease of almost 9 percentage points relative to the starting level.

In response to the material drawdown of the aggregate capital ratio under the adverse scenario, available macroprudential buffers provide an important loss-absorbing capacity and support the continued provision of credit to the real economy. The countercyclical capital buffer (CCyB) is fully released to absorb losses and mitigate the risk of a procyclical tightening of lending conditions.¹⁹ Given the systemic and structural nature of transition shocks, the systemic risk buffer (SyRB), which partly reflects climate-related vulnerabilities (CNB, 2024b), is also released. In addition, partial use of the capital conservation buffer (CCoB) provides further loss-absorbing capacity, although it triggers automatic restrictions on dividend distributions. Overall, the development of the capital ratio under the adverse scenario suggests that the Czech banking sector remains resilient at the aggregate level despite severe climate shocks.

¹⁹ As stated in the CNB's methodology on setting the CCyB, in the case of adverse economic developments (CNB, 2023), CNB "is prepared to release the CCyB so that the credit supply does not become constrained."

Figure 12: Decomposition of the Change in the Banking Sector's Overall Capital Ratio in Scenarios (in pp)



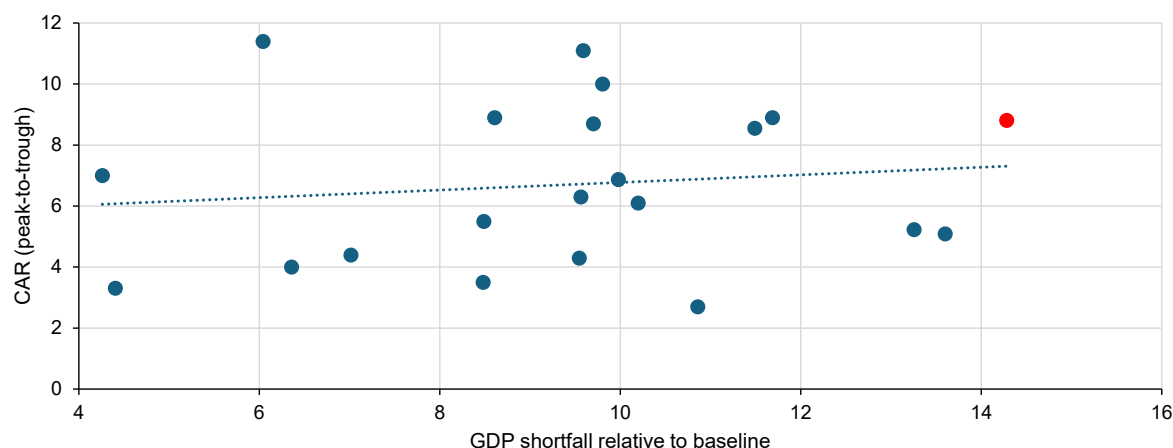
Note: CAR = overall capital ratio. Items increasing the capital ratio are shown in green and items reducing it in red. The decrease in the capital ratio in the baseline scenario is driven primarily by the dividend payout assumption, whereby the test assumes that banks pay out the maximum possible amount of dividends after capital requirements and MREL are met.

Source: CNB

5.1 What Drives Resilience? Interpreting the Results

The resilience of the Czech banking sector under the adverse scenario should be interpreted in light of the severity of the underlying macroeconomic stress.²⁰ To provide a benchmark, we compare the climate scenario with adverse scenarios used in previous CNB stress-testing exercises, relating the deviation of GDP from the baseline to the associated peak-to-trough decline in the capital adequacy ratio (Figure 13). The climate scenario lies towards the upper end of the historical distribution in both dimensions, with a GDP shortfall of more than 14% and a decline in the capital adequacy ratio of around 9 percentage points. Moreover, it lies somewhat above the historical relationship between macroeconomic severity and capital depletion, suggesting a relatively pronounced impact on bank capital given the size of the aggregate GDP shock.

²⁰ Figure B2 in the Appendix B depicts the severity of the adverse climate scenario by comparing the shortfall of GDP and increase in unemployment against their historical distributions.

Figure 13: Macroeconomic Severity and Capital Depletion Across CNB Stress Tests

Note: The red dot represents the climate stress test. The average GDP shortfall is calculated as the percentage deviation of GDP in the adverse scenario from the baseline over the scenario horizon.

Source: CNB

The banking sector's resilience despite the severity of the adverse scenario calls for a closer examination of its underlying drivers.

First, resilience is supported by the structural characteristics and strong initial position of the Czech banking sector. Banks rely on traditional lending and maintain conservative risk profiles and a high level of liquidity, with a significant share of assets held in relatively low-risk instruments, including deposits with the central bank and sovereign bonds. In addition, the sector entered the stress test with solid profitability following the previous rise in interest rates, relatively low average risk weights and low shares of Stage 2 and Stage 3 exposures (around 13% of total loans). Together these factors enhance the sector's loss-absorbing capacity and help explain its resilience under the adverse scenario.

Second, transition risk is unevenly distributed across economic sectors, with emissions-intensive sectors exhibiting disproportionately large increases in credit risk. For instance, PDs in the transportation and storage sector increase more than tenfold over the scenario horizon. However, the aggregate impact is mitigated by the composition of banks' portfolios. Exposures to emissions-intensive sectors subject to additional risk adjustments account for only around 14% of total loans to non-financial corporations. As a result, losses remain contained at the system level, although they may be more concentrated in banks with greater exposures to these sectors.

At the same time, the relatively limited aggregate impact of sector-specific elevated PDs should not be interpreted as evidence that transition risk is negligible. Transition risk may also propagate through indirect channels, including global supply chain linkages, carbon competitiveness and second-round macro-financial effects. In particular, elevated losses and tighter lending conditions could further weaken economic activity, thereby feeding back into credit risk and amplifying the initial shock. While these mechanisms are partially captured in the current framework, their overall impact may still be underestimated.

Moreover, the aggregate results may also mask heterogeneity across institutions. Banks with greater exposure to emissions-intensive sectors could experience larger capital drawdowns, even if the impact remains contained at the system level. A more severe materialisation of climate and broader macro-financial shocks could lead to a larger depletion of capital buffers and, in extreme cases, breaches of binding Pillar I and Pillar II capital requirements.

The final capital ratio is also sensitive to the fiscal policy stance, particularly the scale of government deficits and banks' holdings of sovereign debt over the scenario horizon. A larger volume of government bonds on banks' balance sheets would provide an additional source of relatively stable interest income, partially mitigating the impact of the stress on the capital ratio. However, in the adverse scenario, government deficits were deliberately reduced in the final two years, reflecting the assumed activation of the debt brake.

The results are also subject to inherent uncertainties. The adverse scenario represents only one stylised path of climate risk materialisation, while the actual transition may unfold differently, and potentially more severely. Expanding the framework to incorporate multiple climate scenarios or additional sensitivity analyses would therefore provide a more comprehensive assessment of transition risk and enhance the robustness of the results.

The results thus indicate resilience under the specified adverse scenario, while underscoring the importance of viewing climate stress testing as a tool for identifying underlying vulnerabilities rather than as a definitive assessment of systemic resilience. From this perspective, climate risk represents a potential source of financial system vulnerability and should therefore be incorporated into prudential risk assessments (ECB and ESRB, 2023).

6. Conclusion

This paper presents the latest climate stress test conducted by the CNB, the results of which were originally published in the Financial Stability Report – Autumn 2024 (CNB, 2024a) and demonstrates its usefulness as a forward-looking tool for identifying key transmission channels of climate risks and assessing their potential impact on financial stability. The stress test is tailored to the Czech economy, a small open economy characterised by a relatively carbon-intensive production structure and explores how a delayed and abrupt transition to a low-carbon economy may propagate through macroeconomic conditions, sectoral performance, and banks' balance sheets. By incorporating carbon competitiveness and sector-specific risk adjustments into a top-down stress-testing framework, the paper shows how climate risks can be assessed even when granular firm-level data are limited. The adopted approach provides a pragmatic way to capture differences in transition risk across sectors, consistent with the exploratory nature of climate stress testing.

The results indicate that, given its initial strong capital position, even under a severe adverse scenario characterised by a deep and prolonged recession, the aggregate capital position of the Czech banking sector remains above regulatory minimum requirements throughout the stress-test horizon from mid-2024 to 2030, although a substantial share of releasable capital buffers is utilised. At the same time, climate shocks materially affect credit risk parameters and risk weights, leading to substantial capital depletion and demonstrating that climate risk can represent a relevant source

of systemic vulnerability. The observed resilience reflects favourable initial conditions and structural features of the Czech banking sector, including conservative balance sheet composition and relatively limited exposures to the most emissions-intensive sectors. However, the aggregate results may mask heterogeneity across banks and may not fully capture indirect transmission channels and amplification effects.

Future stress-testing exercises would benefit from greater data availability and methodological granularity. More detailed firm- and household-level data would enable a more precise identification of risk concentrations and, in turn, better calibration of macroprudential and microprudential responses. Such developments, however, should remain proportionate, balancing analytical benefits against the reporting burden and data-collection costs for firms and financial institutions.

Finally, substantial uncertainty surrounds the timing, scale and transmission of climate risks. Climate change is characterised by long horizons, non-linear dynamics, policy uncertainty, and potentially significant second-round effects. These features warrant a cautious and forward-looking approach to financial stability analysis. Within its mandate to safeguard financial stability, the CNB will continue to identify and monitor climate risks to financial institutions, including those stemming from the transition to a low-carbon economy, and further refine its analytical tools for assessing their implications for banking sector resilience.

In line with Aikman (2026), “the objective should shift from certifying resilience to mapping vulnerabilities: which shocks matter most, where amplification is likely to occur, and which institutions or markets the stability of the system is most reliant upon.” In this sense, climate stress testing should not be viewed as a pass-fail exercise, but rather as a tool for identifying systemic vulnerabilities and potential amplification channels. From this perspective, climate stress testing resembles a form of policy “war-gaming”, aimed at strengthening authorities’ analytical preparedness and institutional learning rather than providing ex ante reassurance.

More broadly, the exercise illustrates the role of stress testing as a tool for understanding how different types of shocks propagate through the economy and the financial system. We believe that the insights and methodological experience gained from this exercise will provide a useful basis for further developing the CNB’s stress-testing framework to better capture and quantitatively assess climate and, more broadly, energy-related risk.

References

- ACHARYA, V. V., R. BERNER, R. ENGLE, H. JUNG, J. STROEBEL, X. ZENG, AND Y. ZHAO (2023): “Climate Stress Testing.” *Annual Review of Financial Economics* 15(1), pp. 291–326.
- AIKMAN, D. (2026): “Stress Testing Needs a Reset.” National Institute of Economic and Social Research Blog, 2026-02-27 [cit. 2026-09-22]. Available from: <https://niesr.ac.uk/blog/stress-testing-needs-reset>
- ALLEN, T., S. DEES, J. BOISSINOT, C. M. CAICEDO GRACIANO, V. CHOUARD, L. CLERC, A. DE GAYE, A. DEVULDER, S. DIOT, N. LISACK, F. PEGORARO, M. RABATÉ, R. SVARTZMAN, AND L. VERNET (2020): “Climate Scenarios for Financial Stability Assessment: An Application to France.” BdF Working Paper Series No. 774, Banque de France.
- ALOGOSKOUFIS, S., N. DUNZ, T. EMAMBAKSH, T. HENNIG, M. KAIJSER, C. KOURATZOGLU, M. A. MUNOZ, L. PARISI, AND C. SALLEO (2021): “ECB Economy-Wide Climate Stress Test: Methodology and Results.” ECB Occasional Paper Series No. 281, European Central Bank.
- ANYFANTAKI, S., M. BLIX GRIMALDI, C. MADEIRA, S. MALOVANA, AND G. PAPADOPOULOS (2025): “Decoding Climate-Related Risks in Sovereign Bond Pricing: A Global Perspective.” ECB Working Paper Series No. 3135, European Central Bank.
- BAILEY, A. (2020): “The Time to Push Ahead on Tackling Climate Change – Speech by Andrew Bailey.” Bank of England, 2020-11-09 [cit. 2026-08-19]. Available from: <https://www.bankofengland.co.uk/speech/2020/andrew-bailey-speech-corporation-of-london-green-horizon-summit>
- BANK FOR INTERNATIONAL SETTLEMENTS (BIS) (2020): “A Global Sudden Stop.” BIS Annual Economic Report 2020. 2020-06-24 [cit. 2026-09-22]. Available from: <https://www.bis.org/publ/arpdf/ar2020e1.htm>
- BANK FOR INTERNATIONAL SETTLEMENTS (BIS) (2021): “Climate-Related Risk Drivers and Their Transmission Channels.” April 2021 [cit. 2026-09-01]. Available from: <https://www.bis.org/bcbs/publ/d517.htm>
- BANK OF ENGLAND (BoE) (2022): “Results of the 2021 Climate Biennial Exploratory Scenario (CBES).” 2022-05-24 [cit. 2026-09-01]. Available from: <https://www.bankofengland.co.uk/stress-testing/2022/results-of-the-2021-climate-biennial-exploratory-scenario>
- BAUDINO, P. AND J. P. SVORONOS (2021): “Stress-Testing Banks for Climate Change – A Comparison of Practices.” FSI Insights No. 34, Bank for International Settlements.
- BERTHOLD, B., A. CESA-BIANCHI, F. DI PACE, AND A. HABERIS (2024): “The Heterogeneous Effects of Carbon Pricing: Macro and Micro Evidence.” BoE Staff Working Paper No. 1076, Bank of England.
- BEST, F., M. PAHLE, D. SULTANI, C. GÜNTHER, M. HERTEN, J. RICHSTEIN, AND O. EDENHOFER (2026): “A Safety Valve for the EU ETS Endgame: Containing Prices through Carbon Dioxide Removal.” Ariadne Dossier, Potsdam Institute for Climate Impact Research.

- BRÁZDIK, F., T. HLÉDIK, Z. HUMPLOVÁ, I. MARTONOSI, K. MUSIL, J. RYŠÁNEK, T. ŠESTOŘÁD, J. TONNER, S. TVRZ, AND J. ŽÁČEK (2020): “The g3+ Model: An Upgrade of the Czech National Bank's Core Forecasting Framework.” CNB Working Paper No. 7/2020, Czech National Bank.
- CARNEY, M. (2015): “Breaking the Tragedy of the Horizon—Climate Change and Financial Stability – Speech by Mark Carney.” 2015-09-29 [cit. 2026-09-09]. Available from: <https://www.bis.org/speeches/20151009-breaking-tragedy-horizon-climate-change-and-financial-stability>
- CARNEY, M. (2019): “Remarks at UN Climate Action Summit – Speech by Mark Carney.” 2019-09-23 [cit. 2026-09-09]. Available from: <https://www.bankofengland.co.uk/speech/2019/mark-carney-remarks-at-united-nations-climate-action-summit-2019>
- ČASTA, M. (2022): “Deriving Equity Risk Premium Using Dividend Futures.” *The North American Journal of Economics and Finance* 60, 101667.
- CHEN, Z., P. E. BROCKWAY, S. FEW, AND J. PAAVOLA (2025): “The Impact of Emissions Trading Systems on Technological Innovation for Climate Change Mitigation: A Systematic Review.” *Climate Policy* 25(8), pp. 1293–1309.
- CHENET, H. (2021): “Climate Change and Financial Risk.” In C. Zopounidis, R. Benkraiem, and I. Kalaitzoglou (Eds.). *Financial Risk Management and Modeling*. Springer International Publishing, Cham, pp. 393–419.
- CZECH NATIONAL BANK (CNB) (2022): “Solvency Macro Stress Test of the Domestic Banking Sector.” <https://www.cnb.cz/en/financial-stability/stress-testing/banking-sector/>
- CZECH NATIONAL BANK (CNB) (2023): “The CNB’s Approach to Setting the Countercyclical Capital Buffer.” <https://www.cnb.cz/en/financial-stability/macprudential-policy/the-countercyclical-capital-buffer/>
- CZECH NATIONAL BANK (CNB) (2024a): “Financial Stability Report – Autumn 2024”. <https://www.cnb.cz/en/financial-stability/publications-on-financial-stability/Financial-Stability-Report-Autumn-2024-00001/>
- CZECH NATIONAL BANK (CNB) (2024b): “Provision of a General Nature of 6 June 2024: on Setting the Systemic Risk Buffer Rate.” <https://www.cnb.cz/en/financial-stability/macprudential-policy/the-systemic-risk-buffer/provision-of-a-general-nature-on-setting-the-systemic-risk-buffer-rate/Provision-of-a-general-nature-of-6-June-2024/>
- DIRECTIVE 2003/87/EC of the European Parliament and of the Council of 13 October 2003 Establishing a Scheme for Greenhouse Gas Emission Allowance Trading Within the Community and Amending Council Directive 96/61/EC (Text with EEA relevance), *Official Journal of the European Union*, L 275, 25 October 2003, pp. 32–46. Available from: <https://eur-lex.europa.eu/eli/dir/2003/87/oj/eng>.
- DIRECTIVE (EU) 2023/1791 of the European Parliament and of the Council of 13 September 2023 on Energy Efficiency and Amending Regulation (EU) 2023/955 (recast) (Text with EEA relevance), *Official Journal of the European Union*, L 231, 20 September 2023, pp. 1–111. Available from: <https://eur-lex.europa.eu/eli/dir/2023/1791/oj/eng>.

- DIRECTIVE (EU) 2023/2413 of the European Parliament and of the Council of 18 October 2023 Amending Directive (EU) 2018/2001, Regulation (EU) 2018/1999 and Directive 98/70/EC as Regards the Promotion of Energy from Renewable Sources, and Repealing Council Directive (EU) 2015/652, *Official Journal of the European Union*, L 2023/2413, 31 October 2023. Available from: <https://eur-lex.europa.eu/eli/dir/2023/2413/oj/eng>.
- EMAMBAKSH, T., M. FUCHS, S. KÖRDEL, C. KOURATZOGLOU, C. LELLI, R. PIZZEGHELLO, C. SALLEO, AND M. SPAGGIARI (2023): “The Road to Paris: Stress Testing the Transition towards a Net-Zero Economy.” ECB Occasional Paper Series No. 328, European Central Bank.
- EUROPEAN CENTRAL BANK (ECB) (2022): “2022 Climate Risk Stress Test.” https://www.bankingsupervision.europa.eu/ecb/pub/pdf/ssm.climate_stress_test_report.20220708~2e3cc0999f.en.pdf
- EUROPEAN CENTRAL BANK (ECB) (2026): “ECB Report on Good Practices for Climate and Nature-related Risk Stress Testing.” https://www.bankingsupervision.europa.eu/ecb/pub/pdf/ssm.202605_ECBreport_on_good_practices_for_climate_and_nature_stress_testing.en.pdf
- EUROPEAN CENTRAL BANK (ECB) AND EUROPEAN SYSTEMIC RISK BOARD (ESRB) (2023): “Towards Macroprudential Frameworks for Managing Climate Risk.” <https://www.esrb.europa.eu/pub/pdf/reports/esrb.report202312~d7881028b8.en.pdf>
- EUROPEAN COMMISSION (2024): “Climate Action Progress Report 2024.” https://climate.ec.europa.eu/document/download/2d4275cc-d6c5-4dfe-8ffa-b6c1071d430a_en
- EUROPEAN SUPERVISORY AUTHORITIES (ESAs) AND EUROPEAN CENTRAL BANK (ECB) (2024): “Fit-for-55 Climate Scenario Analysis.” ESA 2024 21.
- EUROPEAN SYSTEMIC RISK BOARD (ESRB) (2021): “Climate Risk and Financial Stability.” <https://www.esrb.europa.eu/pub/pdf/reports/esrb.climateriskfinancialstability202107~79c10eba1a.en.pdf>
- EUROSTAT (2026): “Domestic net greenhouse gas emissions” [dataset, online data code: sdg_13_10]. [cit. 2026-09-23]. Available from: https://ec.europa.eu/eurostat/databrowser/view/sdg_13_10/default/table
- FINANCIAL STABILITY BOARD (FSB) AND NETWORK FOR GREENING THE FINANCIAL SYSTEM (NGFS) (2022): “Climate Scenario Analysis by Jurisdictions: Initial Findings and Lessons.” <https://www.fsb.org/2022/11/climate-scenario-analysis-by-jurisdictions-initial-findings-and-lessons/>
- FRANKOVIC, I., T. ETZEL, A. FALTER, C. GROSS, J. OHLS, L. STROBEL, AND H. WILKE (2023): “Climate Transition Risk Stress Test for the German Financial System.” DB Technical Paper No. 04/2023, Deutsche Bundesbank.
- GLOBAL CARBON BUDGET (2025): “CO2 Emissions per Capita” [dataset]. Global Carbon Project, “Global Carbon Budget v15”; Various sources, “Population” [original data]. Population based on various sources (2024) with major processing by Our World in Data. [cit. 2026-

- 09-09]. Available from: <https://archive.ourworldindata.org/20260914-084038/grapher/co-emissions-per-capita.html> (archived on September 14, 2026).
- GRIPPA, P. AND S. MANN (2020): “Climate Stress Testing: Transition Risks in Norway.” IMF Working Paper No. 2020/232, International Monetary Fund.
- GROS, D., P. R. LANE, S. LANGFIELD, S. MATIKAINEN, M. PAGANO, D. SCHOENMAKER, AND J. SUAREZ (2016): “Too Late, Too Sudden: Transition to a Low-Carbon Economy and Systemic Risk.” Reports of the Advisory Scientific Committee No. 6.
- GROSS, C., L. C. KUNTZ, S. NIEDERAUER, L. STROBEL, AND J. ZWANZGER (2025): “Climate Stress Test for the German Banking Sector: Impact of the Green Transition on Corporate Loan Portfolios.” DB Discussion Paper 11/2025, Deutsche Bundesbank.
- GUTH, M., J. HESSE, C. KÖNIGSWIESER, G. KRENN, C. LIPP, B. NEUDORFER, M. SCHNEIDER, AND P. WEISS (2021): “OeNB Climate Risk Stress Test – Modeling a Carbon Price Shock for the Austrian Banking Sector.” *OeNB Financial Stability Report* 42, pp. 27–45, Oesterreichische Nationalbank.
- HEBBINK, G., L. BERKVEN, M. BUN, H. VAN KERKHOFF, J. KOISTINEN, G. SCHOTTEN, AND A. STOKMAN (2018): “The Price of Transition: An Analysis of the Economic Implications of Carbon Taxing.” DNB Occasional Study No. 16–8, De Nederlandsche Bank.
- KALMAN, J., J. KLACSO, R. VASIL, AND J. ZEMAN (2023): “What’s the Cost of ‘Saving the Planet’ for Banks? Assessing the Indirect Impact of Climate Transition Risks on Slovak Banks Loan Portfolios.” NBS Working Paper 7/2023, Národná banka Slovenska.
- KOTLÁŘ, M., M. MOTL, AND Z. KOMÁRKOVÁ (2023): “The Impact of Selected Long-Term Climate Scenarios on the Czech Economy.” Thematic article on financial stability 1/2023, Czech National Bank.
- KUČERA, A. AND M. SZABO (2019): “Odhad neutrální výnosové křivky českých státních dluhopisů.” (Czech only). Tématický článek o finanční stabilitě 3/2019, Czech National Bank.
- LAGARDE, C. (2021): “Climate Change and Central Banking – Speech by Christine Lagarde.” 2021-01-25 [cit. 2026-09-09]. Available from: <https://www.ecb.europa.eu/press/key/date/2021/html/ecb.sp210125~f87e826ca5.en.html>
- LE MOIGNE, M., S. LEPOT, R. OSSA, M. RITEL, AND D. Z. SIMON (2024): “Greening Ricardo: Environmental Comparative Advantage and the Environmental Gains from Trade.” WTO Staff Working Paper No. ERSD-2024-07.
- NETWORK FOR GREENING THE FINANCIAL SYSTEM (NGFS) (2023): “NGFS Scenarios for Central Banks and Supervisors.” Network for Greening the Financial System, November 2023. [cit. 2026-09-21]. Available from: <https://www.ngfs.net/en/publications-and-statistics/publications/ngfs-climate-scenarios-central-banks-and-supervisors-phase-iv>
- PANOŠ, J. AND P. POLÁK (2019): “How to Improve the Model Selection Procedure within a Stress Testing Framework.” CNB Working Paper No. 9/2019, Czech National Bank.
- PIETSCH, A. AND D. SALAKHOVA (2022): “Pricing of Green Bonds: Drivers and Dynamics of the Greenium.” ECB Working Paper Series No. 2728, European Central Bank.

- PIGOU, A. C. [1920] (2017): *The Economics of Welfare*. Routledge.
- PLAŠIL, M. (2021): “Designing Macro-Financial Scenarios: The New CNB Framework and Satellite Models for Property Prices and Credit.” CNB Research and Policy Note No. 1/2021, Czech National Bank.
- POLÁK, P. AND J. PANOŠ (2019): “The Impact of Expectations on IFRS 9 Loan Loss Provisions.” CNB Research and Policy Note No. 3/2019, Czech National Bank.
- REINDERS, H. J., D. SCHOENMAKER, AND M. A. VAN DIJK (2023a): “Climate Risk Stress Testing: A Conceptual Review.” CEPR Discussion Paper No. 17921, CEPR Press.
- REINDERS, H. J., D. SCHOENMAKER, AND M. A. VAN DIJK (2023b): “A Finance Approach to Climate Stress Testing.” *Journal of International Money and Finance* 131, 102797.
- SIUDA, V. (2020): “A Top-Down Stress-Testing Framework for the Nonfinancial Corporate Sector.” CNB Working Paper No. 12/2020, Czech National Bank.
- TEIXEIRA, N. (2025): “Green Innovation and National Competitiveness: Rethinking Economic Resilience in the *Sustainability* Transition.” *Sustainability* 17(17), 7660.
- TU, Y. AND W. WU (2021): “How Does Green Innovation Improve Enterprises’ Competitive Advantage? The Role of Organizational Learning.” *Sustainable Production and Consumption* 26, pp. 504–516.
- VÁRGEDÖ, B. (2022): “Climate Stress Test: The Impact of Carbon Price Shock on the Probability of Default in the Hungarian Banking System.” *Financial and Economic Review* 21(4), pp. 57–82.
- VERMEULEN, R., E. SCHETS, M. LOHUIS, B. KÖLBL, D. J. JANSEN, AND W. HEERINGA (2018): “An Energy Transition Risk Stress Test for the Financial System of the Netherlands.” DNB Occasional Study No. 16–7, De Nederlandsche Bank.
- WARD, H., J. C. STECKEL, AND M. JAKOB (2019): “How Global Climate Policy Could Affect Competitiveness.” *Energy Economics* 84, 104549.

Appendix A: Sectoral Distribution of Transition Vulnerability Factors

Table A1: Sectoral Transition Vulnerability Factors

NACE Sector	Average Credit Spread (additional) in p.b.	Average Asset Returns (additional)
A: Agriculture, forestry and fishing	0.93	-5%
B: Mining and quarrying	1.40	-7%
C: Manufacturing	1.47	-8%
D: Electricity, gas, steam and air conditioning supply	14.70	-78%
E: Water supply; sewerage, waste management and remediation activities	1.53	-8%
F: Construction	1.90	-10%
G: Wholesale and retail trade; repair of motor vehicles and motorcycles	0.33	-2%
H: Transportation and storage	1.80	-10%
I: Accommodation and food service activities	0.30	-2%
J: Information and communication	0.35	-2%
K: Financial and insurance activities	0.27	-1%
L: Real estate activities	0.20	-1%
M: Professional, scientific and technical activities	0.40	-2%
N: Administrative and support service activities	0.40	-2%
O: Public administration and defence; compulsory social security	0.60	-3%
P: Education	0.40	-2%
Q: Human health and social work activities	0.50	-3%
R: Arts, entertainment and recreation	0.50	-3%
S: Other service activities	0.50	-3%
T: Activities of households as employers	0.50	-2%

Appendix B: Additional Information on the Scenario Variables

Figure B1: Development of Main Interest Rates in Scenarios

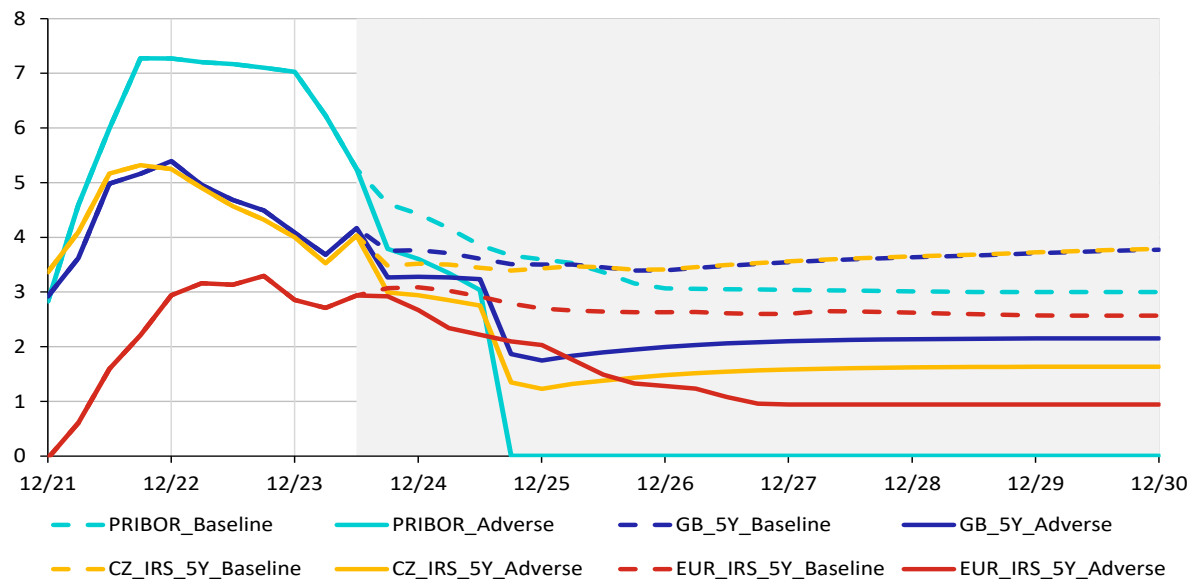
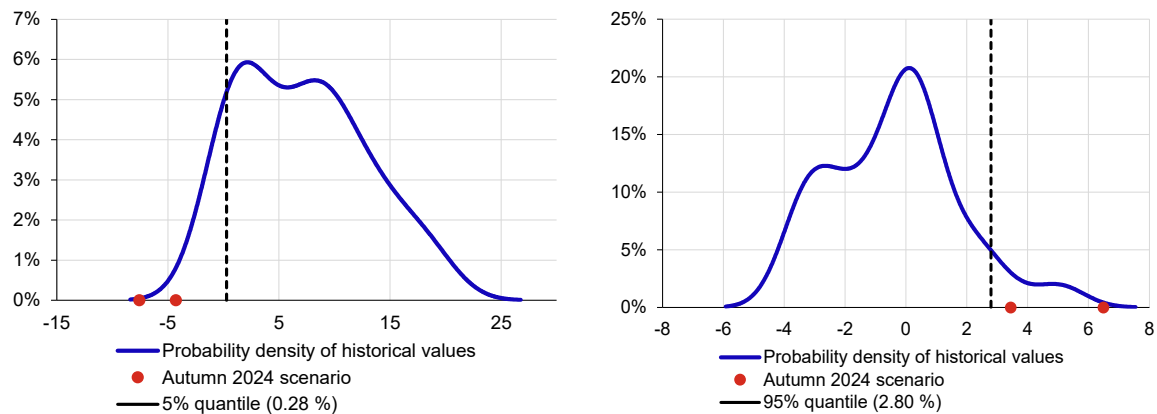


Figure B2: Comparison of the Probability Density of the Historical GDP Growth (left) and Changes in the Unemployment Rate (right) with the Projections in the Climate Stress Test Scenario

(kernel estimate of probability density; x-axis: change in pp)



Note: The probability density curve is based on the observed three-year cumulative values. The climate scenario is captured using two points representing the cumulative change in the first to third and fourth to sixth year of the scenario.

Source: CNB

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