Finance Watch

Making finance serve society

Bridging the gaps in climate scenarios

Prudential approaches to compensate for underestimated climate costs

A Finance Watch Position Paper

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Introduction

Few people now doubt that climate change will be extremely costly. How costly will depend on policy choices made now and in coming years. A key input to these choices is the future economic cost of climate impacts. Unfortunately, methodological and data limitations mean that the economic models most widely used for this are underestimating climate costs by a large margin.

Until economic modelling can overcome these barriers, policymakers will be driving blind; they must find ways to compensate for the underestimation of climate costs. For financial regulators and supervisors, that means taking a more qualitative and precautionary approach to managing climate-related financial risks. This paper looks at some of the options available to prudential policymakers to do that.

Key Takeaways

1. **The costs of climate change are being understated**
   Economists have struggled to incorporate the severity of climate change impacts in economic models, as some climate risk drivers are hard to quantify and therefore excluded, such as climate tipping points, extreme weather, sea level rise, ocean acidification, nature loss, business disruption, migration, and conflict.

2. **Climate-related financial risks are inadequately managed as a result**
   The material underestimation of future climate-related economic losses in climate scenarios is causing financial risks and vulnerabilities to be understated, leading to inadequate internal and supervisory capital and liquidity assessments at financial institutions.

3. **Policymakers must respond with precautionary measures**
   1) The Network for Greening the Financial System (NGFS) has recommended that users of climate scenarios add their own risk assessment tools to account for the missing climate risk drivers. This calls for different approaches such as more qualitative climate scenario analysis and reverse stress testing.
   2) For financial policymakers, the only sure way to deliver on their financial stability mandates is to implement precautionary micro and macroprudential measures.

I. Economic costs of climate change are systematically underestimated

A. Mismatch between economic projections and climate science

Economists have developed sophisticated models for estimating the future economic losses from climate change. However, the results of these models are at odds with the

projections of climate scientists. By their own admission, economists are underestimating climate losses by a large margin.[1]

2024 saw another marked increase in severe heatwaves, floods, wildfires and droughts around the world. Average global temperatures reached 1.6°C above the pre-industrial levels and are moving upwards faster than expected.[2] The Intergovernmental Panel on Climate Change says the world is on track for 3.2°C of warming by 2100.[3] As warming accelerates up to +2°C above pre-industrial levels, further heating could trigger tipping elements in the Earth's systems - melting ice, Amazon forest dieback, and thawing permafrosts among others – which can interact and drive further temperature increases.

The impacts of this level of warming on human societies will be highly disruptive, with outcomes such as flooding of coastal cities, a large reduction in arable land, and deadly heatwaves being just some of the dangers. Going beyond this to 5°C or more would be, in the words of climate scientists, "beyond catastrophic, including existential threats".[4]

Yet academic economists have struggled to incorporate this severity into their economic models. For reasons mainly involving data and methods poorly suited to complex, non-linear outcomes (see box below), the economic models most often used to predict the impact of climate change on the economy only project modest economic losses, even at levels of warming that scientists consider catastrophic. Some estimates stretch credulity, for example projecting that temperature increases of +6°C would lead to GDP losses of only 10% (Nordhaus & Moffatt 2017, Takatura et al 2019). A range of other studies predict losses of less than 15% of GDP for temperature increases of 3°C to 4°C (various 2017-2020).[5]

Recent research has made some improvements. Studies from 2024 by *Kotz et al.*[6] and *Bilal and Känzig*[7] forecast losses relative to a prior trends baseline of 33% and 44% GDP by 2100 for 3°C of warming. However, even these studies still omit many of the main climate impacts and therefore produce a substantial underestimate of future losses.

Box: Some of the reasons why economic models underestimate climate losses[8]

- Excluding or giving low costs to climate risk drivers such as extreme weather, sea level rise, biodiversity loss, mass migration, business disruption, or conflict
- Estimating damages using a quadratic function that excludes the acceleration of losses around tipping points

[1] FSB & NGFS, *Current climate scenario analysis exercises may understate climate exposures and vulnerabilities*, November 2022; *NGFS Climate Scenarios for central banks and supervisors - Phase V*, November 2024.
[2] Science, *Recent global temperature surge intensified by record-low planetary albedo*, December 2024.
[3] IPCC, *Summary for Policymakers, Sixth Assessment Report*, 2023.
[4] Xu & Ramanathan, *Well below 2°C: Mitigation strategies for avoiding dangerous to catastrophic climate changes*, 2017.
[5] IPCC, *AR6 WG2, Box ECONOMIC.1*, 2023.
[6] Kotz, M., et al., *The economic commitment of climate change*, Nature, April 2024.
[7] Bilal, A. & Känzig, D.R., *The macroeconomic impact of climate change*, NBER Working Paper No. 32450, 2024.
[8] Carbon Tracker, *Loading the DICE against Pensions*, 2023.; IFoA, *The Emperor's New Scenarios*, 2023.; See also, Grandjean, A., *Nature at the heart of economic reasoning: the emergence of a new macroeconomics*, February 2025.

- Modelling uncertainties using a probability density function with a normal distribution (thin tail)
- Assuming a gradual, linear materialisation of costs, discounted to present value
- Using historical data to predict the outcomes of novel future events
- Using local GDP differences between today's hot and cold locations as proxies for the future impact of global temperature changes
- Assuming that economic equilibriums can be achieved in a climate-disrupted world (using computable general equilibrium (CGE) models)
- Assuming that CO2 removal at scale will be carried out
- Assuming that only 'outdoor' industries (agriculture and fisheries) will be disrupted by climate change
- Not being peer reviewed by climate scientists

In addition, the way the economic effects of climate change are presented obscures the modelling flaws: GDP losses are typically given relative to a prior trends baseline, which compares them to GDP growth in a hypothetical world without climate change. This means that GDP losses of 33% or 44% refer to a reduction in the GDP *growth rate* by 2100 and not a GDP loss in absolute terms. If the prior trend had assumed 250% growth by 2100, users would simply apply growth rates of 217% or 206% instead. This is at odds with the predictions of climate science.[9] If (or when) climate impacts overwhelm the intrinsic growth of GDP, it would create a fundamental challenge for modern financial markets which have no precedent for long-term falls in world GDP.[10]

B. Climate scenarios and the NGFS's current damage function

One of the uses of the economic forecasts mentioned above is to inform climate scenario analysis, which are tools used in the financial sector to assess climate risks and vulnerabilities and increasingly to inform risk management decisions.[11] Financial regulators and supervisors also use climate scenarios for supervision and to explore systemic vulnerabilities. Scenario analyses are now viewed as a starting point to develop methodologies for measuring climate-related risks.[12]

The most widely used climate scenarios come in a set updated regularly by the Network for Greening the Financial System (NGFS), of which "Current Policies" is the most widely used individual scenario. Current Policies assumes temperature increases of +2.9C by 2100, in line with IPCC expectations.

The latest release of Current Policies (Phase V, November 2024) integrates the damage function from *Kotz et al.*, which converts +2.9C temperature rise into GDP losses of 14% by 2050 and 33% by 2100, relative to a prior trends baseline. The new damage function triples

[9] The Kotz et al analysis is based on Shared Socio-Economic Pathway (SSP) 2, in which social, economic, and technological trends are assumed not to shift markedly from historical patterns, despite the effects of climate change already locked in. Some critics have called for a more realistic choice of SSP to be used.
[10] One study sees this happening around 2060: Bongiorno, R., et al., *Climate scenario analysis*, June 2020.
[11] The distinction between scenario analysis and stress tests being that stress tests, unlike scenario analysis, should lead to conclusions about capital or liquidity adequacy of financial institutions in severe but plausible scenarios.
[12] EBA, *Report on data availability and feasibility of common methodology for ESG exposures*, February 2025.

the very small damages forecast in earlier versions[13] but the NGFS acknowledges that it still fails to account for all potential physical impacts of climate change.[14] The damage function excludes "sea level rise, tropical cyclones and tipping points, as well as non-market damages such as those to ecosystems and human health".[15] Other disruptions, including second-round effects such as mass migrations and conflict, could be added to this list.

If the scale of economic losses is being materially underestimated in climate scenarios because important loss drivers are excluded, it is safe to say that financial risks and vulnerabilities assessed using those climate scenarios are also being materially understated. The inevitable result is that internal and supervisory capital and liquidity assessments made using these climate scenarios will also be inadequate.

This is being increasingly recognised by the supervisors themselves. A 2022 survey of central banks and financial supervisors found the scenarios to be inadequate for assessing financial stability: "measures of exposure and vulnerability are likely understated. Many exercises do not capture second-round effects, potential non-linearities in climate-related risks, and other potentially large sources of risk, such as those stemming from an abrupt correction in asset prices when transition shocks result in fire sales of assets in exposed sectors".[16]

The ECB's 2022 climate risk stress tests for banks, which were based on NGFS Phase II scenarios, found that "existing credit risk models do not seem to incorporate all relevant climate risk channels" and as a result "banks' efforts to incorporate climate risk into their credit risk modelling are still at a preliminary stage".[17] Assuming that regulatory and supervisory mandates do not allow for material risks to be ignored simply because they are hard to model, other approaches such as those described in Section II will be needed.

C. EU Fit-for-55 climate scenario analysis

In 2024, EU authorities concluded a one-off climate scenario exercise for the EU's financial sector as a whole.[18] The economic costs of climate change were not a key variable, as the exercise focused on short term transition risks arising from implementation of the EU's "Fit for 55" transition policy package by 2030. The exercise was unprecedented, as it encompassed banking, insurance, pension and investment fund sectors and modelled contagion and amplification effects across firms and sub-sectors. Yet, by narrowly focussing on a limited time horizon and on a very narrow set of transition risks, the exercise failed to account for the potential of severe, system-wide impacts from both physical and transition risks.[19]

[13] The bank lobby group *BPI* has sought to throw doubt even on these modest increases in loss estimates. However, the commentary appears to be aimed at avoiding potential bank capital increases rather than prudential safety.
[14] NGFS, *Explanatory Note*, November 2024.
[15] Kotz et al, 2024, ibid.
[16] NGFS & FSB, *Climate Scenario Analysis by Jurisdictions: Initial Findings and Lessons*, November 2022.
[17] ECB, *2022 Climate Risk Stress Test*.
[18] EBA, EIOPA, ESMA, ECB, *Report on fit-for-55 climate scenario analysis*, November 2024.
[19] Green Central Banking, *Unfit for 55: why the ECB needs to rethink its climate scenarios*, January 2025.

However, EU supervisors could build on this exercise in future by conducting a new enhanced assessment with a longer-term perspective that better reflects the true scale of climate risks.

II. Options for financial regulators to manage the underestimation of climate costs

The NGFS plans to update its climate scenarios again in 2026, providing an opportunity to add some of the climate risk drivers that were missing from Phase V. While important, this will not be easy given the uncertainties on timing and magnitude of losses, correlations, non-linearities, as well as second-order, compound and spillover effects.[20]

In the meantime, the NGFS has been transparent about some of the modelling limitations it faces and has urged users of its scenarios to make their own adjustments for the missing climate risk drivers. Its January 2024 Explanatory Note said that "scenario users should seek to tailor their analyses" by adding additional risk assessment tools.[21] While it is unlikely that financial regulators and supervisors can quantitatively model elements that have eluded the NGFS, other approaches exist.

A. A qualitative approach to scenario analysis

Given the need for forward-looking risk assessments, an alternative approach is to use more "decision-useful" qualitative climate scenarios and reverse stress tests.

Qualitative climate scenarios could overcome many of the modelling limitations by incorporating a fuller range of climate change outcomes in line with climate science. Such scenarios should focus on combining a realistic baseline physical narrative that would reflect the forecasts of the complex climate-related impacts with political and economic drivers of transition. Experts have started developing examples[22] and upcoming NGFS work on short-term scenarios could take this further.

Reverse stress tests can be a useful "fix" to partially overcome the limitations of the existing scenarios and underlying models to better understand climate-related vulnerabilities.[23] Reverse stress tests are widely used in financial risk management. For climate change risk, reverse stress tests can help identify a breaking point for the financial system and also help determine the required path for net-zero transition to avoid catastrophic outcomes.

The need for such approaches is increasingly recognised, for example the EBA's draft Guidelines on ESG Scenario Analysis[24] warn that modelling limitations "call for great caution when translating the outcomes of climate scenario analysis derived from traditional macroeconomic models" and urge banks to "ensure the robustness of the

[20] FSB, *Assessment of Climate-related Vulnerabilities, Analytical Framework and Toolkit*, January 2025.
[21] NGFS, *Explanatory Note: Purpose, Use Cases and Guidance on Where Institutional Adaptations Are Required*, January 2024.
[22] Universities Superannuation Scheme and University of Exeter, No time to lose, September 2023.
[23] IFoA, *The Emperor's New Climate Scenarios*, July 2023.
[24] EBA, Draft Guidelines on ESG Scenario Analysis, Consultation paper, January 2025.

common narrative and scenarios used." Banks should also document the limitations in the scenarios used.

A further step that supervisors could take is to ask financial institutions how they are implementing the NGFS's advice to tailor climate scenario analyses with additional risk assessment tools (qualitative or quantitative) in their internal stress testing and transition planning. Any information that this reveals about risk management gaps would support the Commission's ongoing strategic commitment to analyse how risks identified by stress tests or scenario analysis can be integrated into micro and macroprudential regulation and supervision.[25]

B. A precautionary approach to prudential regulation

Despite the limitations of climate scenario analysis, two conclusions stand out: orderly and timely transition is a precondition for financial stability, and the cost of mitigation is far less than the cost of unmitigated climate change. This makes a precautionary approach essential. Bank and insurance regulators have some policy tools available that could be implemented without delay. These include:

1. Exposure-level (microprudential) capital requirements

After investigating the need for different prudential treatment of environmentally harmful assets, the insurance regulator EIOPA concluded that fossil fuel-related stocks and bonds are especially vulnerable to transition risks and recommended a 17% capital surcharge on top of current capital requirements for such stocks and a 40% add-on for bonds.[26]

Similar proposals have been tabled for banks to apply a risk weight of 150% to exposures to existing fossil fuel activities and 1250% to exposures to new fossil fuel exploration. The recommendation, first published by Finance Watch in 2020,[27] has been followed by legislative proposals in the UK and Canada but so far not implemented. The work of the EBA is ongoing on this issue.

2. Tools to address systemic risk (macroprudential tools)

In order to address the systemic dimension of climate risk, macroprudential tools such as the systemic risk buffer and concentration limits could be adapted.[28] As a variation on this theme, Finance Watch proposed[29] a loan-to-value (LTV)-based method for linking banks' fossil fuel exposures to the remaining carbon budget. This would trigger a capital surcharge once a set threshold of climate-related risk has been reached.

[25] EC Strategy for Financing the Transition to a Sustainable Economy, Annex, 3(e).
[26] EIOPA, *Final Report on the Prudential Treatment of Sustainability Risks for Insurers*, November 2024.
[27] Finance Watch, *Breaking the Climate Finance Doom Loop*, June 2020, *A Silver Bullet Against Green Swans*, Nov 2021.
[28] Monnin and Hiebert, Climate-related systemic risks and macroprudential policy, August 2023; and Bartsch et al., *Designing a macroprudential capital buffer for climate-related risks*, ECB Working Paper No. 2943, May 2024.
[29] Finance Watch, *Finance in a Hot House World*, Oct 2023.

Conclusion

Financial policymakers are already aware that some of the biggest risk drivers associated with climate change, such as tipping points and sea level rise among others, are missing from the economic modelling of climate losses they have been relying on. When these risks materialise, the economic and financial losses could potentially dwarf those of the Great Depression, the Global Financial Crisis or the Covid-19 pandemic.

Without a full picture of the losses that climate change could cause, the financial system is not only driving blind, it is driving without airbags. Financial regulators and supervisors do not have to wait for a climate Minsky moment before acting. They can adopt a more qualitative and comprehensive approach to climate scenario analysis and stress testing and require the same from financial institutions. Above all, Finance Watch urges policymakers to take a precautionary approach by implementing some of the prudential climate safety measures already on the table.

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