Climate Scenario Analysis for Central Banks

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*The views expressed in this paper are those of the authors and do not reflect the views of De Nederlandsche Bank or the Eurosystem

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Overview

A top-down methodology for climate scenario analysis to assess the vulnerability of a national central bank's (NCB) balance sheet to climate change

1. Climate pathways ⇒ Network of Central Banks and Supervisors for Greening the Financial System (NGFS)
2. Macroeconomic impact ⇒ projections under each scenario from the NiGEM model
3. Translation of macro-impact into security-level impact ⇒ issuer-specific vulnerability factors for both transition risks and physical risks
4. Impact on profit projections and financial risks of an NCB ⇒ standard risk models with stressed input

Motivation

- Climate change induces disruptions to several layers of the economy via natural disasters and transition shocks $\Rightarrow$ **source of price and financial instability** (Bolton et al., 2020; Carney, 2015; Giglio et al., 2021)
  - Transition risk materializes in stranded assets (Campiglio et al., 2017)
  - Physical risk lead to shocks in prices
- Fundamental uncertainty about climate change
  - Uncertainty about the path of climate change as a source of risk for the economy (Wagner & Weitzman, 2015; Weitzman, 2012, 2014)
  - Uncertainty about the evolution of the economy, the actual release of GHG emissions, and consequently the evolution of climate change (Nordhaus & Boyer, 2000)
- The Eurosystem via its monetary holdings can have exposure to industries particularly affected by climate change (Papoutsi et al, 2022)

Contribution

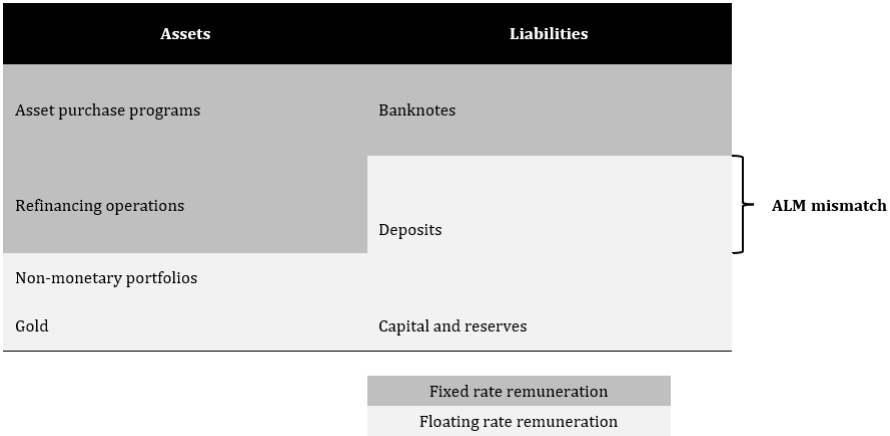
Previous work

- The fundamental uncertainty of climate change makes traditional financial risk management tools not always adequate (Ackerman, 2017; Barnett et al., 2020)
- Alternative techniques to identify and assess climate-related risks should be considered
  - Climate stress test (Battiston et al, 2017)
  - VaR and Expecated Shortfall conditioned on forward-looking climate risk scenarios (Battiston and Monasterolo, 2020)
- Several central banks performed different types of climate stress tests on the economy (ECB, BoE, BdF, DNB)

We introduce a methodology to perform a climate scenario analysis on an NCB balance sheet ⇒ gauge the impact of climate risk on profitability and financial risks

⇒ **Protective approach**: climate change as a risk management problem in addressing balance sheet risks

An NCBs balance sheet and financial risks



- ALM mismatch generates interest rate risk
- Monetary and non-monetary holdings are exposed to credit risk. Non-monetary holdings also to market risk

Data

Proprietary data on DNB's balance sheet

- Eurosystem security holdings of all asset purchase programs
- Only a share of it contributes to DNB's risks and profits
- Nominal values, credit ratings, maturity, sector, etc

Data on the climate scenarios from NGFS

- Projections under different climate scenarios, for the period 2022-2050
- Country's stock market index development
- Country's long-term interest rate development
- Deposit facility rate development

Transition and Physical risk indicators

- Scope 1+2 GHG emissions for corporate and sovereign issuers from MSCI ESG Manager
- Notre Dame Global Adaptation Initiative: country-specific physical risk score

1. Climate scenarios

- Orderly transition ⇒ Net Zero 2050
- Disorderly transition ⇒ Delayed Transition
- Hot house world ⇒ Current Policies

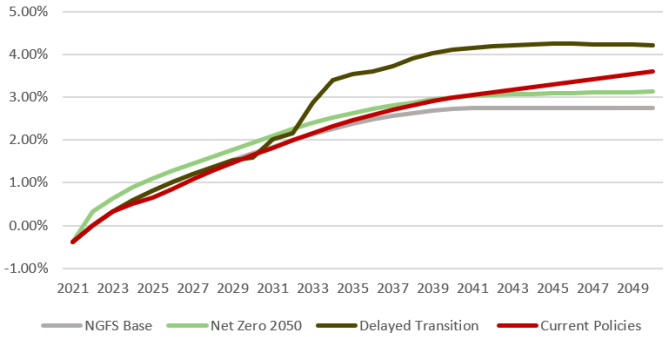
	Physical risk	Transition risk			
Scenario	**Policy ambition**	**Policy reaction**	**Regional policy variation**	**Technology change**	**CO_2 removal systems use**
Net Zero 2050	1.5˚C	Immediate	Medium	Fast	Medium
Delayed Transition	1.8˚C	Delayed	High	Slow/Fast	Low
Current Policies	3˚C+	None	Low	Slow	Low

Note: The different shades of gray indicate whether the characteristic makes the scenario more or less severe from a macro-financial risk perspective:

Low risk | Moderate risk | High risk

2. Macroeconomic impact: Output of NiGEM from NGFS

Dutch treasury rate paths



- **Net Zero 2050**: Interest rates increase immediately and remain higher over time
- **Disorderly transition**: Sudden increase when policy reactions occur
- **Current policies**: In line with the baseline and increase in the long term

3. Translation of macro impacts into security-level impacts

Vulnerability factors that measure the sensitivity of an asset's price to market developments under a scenario

- Transition Vulnerability Factors (TVFs)

$$Corporate: TVF_i^S = \frac{tCO_2Emission}{\$mSales} \tag{1}$$

$$Sovereign: TVF_i^S = \frac{tCO_2Emission}{\$mGDP} \tag{2}$$

  Where i is na issuer and S is a scenario

- Physical Vulnerability Factors (PVFs) $\Rightarrow$ ND-GAIN Country Index Score 2019

Vulnerability factors are scaled such that the equally weighted average across all issuers equals one. **The higher the scores the higher the sensitivity to climate events**

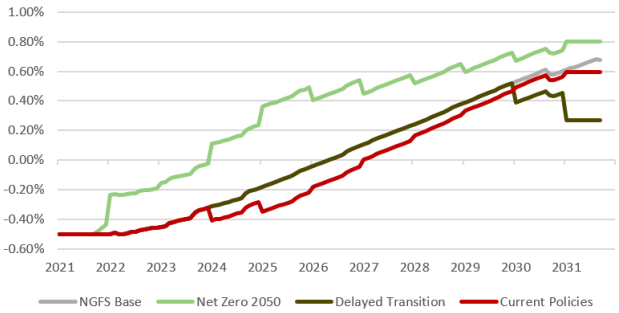
3. Translation of macro impacts into security-level impacts

Under each scenario the issuer-specific TVFs and PVFs are combined in Climate Vulnerability Factors (CVFs) as follows

Net Zero 2050	$CVF_i^{Net\ Zero\ 2050} = 0.8 * TVF_i + 0.2 * PVF_i$
Delayed Transition	$CVF_i^{Delayed\ Transition} = 0.5 * TVF_i + 0.5 * PVF_i$
Current Policies	$CVF_i^{Current\ Policies} = 0.2 * TVF_i + 0.8 * PVF_i$

4. Impact on profit projections ∼ interest rate risk

DNB's profits are driven by policy and market interest rates developments. The key policy rate affecting future profits is the Eurosystem's deposit facility rate (DFR), which is the remuneration rate for the deposits held by commercial banks at DNB.



- **Net Zero 2050**: short-term rates increase following the increase in carbon pricing that creates inflation. **High impact** (large mismatch)
- **Disorderly transition**: DFR spikes only after 2030 when mismatch is lower. **Medium impact**
- **Current policies**: Slightly lower policy rates in the long term. **Low impact**

4. Impact on credit risks

Internal model: Expected Shortfall (ES) at a 99% confidence level over a one-year period

- Climate-related risks can be transmitted through the credit risk channel via issuers' creditworthiness
- Credit rating adjusted based on the projected equity index return of the country of the issuer

$$r^{S}_{i,j,t} = r^{S}_{index,j,t} * CVF^{S}_{i} \tag{3}$$

Where i is an issuer, S is a scenario, and $r_{index,j,t}$ is the return of the stock index of country j in year t

- If -20% $< r^{S}_{i,j,t} \leq$ -10% $\Rightarrow$ 1 notch downgrade
- If -30% $< r^{S}_{i,j,t} \leq$ -20% $\Rightarrow$ 2 notches downgrade ...
- This procedure provides us with stressed inputs for the internal credit risk model

4. Impact on credit risks

Measure of the impact: difference w.r.t. DNB credit risk figures in 2021

Scenario / Year	Net Zero 2050	Delayed Transition	Current Policies
2022	Low	Low	Low
2033	Medium	High	Low
2050	Medium	Low	High

- **Net Zero 2050**: No impact in the short term and moderate impact in the medium-long term
- **Disorderly transition**: Severe increase in credit risk when sudden policies are put in place
- **Current policies**: Severe increase in credit risk only in the very long term when climate risk materialize

4. Impact on market risks

Non-monetary portfolio: equity investments

- **Market risk: portfolio value in a climate scenario relative to what the portfolio value would have been under the NGFS Base scenario**
- We apply Formula (3) to get the shocked return of each individual stock
- The shocked return of the equity portfolio in year t under scenario S is given by

$$r_t^S = \sum_{i=1}^{N} w_i r_{i,j,t}^S \tag{4}$$

  where w_i is the weight of stock i in the portfolio
- The value of the portfolio under the NGFS Base scenario evolves following a base year-on-year return

$$BaseValue_t = BaseValue_{t-1}(1 + r_t^{BaseYoY}) \tag{5}$$

- The value of the portfolio each year under each scenario is

$$Value_t^S = BaseValue_t(1 + r_t^S) \tag{6}$$

4. Impact on market risks

Scenario	Equities	
	Short term	Long term
Net Zero 2050	Medium	Medium
Delayed Transition	Low	High
Current Policies	Low	High

- **Net Zero 2050**: Medium short-term impact on market risk because of the moderate reaction of financial markets to new policies
- **Disorderly transition**: High impact in the long term due to the sudden policy transition
- **Current policies**: High impact in the long term due to the materialization of physical risk

Summary

- An orderly transition to a low-carbon economy strongly impacts profitability and the interest rate risk in the short term
- A disorderly transition or a failure to implement climate policies leads to a significant increase in credit risk and market risk in the long term
- The impacts on DNB's profits and risk must be distinguished from the effect of climate scenarios on the financial stability of the economic system at large

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