



Quantitative Climate Scenario Analysis in Financial Decisions: Case Studies

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Acknowledgements

This chapter has been written by the Scenario Analysis sub-group of the Climate Financial Risk Forum (CFRF) Resilience Working Group. It is largely written by practitioners, and is intended to assist practitioners working in banks, insurers, and asset managers, who support risk identification and strategy for climate change and/or environment-related risks. It provides examples of quantitative scenario analysis that can be integrated into financial decisions.

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Foreword

Forward-looking climate scenario analysis is a particularly important tool for financial professionals in the context of climate change, where it is known that the past is not a good guide to future risks.

This importance has been highlighted by recent communications from regulatory bodies, such as the discussion paper published by the Basel Committee on Banking Supervision and the recent consultation by the Bank of England's Prudential Regulatory Authority on '[Enhancing banks' and insurers' approaches to managing climate-related risk](#)'.

This report builds on prior work from the Climate Financial Risk Forum on [climate scenario analysis](#). For example, a proposed framework for short-term scenario analysis; and overviews of the latest scenario analysis data, tools or evolving practices within financial firms.

This year's report deliberately focuses on the quantification of financial impact, as this is what matters most to financial professionals. The quantification of the financial impact of climate scenarios enables the financial materiality of risks and opportunities to be assessed and risk-based decisions to be made.

This report curates a set of case studies, which assess the financial impact of different climate scenarios on various assets or investments.

It offers a diverse range of perspectives from asset managers, banks, insurers, and academia, to data providers, on a range of asset classes from listed equity and corporate bonds, to real estate and sovereign bonds, with impacts expressed in different financial metrics, such as equity prices, asset value or credit rating.

There is a high level of uncertainty around the climate transition - with a fragmented global policy environment, increasing trade barriers and diverging forecasts for the deployment of low carbon technologies - and around the associated response of the climate system to elevated greenhouse gas emissions, all within the context of a [low level of preparedness](#).

The aim of bringing these case studies together – and comparing and contrasting their approaches and results - is to assist financial professionals to progress their understanding of the financial risks of climate change and its uncertainties, manage them and meet regulatory expectations.

Billy Suid – Head of Climate Risk at Barclays, Chair of the CFRF Resilience Working Group

1. Introduction

Purpose

This paper presents a curated set of 9 case studies from financial institutions, academia, and data and analysis providers, bringing in one place high quality quantitative climate scenario analysis.

These case studies aim to inform financial decisions by quantifying physical and/or transition risk drivers. Individually, they provide concrete and transparent quantified scenario analysis examples which differ considerably as they focus on different asset classes, geographies, time horizons and scenario severity. This diversity is hopefully valuable for financial professionals.

As a combined paper, it can help benchmark against peers, inspire new use cases or methods, and support risk-based internal discussions. It provides examples of the latest forward-looking quantitative climate scenario analysis, a practice that is continuously developing within the industry.

While some case studies have been previously been published, most have only been seen internally by firms and are made available for the first time.

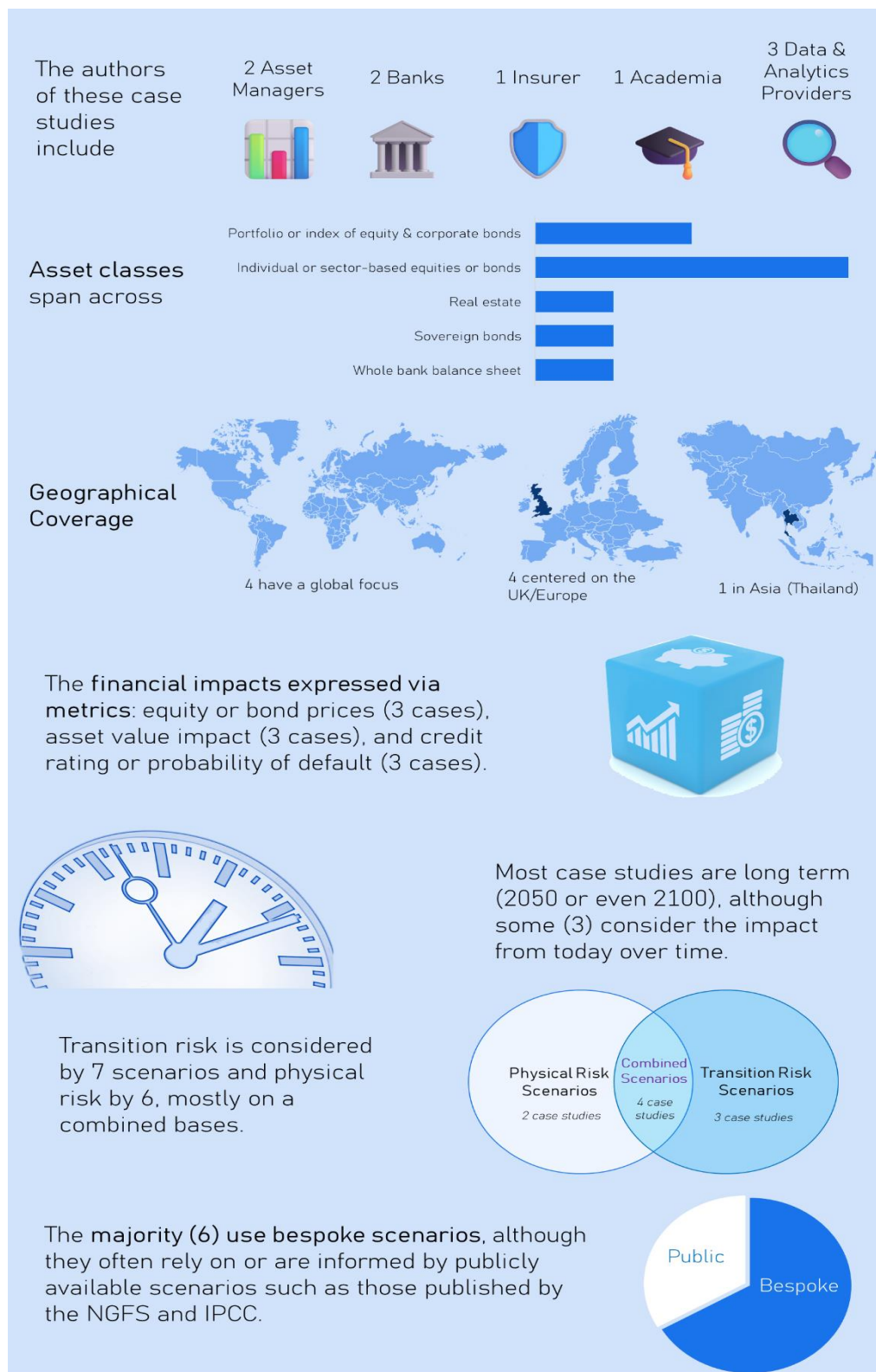
Intended Use and Audience

This report is aimed at risk managers, portfolio managers, analysts, and climate leads interested in a materiality-based approach to climate risk management.

2. Case Study Summary

This section contains a high-level summary of the nine case studies, which are shown alphabetically by the contributing organization's name. The statistics below illustrate the diversity they offer.

1



¹ NGFS = Network for Greening the Financial System
IPCC = Intergovernmental Panel on Climate Change

Table 1: Overview of 9 Case Studies Presented in this Report

Firm	Scenario	Scenario source	Time Horizon	Asset Class	Geography	Physical / Transition	Key Highlights on Financial Impact
Aberdeen Investments	2 scenarios; Mean and Paris-aligned, resulting from probability-weighting 16 underlying scenarios.	Bespoke and various off-the-shelf	Today to 2050	Materials listed equity	Global	Physical & Transition	Equity Price: Most companies within a -20/+10% range, with significant upside (up to 120% for some).
Aviva / JBA	2 scenarios; calibrated to Representative Concentration Pathway (RCP) 4.5 & 8.5.	IPCC	2050	Residential real estate	UK	Physical (flood risk)	Annual Average Loss (AAL): portfolio level AAL increase from £0.5bn in baseline to £1bn in RCP 8.5 vs. a portfolio size of £6.2tn. 1-in-200 Year Loss: portfolio level losses increase from £5.9 billion to £8.4 billion in RCP 8.5.
Barclays	1 Net Zero 2050 scenario.	Bespoke	2050	Cement listed equity	Europe	Transition	Equity Price: Impact ranges from -100% to +25%, depending on the firm's pricing power and strategic response.
L&G	4 scenarios; from 1.5°C to >2°C.	Bespoke	2100	Listed equity and corporate bonds	Global	Transition	Equity Price: Portfolio valuations decline by 11.5% to 30.5%. Credit Rating: 2-9% of the portfolio subject to downgrade to sub-investment grade.
Moody's	3 scenarios; from 1.5°C to > 3°C.	NGFS	2050	Automotive corporate bonds	Global	Physical & Transition	Probability of default: increase from c.1% to c.2%, depending on production mix and location.
MSCI	2 scenarios; 1.5°C and 3°C.	Bespoke, informed by NGFS and IPCC	Today to 2100	Listed equity (MSCI UK IMI Index)	UK	Physical	In the SSP3-7.0 scenario, direct revenue losses from a 1-in-200-year fluvial flood for MSCI UK IMI companies rise from \$0.64B today to \$1.33B by 2100. Indirect macroeconomic impacts grow from \$225.1B to \$915.3B (with nonlinearity), against present-day revenues of \$2.7T. MSCI UK IMI companies.

Firm	Scenario	Scenario source	Time Horizon	Asset Class	Geography	Physical / Transition	Key Highlights on Financial Impact
NatWest and Planetrics	4 Transition Risk Scenarios.	Bespoke, calibrated using different external scenarios and internal modelling	2035	Loan portfolio	UK	Transition	Contribution of £8 million to the total ECL of £3.4 billion from the current climate transition policies at the end of 2024; Sectoral impacts (for transition sensitive sectors) ranging from -4.2% to -25% in a stress transition scenario.
S&P	2 scenarios; from 1.5°C to >3°C.	NGFS	Today to 2050	Corporate bonds	Global (US focus)	Physical & Transition	Credit Rating: 7-notch downgrade (from BBB+ rating) for Data Centre and 4-notch downgrade (from A- rating) for Oil & Gas production firm.
University of Oxford	5 scenarios; based on a mix of SSP scenarios and Adaptation assumptions.	Bespoke	2075	Sovereign debt	Thailand	Physical & Transition	Sovereign rating: Downgrade up to 4 notches, which can be substantially reduced by adaptation investments with benefit cost ratio > 1.27.

Key Insights and Takeaways

These case studies offer a range of insights about the financial impact that climate risk factors could have on portfolios.

Many of those insights are specific to the asset class or the approach taken and are included directly in each of the case studies. There are also a number of insights coming out of their comparisons:

1. **Risks and opportunities:** Most of the case studies assess the downside risk that climate change poses to the assets being assessed. But some also identify upside potential:
 - a. The analysis from University of Oxford of Thailand's sovereign risk quantifies the benefit of adaptation to reduce physical risk;
 - b. The analysis from Barclays on European cement companies highlights the potential valuation upside, depending on the companies pricing power and transition strategy;
 - c. The Aberdeen case study shows companies in the materials sector could substantially benefit from the transition.
2. **UK physical risk:** The two case studies considering physical risk for the UK exhibit relatively low direct physical risk impact, on real estate (Aviva) and equities (MSCI). However, the MSCI report highlights that the indirect physical risk can be significantly higher than the direct impact, in particular over the long-term.
3. **Equity vs. credit impact:** The impact on equity prices is assessed to be higher than on bond prices. The potential impact on the credit quality of individual issuers can be significant however, with downgrades of up to 4 and 7 notches in the S&P and University of Oxford case studies, respectively, and up to 9% of L&G's portfolio potentially being downgraded to sub-investment grade.

These case studies also provide useful takeaways for financial professionals looking to perform climate scenario analysis on their portfolios.

1. **Consider adaptation capacity in sovereign risk analysis.** It can materially affect the financial impact and helps assess the case for investment in adaptation.
2. **Assess both direct and indirect physical risks.** While direct risks (impact on a company's own physical assets) are easier to model, the indirect risk (e.g., via supply chains) can be significant and increase materially over time.
3. **In addition to one time event-driven shocks, consider the impact of the recurrence of physical risk events.** One-time shock may cause temporary business interruptions or repair costs; while recurring hazards could drive continuing increases in operating expenses and over time may lead to a significant impact on the company's financial profile.
4. **Consider company specifics and the carbon "value chain" within a sector.** The financial performance of companies within a sector can vary greatly. In addition to a firm's own emission profile or direct carbon costs, it matters how these costs are absorbed or passed along the value chain. This pass-through can reshape the competitiveness of the

upstream and downstream players and may accelerate the adoption of alternative climate solutions, which can ultimately transform the industry value chain.

3. Case Studies

Aberdeen Investments – Aberdeen Investments Climate Scenario Analysis

Aberdeen Investments conducted a bespoke scenario analysis, applying probability weighting to 16 different future outcomes, including 7 bespoke scenarios. Their assessment, covering global listed equity and corporate bonds, focuses on both physical and transition risks. The analysis highlighted that dispersion of impact within a sector is key and that electrification, for example, could lead to an equity valuation uplift of up to 120% for firms in the materials sector exposed to “future minerals”, whilst the sector as a whole is impaired. This case study is based upon a wider [Aberdeen investments publication](#), which considers all sectors across listed equities and corporate bonds.

1. Going beyond regulatory requirements to improve investment insight

Aberdeen's climate scenario analysis was designed with the aim to produce investment-relevant insights, rather than just fulfilling regulatory and stress-testing requirements. The approach, which includes a suite of bespoke scenarios, aims to address some of the limitations of typical ‘off-the-shelf’ scenario analysis:

Limitation	Typical approaches	Approach
Assumption of uniformity	Make uniform assumptions of climate policy across countries and sectors. This improves comparability but does not reflect the real world.	Aberdeen built bespoke scenarios that apply more realistic assumptions across sector and country groupings. The assumptions are underpinned by internal research insight.
Navigating the uncertainty of future pathways	Rely on just a few scenarios considered to be equally probable. This can produce misleading results and limit the investment insight. ²	Aberdeen uses 16 bespoke and off-the-shelf scenarios to represent a broad range of potential pathways. Probabilities are applied to this suite, allowing Aberdeen to calculate the most likely, probability-weighted, scenario.
A missing middle ground	Tend to focus on the tail risks of achieving ‘net zero’ and ‘no action’, largely ignoring the broad spectrum that lies between.	Aberdeen’s bespoke scenarios fill the middle ground between tail events, allowing consideration of differing policy and technology pathways within the most likely outcome range.
Single technology pathway	Tend to focus too much on a single technology pathway for decarbonisation. This can lead to	Aberdeen’s analysis is not ‘technology restricted’ to the assumptions of a single model. This enables consideration of a diverse range of technological pathways.

² Environmental Finance 2024 <https://www.environmental-finance.com/content/news/investors-scenario-testing-not-recognising-full-climate-risk-warns-academic.html>

	misleading results if the pathway is more complex.	
Baseline unreflective of the market	Tend to use overly simplistic baselines. Typically, the Current Policy scenario is used. Aberdeen believes this to be short-sighted.	Aberdeen's baseline uses internal sector and regional insights to reflect current market prices, allowing it to vary across different regions and sectors, and better reflect market values.
Credibility of company transition plans	Tend to ignore credible company transition plans. Many companies have set a net-zero objective, with varying degrees of credibility. These should be integrated into climate scenarios.	Aberdeen considers company targets, creating a more dynamic, forward-looking view of company behaviour. The credibility of the targets being achieved is also assessed, reducing the risk of overestimating their impact.

Aberdeen thinks that a considered, and probabilistic, methodology is crucial for integrating climate risks into investment decisions as it increases the confidence placed in the resulting output. Aberdeen's research-rich approach to developing bespoke scenarios also relies on developing a good understanding of the assumptions built into the models on which they are based. In doing so, their limitations are recognised - which is also critical for determining how to integrate the resulting insight.

2. Overview of methodology³

To take a probabilistic approach, Aberdeen uses a comprehensive suite of 16 bespoke and off-the-shelf scenarios, assign probabilities, and produce two probability-weighted scenarios:

- A probability-weighted mean scenario (based on the full suite), which reflects Aberdeen's base-case view of the most likely energy-transition path; and
- A Paris-aligned weighted scenario (based on the probabilities assigned to the seven scenarios that limit warming to below 2°C).

Aberdeen's off-the-shelf scenarios are those developed by the Network for Greening the Financial System (NGFS)⁴. These are used as the starting point for building internal bespoke scenarios. Underpinning the NGFS scenarios Aberdeen use two Integrated Assessment Models (IAMs), as this avoids a bias towards one set of technology pathway assumptions.

Aberdeen updates their scenarios and their assigned probability weighting every year⁵, incorporating changes in the underlying models and NGFS 'building blocks', observations of climate technology readiness, and policy changes in the real economy. These judgement-based adjustments are based on consultation between internal dedicated climate experts and macro economists, and regional and sectoral insight across the asset classes.

This is informed by consideration of:

³ The report covering Aberdeen's [Year 4 analysis](#) provides detail of the methodological approach.

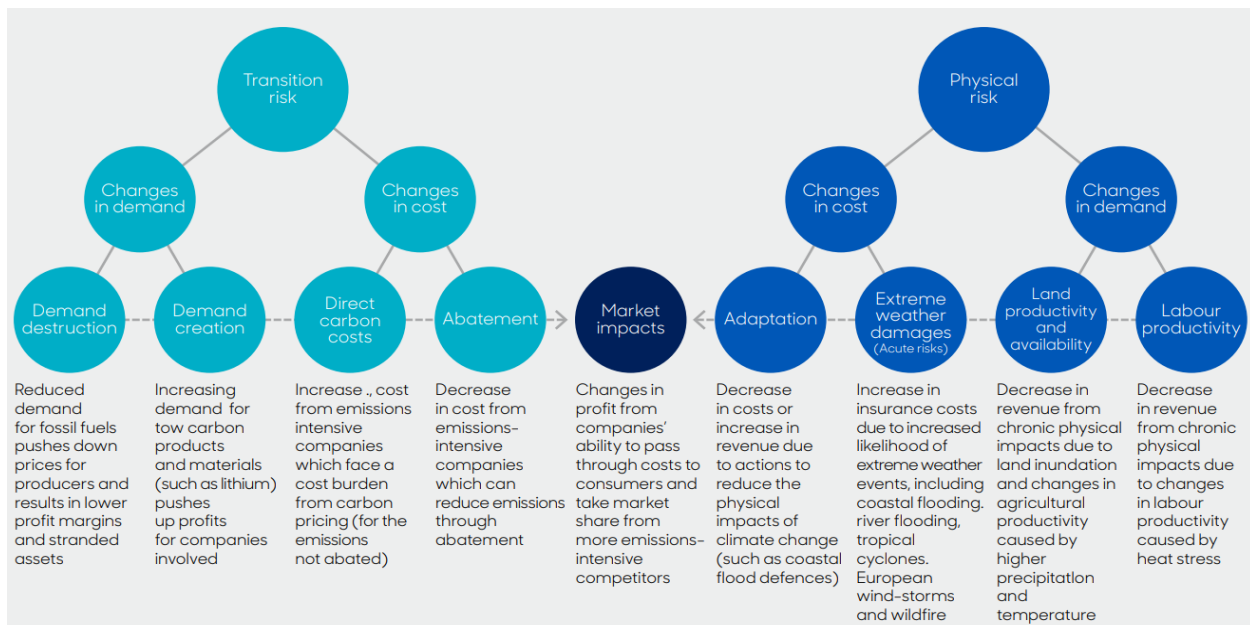
⁴ Aberdeen also use an additional 'off-the-shelf' scenario: [The Inevitable Policy Response \(IPR\) Forecast Policy Scenario](#).

⁵ Aberdeen's previous papers are available on request: ESGClientQueries@abrdn.com.

- What is considered to be significant (and lasting) directional signals from regional policy and sectoral technology developments. For example:
 - To what extent could regional climate policy be delayed due to changing priorities (e.g., defence spending, energy security, recession risk)?
 - How might regional bottlenecks in clean tech supply chains, combined with geopolitical tensions, disrupt the transition?
- What is already being priced in by the markets and how can this best be reflected by both region and sector in the Baseline?
- What change is merited to the combined probability applied to Paris-aligned scenarios overall?
- What change is merited to the differential probability applied to the two underlying energy systems models used?

Aberdeen's scenarios set out the potential pathways for policy and technology developments. This determines the different pathways for carbon pricing, primary energy demand, transition-technology development, sectoral emission trajectories, and resulting global temperature. From these, economic shocks are simulated which consider both direct and indirect impacts on individual companies. These, in turn, create direct and indirect transition and physical impacts on companies, which then drive changes in company earnings and value. The impacts are summed at company level and discounted to estimate the impact on net present value (NPV) relative to the baseline scenario. Figure 1 shows how these climate impacts can be disaggregated into the different transition and physical impact channels to enable us to better understand what is driving climate risk at a sectoral, regional and company level.

The development and update of these bespoke scenarios is resource intensive, but it enables a much greater understanding of the scenarios and reduces some of the limitations of the utility of the output. Considering how scenario output is intended to be used is a key point of prioritisation when deciding the extent of development and use of bespoke scenarios.

Figure 1: Scenario impact channels

Source: Aberdeen Investments, Planetrics⁶ 2024

3. Examples of investment-useful insight

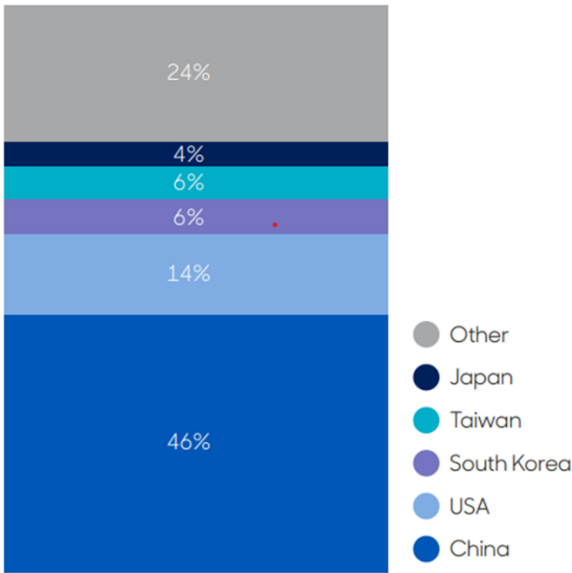
The report covering Aberdeen's Year 4 analysis provides extensive coverage of their key findings, but the following illustrates some examples of how internal annual analysis provides investment-useful insight.

A regional view of demand creation: Demand creation uplift can be used as an indicator of potential climate solutions. If the companies with a demand creation uplift of more than 25% are looked at, it can be seen that China clearly dominates, making up nearly half the global share of climate solutions in this segment (Figure 2). China's dominance has been driven by large domestic incentives, which have been supported by a large and growing domestic market. However, there is currently an overcapacity – driven by China – in some green technologies, including solar PV and EVs. While cheaper products can accelerate the climate transition, this is creating headwinds for manufacturers, which are likely to persist until the industries consolidate. It also incentivises Chinese companies to increasingly rely on export markets - leading to growing trade tensions.

Europe sits outside the top 5 and exhibits a differential performance between the 'decarbonisation' and 'demand creation' pillars of the energy transition. The region has the most ambitious decarbonisation agenda, providing a competitive advantage to many European companies best placed to reduce their carbon costs more quickly. But on the other side, few European companies benefit significantly from additional demand for green products. This raises the question of whether the region's dependence on other countries to implement the energy transition could risk dampening its industrial basis and competitiveness, in addition to potential political tension.

⁶ Planetrics, part of McKinsey Sustainability, have been Aberdeen's modelling partner since 2020. Aberdeen Investments is solely responsible for all assumptions underlying the scenarios, and all resulting findings, conclusions and investment decisions.

Figure 2: Green-technology companies- geographical split



Source: Aberdeen Investments, 2024. Entire equity universe equally weighted. Charts show companies with a demand creation uplift above 25% (a proxy for green-technology companies). Probability-weighted mean scenario

Electrification - an expanding universe: At the stock level, a widening breadth of companies benefit from this demand creation uplift, signifying an expanding investment universe of climate solutions. End products like solar PV and EVs are the most well-known beneficiaries, but other segments, such as the associated equipment, would equally gain. It is therefore important to consider the investment risks and opportunities through the entire value chain, and the important insight that is gained by delving into the dispersion of impacts within sectors (see Figure 3 for example). This highlights specific stocks in other sub-industries that would benefit from providing key equipment and materials to clean technologies.

The energy transition, to a degree, is characterised by a transition away from a fossil-fuel-intensive world to a material-intensive world. This creates a positive valuation impact for firms exposed to green ‘future minerals’ that are required to electrify sectors downstream.

Figure 3: High dispersion of climate-related valuation impact across and within materials sub-industries



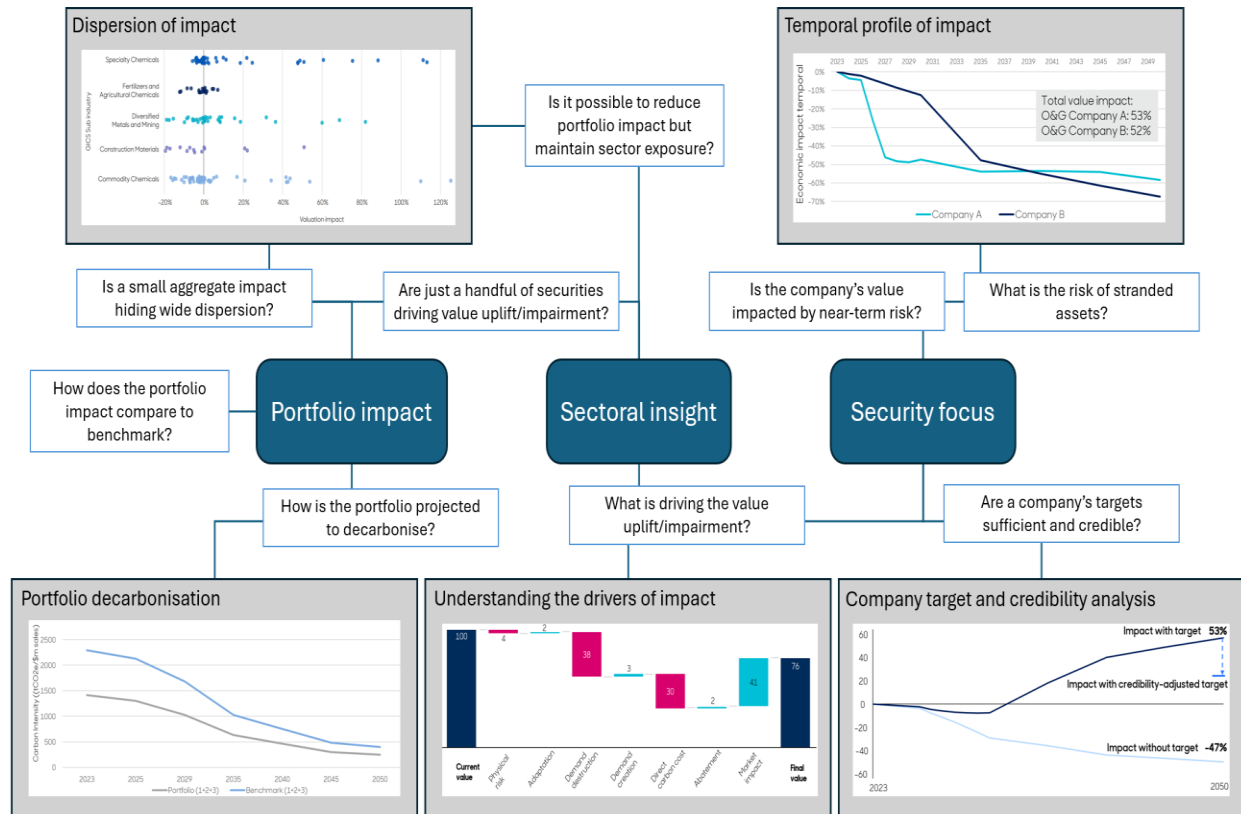
Source: Aberdeen Investments, 2024. MSCI ACWI Index. Probability-weighted mean scenario

4. Integrating insight

The following table provides an overview of how insight at security, sector and portfolio levels can be integrated into the investment process, and Figure 4 provides a visual guide to utilising the analysis to answer investment-useful questions.

Differentiating between sector peers	Aggregate scenario impact at sector or portfolio level will typically hide wide dispersion, with significant uplift for some securities being cancelled out by impairments in others. This provides an opportunity for actively managed investment strategies to tilt portfolios towards more transition-resilient securities, whilst enabling a fund to maintain sector weights if required. In most sectors it is also possible to identify securities that not only show uplift in the mean, 'most likely' scenario but are also resilient across a broad range of climate pathways. For example, firms exposed to 'future minerals' that are required to electrify sectors downstream, can see considerable uplift from demand creation across the majority of scenarios in a sector that, in aggregate, is impaired under most transition scenarios.
Identifying credible transition leaders	Having transparency regarding the drivers of value impact, coupled with analysis which considers the potential impact of a company's targets, allows us to identify companies which have the potential to minimise carbon costs as well as benefit from higher demand as they transform their business to generate green revenues. By combining this top-down scenario analysis along with bottom-up assessment of the credibility of company transition plans enables us to consider how companies rank against peers within a sector or region; and identify those more likely to be better positioned to proactively transform their businesses, mitigate climate risks and develop the solutions needed to decarbonise the economy.
Temporal profile of impact	Companies which have similar value impact resulting from a scenario can differ quite significantly in terms of <u>when</u> that impact will manifest. Being able to explore this provides the potential to highlight companies where impacts are likely to be more near-term as well as to assess the risk of stranded assets. The temporal profile of impact can be utilised to provide insight regarding <u>current</u> market uplift or impairment and the likelihood that it will continue to play out in the short, medium or long-term. For example, the latest analysis highlighted that short-term demand creation presents upside opportunities driven by improvements in technology readiness, improved competitive dynamics for electrification climate solutions, and infrastructure capex cycle. Furthermore, by building in more realistic regional variation in the scenarios it is easier to identify regional variation in that demand creation.

Forward-looking emission trajectories	Some clients have set forward-looking carbon targets against their portfolios. Backing out company emission trajectories from the analysis allows us to examine a portfolio's projected decarbonisation pathway and compare this to benchmark. The analysis can then inform necessary portfolio changes based on expected emission reduction rates in the probability-weighted scenario. This top-down view can then be combined with Aberdeen's bottom-up portfolio alignment and credibility framework. The framework provides a view of companies' alignment with a decarbonisation trajectory (normally through the targets they have set) and Aberdeen's view on how credible it is that they will achieve those targets.
Informing engagement	As an active manager, Aberdeen's climate scenario analysis provides additional insight that can inform engagement: • The projected impairment of a company's current strategy and how (and when) that is likely to manifest in comparison to their peers. • The drivers of that impairment (e.g. demand destruction, carbon costs or physical impact) to identify if strategies are in place to reduce these risks. • The adequacy and credibility of existing strategies and targets to mitigate these risks. This can also provide insight for voting decisions where resolutions are focussed on a company's emission targets or climate strategy.

Figure 4: Scenario insight providing answers to investment questions

Aviva – Climate Change and Insured Losses: What Impacts Can We Expect? An Aviva/JBA Case Study Using the JBA UK Flood Model

This Aviva/JBA case study evaluates the physical flood risk exposure of UK residential real estate under two IPCC-aligned climate scenarios — RCP 4.5 and RCP 8.5 — by 2050. Under the RCP 8.5 scenario, the portfolio-level Annual Average Loss (AAL) is projected to double from £0.5 billion in the baseline to £1 billion, against a total portfolio size of £6.2 trillion. Additionally, the 1-in-200 year loss is expected to rise from £5.9 billion to £8.4 billion under the same scenario.

The UK Government's National Risk Register identifies the combined impacts of coastal, river, and surface water flooding as the most significant environmental risk. Understanding these risks is critical for the insurance industry to manage exposure and evaluate the effectiveness of mitigation measures.

This Aviva/JBA case study uses JBA's UK Flood Model and market portfolio⁷ to quantify the impact of mid-century climate change on river, surface water and coastal flood risk for residential properties throughout Great Britain. By doing so, it provides valuable insights into the evolving landscape of flood risk.

The primary aim of this paper is to help users to understand the challenges associated with changing flood risk and to ensure continued access to affordable insurance as these risks grow and modelling becomes more accurate.

1. What data and scenarios to consider?

Catastrophe models, such as the JBA UK Flood Model, are invaluable tools for General Insurance companies. These models quantify a full distribution of possible losses by combining data that describe exposure locations and their vulnerability with hazard information provided as a set of plausible events.

JBA's baseline event set consists of thousands of years of river, surface water, and coastal flood events, with different intensities occurring with a frequency representative of the present day. It is built by extending the observed record using statistical models to better represent the full range of plausible intensities, resulting in events that are comparable in magnitude to past events but also events that are plausible but more extreme than observed ("black swans"). This comprehensive approach allows insurers to better understand and manage their risk exposure.

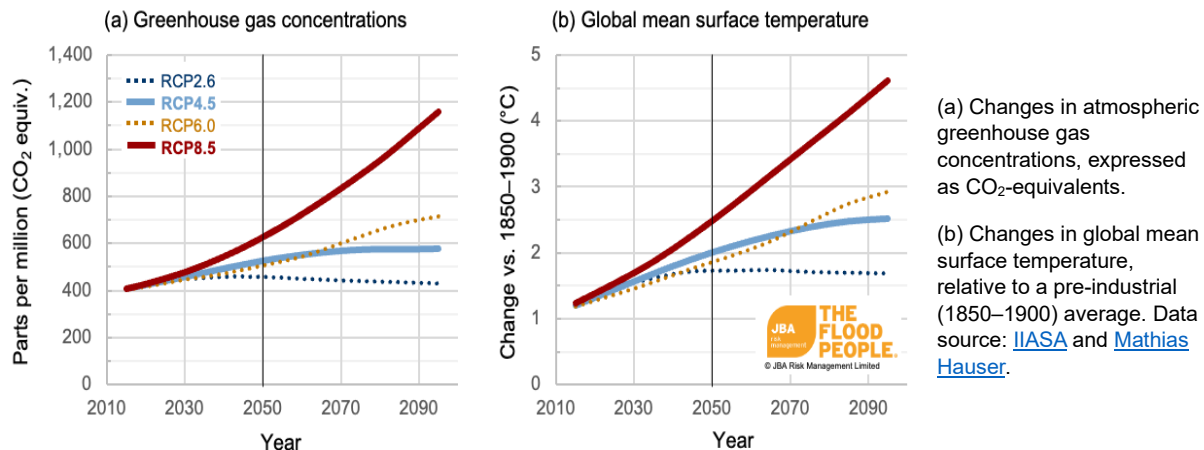
Studies of potential future climate changes typically use climate scenarios. In this case study Aviva/JBA use two Representative Concentration Pathway (RCP) scenarios: RCP4.5, a medium emission scenario broadly consistent with current global emission policies, and RCP8.5, a high emission scenario that is nominally a "worst case".⁸

⁷ JBA's Market Portfolio represents residential exposures, comprising of an estimate of the total insured value for every postcode in Great Britain, as reported in 2021.

⁸ More details on the RCPs and other climate scenarios can be found in JBA's blog on the topic, [here](#).

By 2050, both scenarios are characterised by substantial changes compared to today (**Figure 1**). For RCP4.5 and RCP8.5, respectively, greenhouse gas concentrations increase by 30% and 50% and the global mean surface temperature increases by approximately 0.9°C and 1.4°C. Compared to the pre-industrial era benchmark used in climate science and climate policy (i.e., 1850–1900), these temperature increases amount to 2°C and 2.5°C of warming for RCP4.5 and RCP8.5, respectively, putting them well above the Paris Agreement’s ambition of 1.5°C warming.

Figure 1. Climate drivers and climate change for the RCP scenarios.



Event sets consistent with the RCP4.5 and RCP8.5 scenarios are generated by modifying the baseline event set using output from the UK Met Office’s UK Climate Projections (UKCP) project.⁹ Return period change factors are used to map the extreme value distributions for the climate change data to the baseline (e.g., a change factor of two means that the intensity of a climate change event with a return period of 100 years is the same as a baseline event with a return period of 200 years).

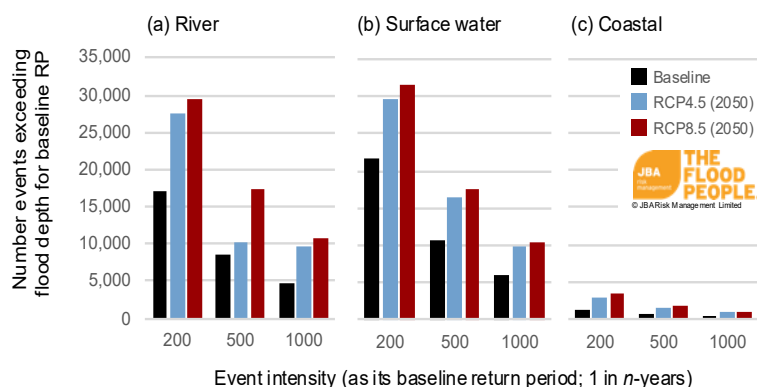
The insurance event selection algorithm is then reapplied, producing new events with different extents, intensities, and durations compared to the baseline. UK-wide, flood events increase in number and intensity (**Figure 2**), although there is some geographical variation (see **Figure 4**).

⁹ More information on the UKCP dataset can be found on the Met Office pages, [here](#).

Figure 2. The increase in intensity and number of flood events with climate change compared to baseline

Number of (a) river, (b) surface water, and (c) coastal flood events exceeding different intensities across the UK for the baseline, RCP4.5, and RCP8.5 event sets.

Intensity is defined as the baseline return period (RP) flood depth, focussing on the 1 in 200, 500 and 1000-year intensities – i.e., the figure shows the increase in the number of events whose probability is at or more than 1 in 200-year (etc.) under baseline conditions.



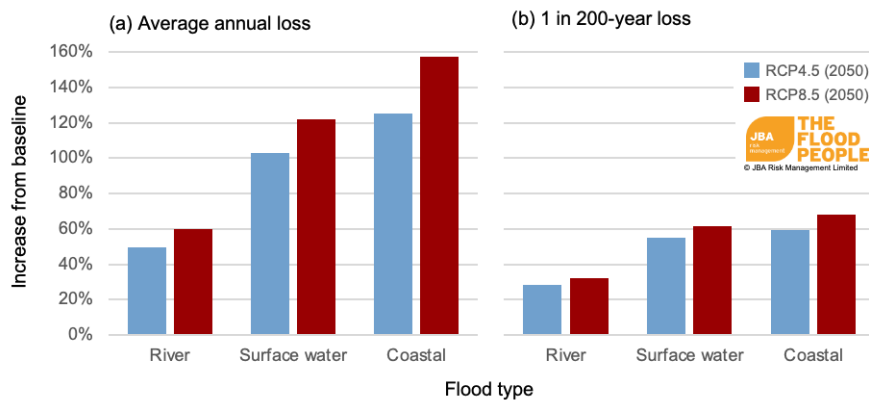
2. What are the estimated losses?

This case study considers three scenarios of JBA's UK Flood Model: baseline, RCP4.5 by 2050, and RCP8.5 by 2050. All analyses use the same JBA residential market portfolio, vulnerability information, and defence standard of protection. This means that all differences are due to the impact of climate change on the hazard, rather than any change in exposure and vulnerability.

Compared to the baseline scenario, portfolio-level losses increase substantially for both the RCP4.5 and RCP8.5 scenarios by the mid-century (**Figure 3**). The Average Annual Loss (AAL) is a commonly used loss metric that places greater weight on more frequent events. The baseline AAL is £528 million, increasing to £907 million under the RCP4.5 scenario and £986 million under RCP8.5 representing increases of 72% and 87%, respectively. When broken down by flood type, the AAL rises by 50–60% for river flooding, approximately doubles for surface water flooding, and increases by 120–160% for coastal flooding, with the most significant changes occurring under the more extreme RCP8.5 scenario.

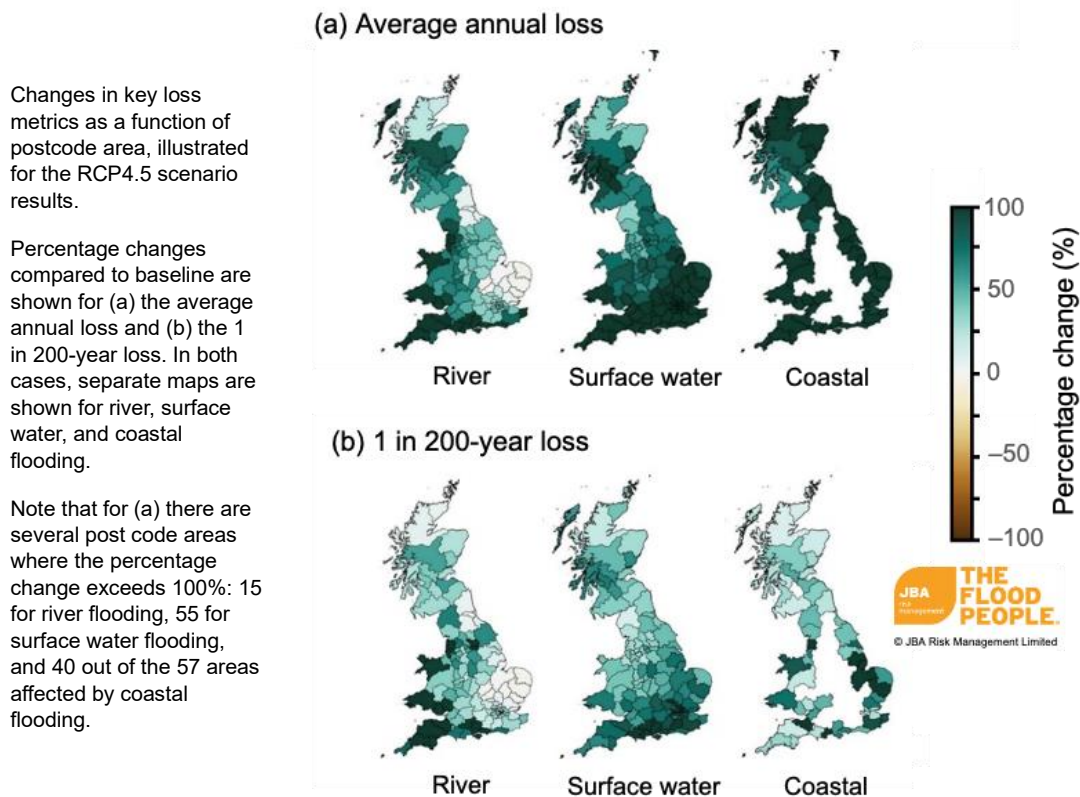
The 1 in 200-year loss highlights the impacts of more extreme events and is relevant in regulatory contexts like Solvency II. The baseline 1 in 200-year loss is £5.9 billion increasing to £8.04 billion under the RCP4.5 scenario and to 8.36 billion under RCP8.5—representing increases of 36% and 42%, respectively. The 1 in 200-year loss has the largest percentage increase for coastal flooding (60–70%), followed by surface water flooding (approximately 50%) and river flooding (approximately 30%). While still substantial, these proportional changes are smaller than for AAL.

For both loss metrics, the mid-century differences between the two climate change scenarios are smaller than their differences compared to the baseline scenario, although it would be expected that the difference between the climate scenarios increases as they increasingly diverge later in the century (**Figure 1**).

Figure 3. The impact of climate change on portfolio level loss metrics

The percentage changes in (a) average annual loss and (b) 1 in 200-year loss for the RCP4.5 and RCP8.5 scenarios at 2050 relative to the same metric in the baseline simulation. Each panel shows the loss for the three flood types separately.

In absolute terms, portfolio-level losses in all scenarios are highest for river flooding, followed by surface water flooding and then coastal flooding. This is related to the widespread nature of river flooding combined with river defences typically being a lower standard of protection compared to coastal defences (surface water flooding is widespread, but events are less extensive). However, due to the proportionate changes in the different flood types (**Figure 3**), surface water and coastal flooding both increase in their relative importance. For instance, the AAL from surface water flooding is ~40% of the river flooding value in baseline, but this grows to be over 50% of the river flooding value for the climate change scenarios. For the coastal flooding AAL, the increase is starker, growing from 18% of the river flooding value to nearly 30% under these scenarios. While these values are specific to the precise portfolio, Aviva/JBA expect that the general trend to hold for any UK-wide portfolio.

Figure 4. The spatial patterns of change for loss metrics under climate change

The changes in loss are not felt evenly across the country (**Figure 4**) (note, spatial patterns for RCP8.5 are like the RCP4.5 results shown in Figure 4). There is a broad east-west pattern in the river flood loss results, with the highest percentage changes in the west and lowest percentage changes in the east. This is consistent with an amplification of the “rain shadow effect” in a warmer world whereby large river flood events are driven by mid-latitude cyclones that approach the UK from the south-west, which then have depleted their rainfall by the time they cross to the east.

For surface water flood, the largest differences in losses are in southern England and the west of Scotland. This is consistent with an increase in extreme precipitation from mesoscale convective bands, which occur on the west coast of Scotland, over the Pennines, in southern Wales, and in the corridor between Cornwall and London.

The increases in coastal AALs range from 60% to 270%, driven by the increase in average sea-level under climate change. Larger spatial differences are more apparent for the 1 in 200-year events, where the combination of high exposure levels and low-lying areas lead to large increases around Liverpool, the Bristol Channel, east Dorset and the Wash. These are all areas that have experienced notable flood events in the past.

3. What are the benefits and challenges from this approach?

Benefits	Limitations
- JBA's UK climate change event sets are underpinned by well-documented scientific approaches and driven by the latest peer-reviewed data from the UK Met Office. - Climate change will impact the probabilities of different weather conditions occurring and new ones. JBA's climate change event sets are not simply a scaled version of the baseline event set but instead allow for the number, duration, and footprint of the simulated events to change.	- Event extents are limited by the maximum mapped baseline return period. - Non-hazard factors are excluded. The same vulnerability and defence data are used for both the baseline and future analyses. - The spatial distribution and market value of properties is the same in baseline and 2050. - There are uncertainties across the modelling chain – particularly in how realistically climate models simulate the magnitude and spatial pattern of future extremes and how these are reflected in flood and insurance losses.

4. Concluding remarks

The insurance industry needs to continue to consider how climate change could impact their exposure so that they are ready to respond to the future world challenges. To this end, JBA's UK Climate Change Flood Model serves as a valuable tool, encouraging insurers to consider critical questions such as: "How will insurers continue to ensure access to affordable insurance as the risk of flooding increases and modelling becomes more accurate?"

The outcomes will vary depending on the exposure. However, these models can be used to support insurers in their business planning, pricing and reinsurance implications, as well as explore the implications of Flood Re ending. Additionally, they can also be used to investigate various "what-if" scenarios, such as futures with different levels of flood defence spending, changing building standards, and increasing urbanisation.

The results in this JBA UK Flood Model and market residential portfolio case study support Aviva's concerns that climate change will place more residential properties at risk of flooding in the future. Climate attribution studies indicate that climate change since the pre-industrial period has already driven an increase in the intensity of flood events due to extreme precipitation.¹⁰ Increased rainfall also strains built defences, sometimes leading to unprecedented river levels.

Flood Re will exit the insurance market in 2039, which is now less than 15 years away. These results reiterate the urgent need for adaptation and improved resilience in UK housing stock. Planning controls and building regulations need to be tightened to ensure that new build properties are resilient to the increasing risks of flooding and other climate-related threats.

¹⁰ For instance, the World Weather Attribution project found that Storm Desmond, in December 2015, was made 60% more likely due to human-caused climate change. See [here](#) for more details.

Barclays – Decarbonisation Scenarios in the European Cement Industry: A Financial Analysis

Barclays' scenario analysis explores three distinct bespoke transition scenarios – bear, base and bull – to assess the financial implications of decarbonisation for European cement producers. These scenarios reflect different assumptions about the test companies' pricing power and ability to withstand the scenarios' specific transition risks. This analysis shows cement firm equity prices could change by -100% to +25%. This case study is based upon a wider [Barclays publication](#).

1. Executive summary

This scenario analysis examines the financial implications of decarbonisation pathways for the European cement industry. The cement industry currently accounts for approximately 7% of global carbon dioxide emissions. The Global Cement and Concrete Association (GCCA) has targets of reducing emissions intensity by 25% by 2030 compared to 2020 levels, with the ultimate goal of achieving net-zero emissions by 2050. These targets have received endorsement from forty leading cement and concrete producers, representing approximately 80% of global production outside China. In the EU, the cement industry will see a gradual phase-out of free carbon allowance starting in 2026, replaced by the Carbon Border Adjustment Mechanism (CBAM) which ensures imported cement faces the same carbon costs. Free allowances will be reduced annually and fully eliminated by 2034, encouraging decarbonisation while preventing carbon leakage.

This analysis focuses on four European cement producers: two large-cap companies (Heidelberg Materials (HEI) and Holcim (HOLN)) and two small-cap companies (Buzzi Unicem (BZU) and Vicat (VCT)). It is worth noting that this analysis was undertaken prior to Holcim's spin-out of its North American business (Amrize).

The report examines three distinct decarbonisation scenarios to evaluate the financial implications for these producers; considering varying degrees of pricing power and cost absorption. The analysis reveals that concerns regarding value-destructive capital expenditure may be overstated, as most companies appear positioned to absorb the necessary investments without significant margin deterioration. Notably, the market has largely priced in a scenario where companies can pass on costs to consumers while maintaining stable margins, suggesting a balanced risk-reward profile for investors in the sector.

2. Scenario details

This scenario analysis focused on three distinct scenarios to assess the financial implications of decarbonisation for European cement producers. In the first scenario, termed the "bear case," companies are assumed to have minimal pricing power, resulting in their absorption of both the full capital expenditure required to reach net zero by 2050 and the costs associated with emissions before achieving this target. The second scenario, designated as the "base case," assumes cement producers can pass on costs to consumers but any benefits from investments

in carbon capture, utilisation and storage (CCUS) and other decarbonisation technologies are competed away, maintaining margins at 2023 levels. The third scenario, labelled the "bull case," envisions companies benefiting from margin expansion due to sufficient pricing power, allowing them to retain the current spread with cost savings from lower emissions offsetting the costs associated with carbon capture.

For all three scenarios, the analysis incorporates several consistent assumptions including a sector-wide capital expenditure intensity of €340 per tonne of CO₂ avoided and a carbon price of €100. The analysis also assumes 100% free carbon allowances until 2025, after which this figure declines linearly before reaching 0% in 2032. Additionally, each company is assumed to shut down one-third of its global capacity between the present and 2050.

3. Methodology

The financial impact assessment methodology incorporates company-specific parameters (see Assumption Table below). For example, the average cost of capital (WACC) values are used to discount future cash flows associated with decarbonisation investments and carbon costs, providing a more accurate representation of the present value impact on each company. The analysis assumes that carbon capture technology will contribute 100%¹¹ to achieving net-zero emissions, which is a simplification but aligns with industry expectations that CCUS will play a dominant role in cement decarbonisation. For each company, the total net emissions figure from 2023 serves as the baseline for calculating the total CCUS capital expenditure required to reach net zero, multiplied by the standardized capex intensity figure of €340 per tonne of CO₂ avoided. This approach yields company-specific total CCUS capital expenditure estimates ranging from €3.62 billion for Buzzi Unicem to €16.06 billion (CHF) for Holcim, proportionate to their current emissions profiles. By standardising these assumptions across all companies, the analysis isolates the impact of company-specific factors - such as emissions profiles, operational efficiency, and financial structure - on decarbonisation outcomes.

Assumption	HEI	HOLN	BZU	VCT
Capex intensity (€/tCO ₂ avoided)	340	340	340	340
Contribution from CCUS (to achieving net zero)	100%	100%	100%	100%
2023 Total net emissions (Mt)	57	75	16	17
Total CCUS capex bill	€13,007m	CHF16,060m	€3.62m	€3.77m
Share of capacity to close	33%	33%	33%	33%
Price of carbon permit (€)	100	100	100	100
BBG WACC	8.9%	7.7%	8.9%	10.5%

Source: Company data, Bloomberg, Barclays Research

The methodology further incorporates the EU Emissions Trading System (ETS) as a central policy mechanism influencing decarbonisation economics. The ETS creates a financial incentive for emissions reduction by putting a price on carbon, which the analysis captures through the assumed carbon price of €100. This price point represents a forward-looking view on carbon pricing that accounts for expected policy tightening as the EU pursues its climate objectives. The analysis recognizes that the ETS not only imposes costs on emissions but also generates revenue that supports decarbonisation efforts, such as the EU Innovation Fund which provides

¹¹ This 100% assumption is for illustrative purposes, and to be as prudent as possible in the valuation analysis.

grants for large-scale CCUS projects. The report identifies thirteen cement and lime industry projects that have received EU Innovation Fund support, with funding amounts ranging from €4 million to €234 million per project (see Table below). These projects encompass various technologies including carbon capture and storage, oxy-fuel combustion, and the development of supplementary cementitious materials, illustrating the diverse approaches being pursued by the industry with policy support. The timeline for the analysis aligns with the European Union's policy trajectory for the Emissions Trading System, providing a realistic basis for projecting future carbon costs.

Project	Company	Technology	Location	EU funding (€'m)
GeZero	Heidelberg Materials	Carbon capture and storage	Germany	191
IFESTOS	Titan Cement	Carbon capture and storage	Greece	234
KOdeCO net zero	Holcim	Carbon capture and storage	Croatia	117
EVEREST	Lhoist Group	Carbon capture	Germany	229
GO4ZERO	Holcim	Carbon capture and storage	Belgium	230
ERACLITUS	Cementos La Cruz	Substitute products - developing new SCMs	Spain	5
CLYNGAS	Cemex	Syngas from waste residues	Spain	4
Carbon2Business	Holcim	Oxy-fuel + carbon capture; carbon use for methanol production	Germany	110
ANRAV	Heidelberg Materials	Oxy-fuel + CCS	Bulgaria	191
GO4ECOPLANET	Holcim	Cryocap carbon capture technology + CCS	Poland	228
CalCC	Lhoist Group	Cryocap carbon capture technology + CCS	France	125
OLYMPUS	Holcim	Partial oxy-fuel carbon capture technology + CCS	Greece	124
K6 Program	CRH	CCUS (CO2 incorporated in concrete)	France	153

Source: European Commission, Barclays Research

The analytical framework also considers the structural impact of carbon pricing on industry dynamics, particularly how it changes the economics of capacity utilisation. Historically, the potential for fixed cost dilution has encouraged overproduction among cement producers as long as prices covered marginal production costs. However, the addition of carbon permit costs fundamentally alters this dynamic, potentially accelerating the rationalisation of excess capacity in the European cement industry. The analysis captures this effect by modelling the decoupling of utilisation rates and profitability, reflecting observed industry trends in recent years. This structural change is incorporated into the scenario analysis through the assumption of capacity closures and the varying degrees of pricing power across the three cases, providing a more comprehensive assessment of how decarbonisation will reshape industry economics beyond the direct costs of emissions reduction technologies. The analysis also factors in capacity rationalisation by assuming each company will close approximately one-third of its global production capacity between now and 2050, reflecting industry expectations of consolidation and optimisation as part of the decarbonisation journey.

4. Results analysis

The overall conclusion is that, for the bulk of Barclays coverage, the "base case scenario" is already largely priced in. This suggests that concerns over a wave of value-destructive capex in the next few years is overblown, and these capex costs are absorbable by producers.

Of the large-caps, the upside/downside skew is relatively more favourable for HOLN than HEI, with significantly more upside in the bull case for the former, and only significantly less downside in the bear and base cases.

Of the small-caps, Barclays note Vicat shows the largest variance in outcomes. Group net emissions for Vicat are at a comparable absolute level already to Buzzi, though Vicat comes from a more disadvantageous position with higher starting net debt and lower EBITDA margins. This is true even when factoring in their sizeable ETS allowance inventory. On the upside though, they show the highest potential upside across Barclays coverage under a scenario of better pricing power.

Figure 1: BZU upside/downside change in equity under each decarbonizing scenario

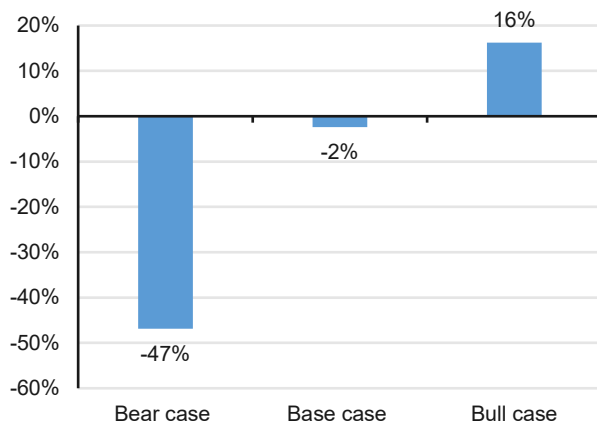


Figure 2: VCT upside/downside change in equity under each decarbonizing scenario

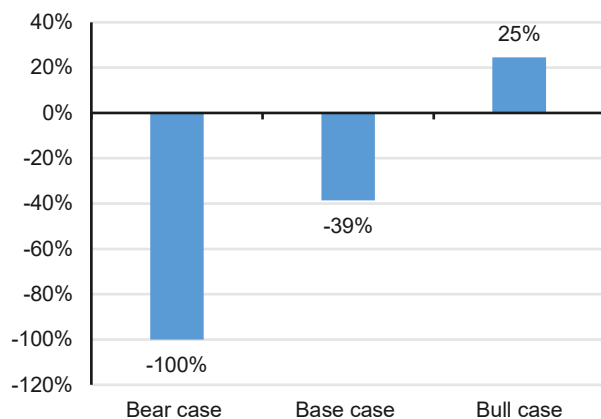


Figure 3: HEI upside/downside change in equity under each decarbonizing scenario

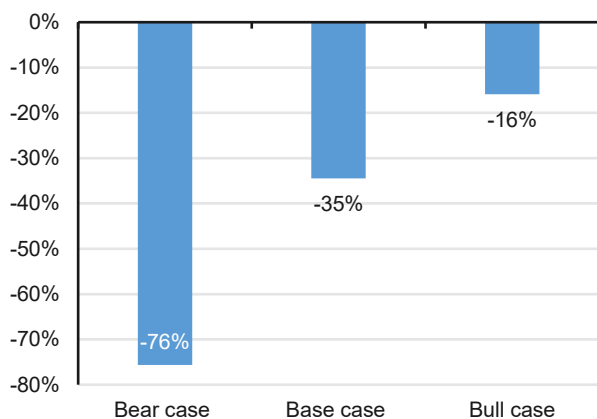
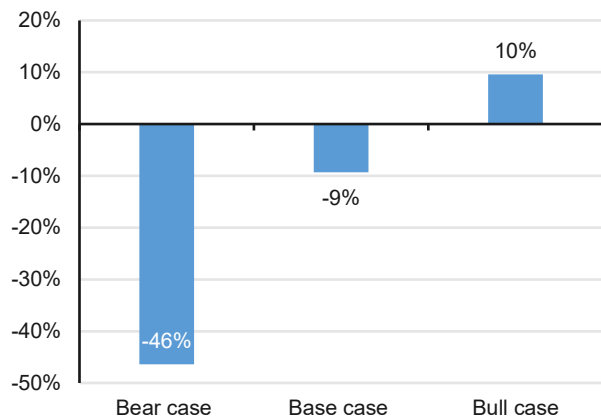


Figure 4: HOLN upside/downside change in equity under each decarbonizing scenario



5. Implications

The scenario analysis offers valuable insights for investors and industry participants navigating the cement sector's decarbonisation journey.

For investors, market concerns about decarbonisation costs appear overstated, as the base case scenario - where companies maintain stable margins while passing on costs - is largely priced in across the coverage universe. This creates a balanced risk-reward profile with potential upside if companies demonstrate stronger pricing power than anticipated. Company-

specific factors like operational gearing, financial position, and emissions profile significantly influence investment outcomes, suggesting investors should focus on these differentiators when allocating within the sector, potentially favouring small cap companies (VCT and BZU) that show more favourable upside potential.

For cement producers, maintaining pricing power during the transition to net-zero emissions is critical, as illustrated by the stark contrast between bear and bull case scenarios. Companies should prioritize strategies that strengthen market position and pricing power, such as consolidation in fragmented markets, product differentiation, and developing value-added services that reduce price sensitivity. Early investment in decarbonisation technologies may provide competitive advantages through learning effects, economies of scale, and preferential access to limited resources like carbon storage capacity and government subsidies.

The implications extend to the broader construction value chain, as cement decarbonisation costs will ultimately need to be absorbed somewhere in the system. In the base case scenario, these costs can be passed on without significant margin erosion for cement producers, but this implies higher input costs for downstream construction activities. This could accelerate adoption of alternative building materials and construction techniques that reduce cement intensity, potentially reshaping material flows and design practices across the industry. The analysis also highlights the importance of whole-value-chain approaches to decarbonisation, where emissions reductions are pursued not only in cement production but also in concrete formulation, construction efficiency, and building design to achieve required emissions reductions at lower overall cost.

L&G – Legal & General’s Climate Scenario Analysis for Portfolio Risk and Valuation Assessment

Legal & General (L&G) explores four bespoke climate scenarios, with temperature increases ranging from 1.5°C to over 2°C by the end of the century. The analysis on corporate bond and equity portfolios centres on transition risk scenarios. The study finds that as a long-dated “buy-and-hold” bond investor, c.2-9% of their holdings could be downgraded to sub-investment grade, while the listed equity portfolio may decline by c11% to c31%, both by 2050, without ongoing active management. This case study is based upon a wider [L&G publication](#).

Legal & General (L&G) integrates climate scenario analysis into its financial and risk management framework and focuses on assessing potential financial impacts from both physical and transition risks across different climate pathways. This work is embedded in how the firm evaluates risk in its proprietary portfolio — £97.6 billion in assets that predominantly directly support long-dated liabilities, such as institutional and retail annuity and retirement businesses. Further detail is provided in the L&G 2024 Climate & Nature report found [here](#), “Scenarios” section.

1. Scenario design and purpose

L&G has developed four bespoke climate scenarios to explore how different climate policy outcomes and levels of global warming could affect asset values, and reviews these scenarios to reflect emerging consensus and views on annual basis. The scenarios are:

- Inaction – Approximate global warming by 2100 3-4°C

Global failure to act on climate change means emissions continue to grow at historical rates.

- Below 2°C – Approximate global warming by 2100 < 2°C

Immediate, ambitious policy and investment action to address climate change limits global warming to below 2°C, but warming most likely exceeds 1.5°C.

- Net Zero – Approximate global warming by 2100 1.5°C

Immediate, highly ambitious action to address climate change leads to a reduction in emissions to net zero around 2050.

- Delayed Below 2°C – Approximate global warming by 2100 < 2°C

Policy and investment action to limit global warming to well-below 2°C is delayed by 10 years, resulting in much more disruptive change from 2030. Warming most likely exceeds 1.5°C.

These scenarios, which are developed off bottom-up energy and land systems projections and macroeconomic physical risk developments, are built to capture plausible variation in market

response, policy ambition, and physical outcomes. The goal is not to forecast the future but to test the sensitivity of the portfolio under different pathways and inform decision making.

2. Methodology

L&G's climate scenario analysis spans multiple asset classes and is designed to estimate directional changes in valuation, and corporate credit ratings, under each scenario. The modelling methodology underlying the in-house "LGIM Destination@Risk" framework is summarised in the grey box below:

LGIM Destination@Risk framework		
Risk type	Transition	Physical
Objective is to understand:	How might energy and land systems transition to achieve global climate targets?	How would physical climate change affect macroeconomic output?
To do this we assess:	The least costly solution to limiting future emissions to the levels required to limit global warming to below 2°C, preferably 1.5°C.	The impact of temperature on economic productivity.
Based on:	Our bespoke energy system model, relying on: • >100 unique public and proprietary data sources • >2 million variables and assumptions including detailed energy technology costs • an open-source land use model².	Academic studies on the impact of climate change on economic productivity and output.
This produces outputs including:	• carbon prices • GHG emissions • afforestation • sector-level decarbonisation requirements • energy prices • bioenergy and food prices • changes in GDP.	• changes in GDP.
We first translate these to:	Country- and sector-level impacts, which we can translate into changes in listed companies: • net income • balance sheet • cash flow • temperature alignment.	
Finally, we are able to evaluate:	Financial impacts on the value of individual: • sovereign bonds • corporate bonds • listed equities. We are also able to evaluate at the whole portfolio-level.	

The toolkit allows the evaluation of climate risk and net-zero alignment at a company-, sector- and portfolio-level, by:

1. converting scenarios into company- and sector -level impacts, through product supply and demand assessments based on the scenario output variables noted above; providing financial impacts on various metrics including net income, balance sheet and cash flows – this covers both transition and physical impacts of the scenario.
2. using asset valuation models to convert these company financial impacts into corporate security impacts (i.e. equity and bond valuations and bond ratings).
3. using a sovereign bond valuation model to convert corresponding country-level scenarios into sovereign bond valuations.

Asset-level results are aggregated across the portfolio to estimate overall exposure to transition and physical risks. Metrics such as potential valuation shifts and downgrade proportions are used to identify risk concentrations.

Several limitations are noted in the analysis. These are scenarios, not projections of the future. There is a large degree of uncertainty associated with the energy transition and the associated global temperature increase. These scenarios require many assumptions, any of which could prove incorrect with the potential of materially invalidating all, or key parts, of the scenarios. The model holds company behaviour constant and does not fully capture dynamic feedback loops, such as evolving policy regimes or market reactions. These limitations are considered when interpreting results, and the framework is updated over time as data and methods improve.

3. Results

3.1 Bond downgrade analysis

L&G is “primarily a long-dated ‘buy-and-hold’ bond investor,” focused on matching the cash-flow profile of liabilities arising within the retirement businesses. The latest scenario run covers about £32 billion (37%) of the Group’s £87.2 billion proprietary bond book, modelled line-by-line. As shown in Chart 8 & 9 below:

- Portfolio quality is high: 99% of holdings are investment-grade (BBB or above).
- The BBB bucket represents 30% of the total portfolio—and only 8% of the overall portfolio sits in BBB bonds from high-carbon sectors (energy, utilities, materials, industrials).

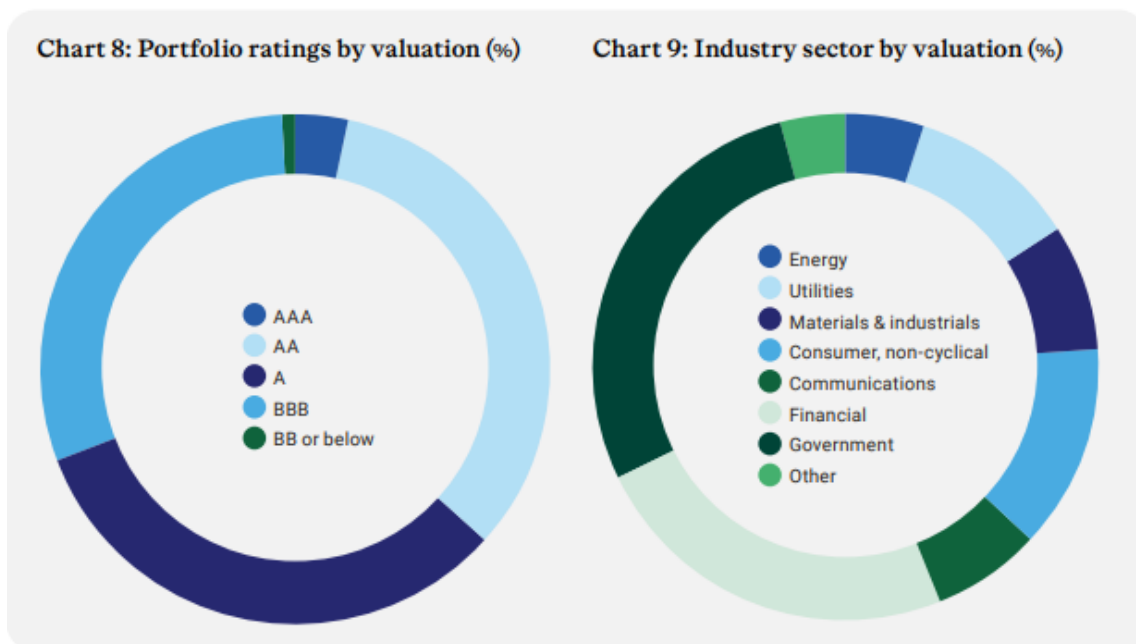
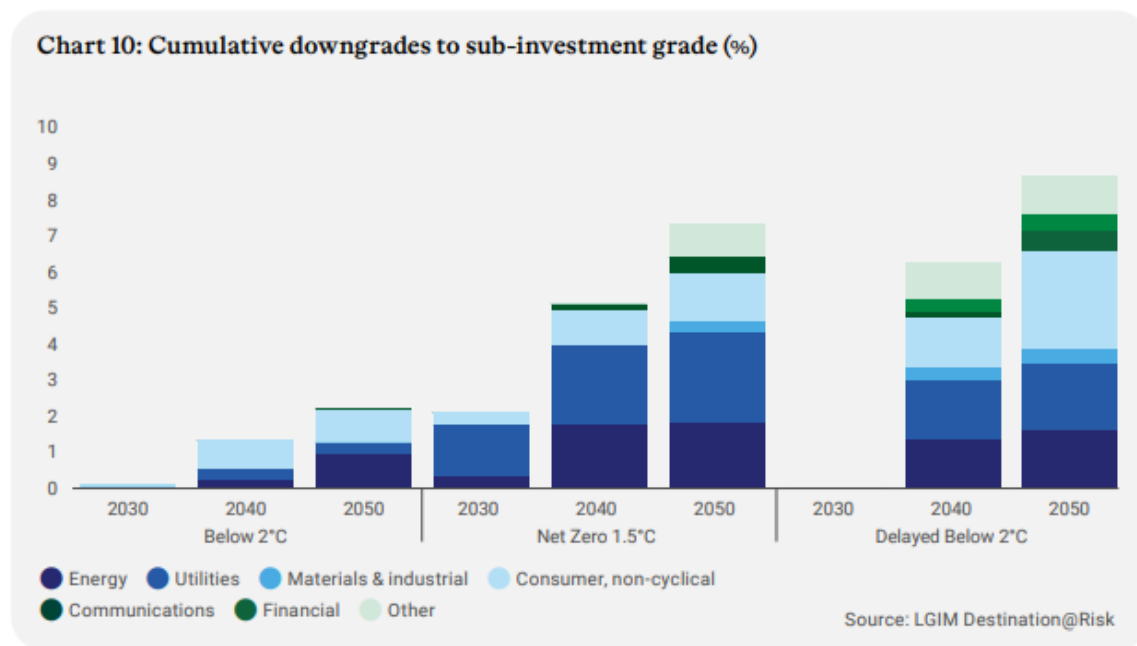


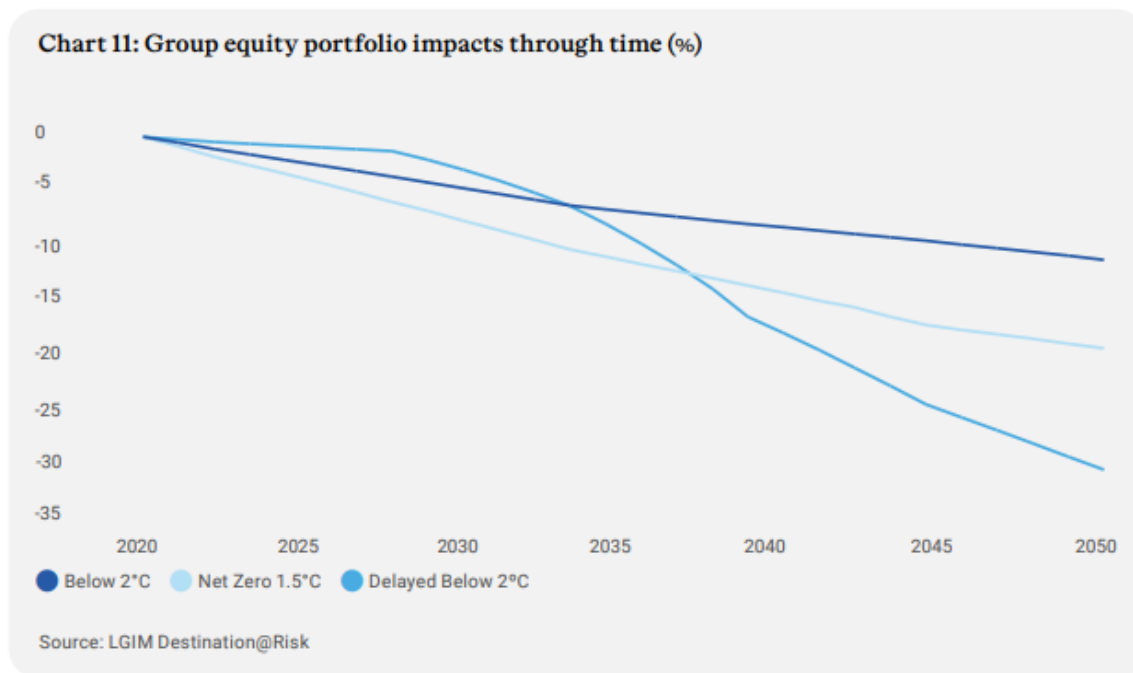
Chart 10 shows the cumulative share of bonds migrating to sub-investment-grade (BB or below) by 2050. After allowing for routine re-balancing at or after maturity, the model projects downgrades of 2%, 7% and 9% respectively, across the three scenarios.



If no re-balancing took place (“left unmanaged”), the downgrades would rise to 5%, 14% and 18%, respectively. Most of the modelled downgrades arise in high-carbon sectors, and the delayed-action pathway shows the largest GDP shock and cross-sector impact.

3.2 Equity portfolio analysis

For equities, L&G models c. £0.6 billion of the £1.3 billion proprietary traded equity book on a line-by-line basis. Assuming a static mix to 2050, the analysis finds portfolio valuation impacts of -11.3%, -19.4% and -30.5%, in the Below 2°C, Net Zero 1.5°C and Delayed Below 2°C pathways, respectively, as shown in Chart 11.



Across all three transition pathways, transition risk dominates; physical-risk effects remain muted over the model horizon. Climate risk is not fully priced today, so some repricing is expected as the transition unfolds. L&G plans to mitigate impacts through ongoing active portfolio management, as explained in the L&G 2024 Climate & Nature report found [here](#), “Invest Strategy” and “Risk Management” sections.

3.3 Combined portfolio valuation impacts

L&G also estimated the overall valuation impact across the combined bond and equity portfolio modelled under each scenario. The cumulative effect by 2050 is shown below:

Table 9: Group portfolio undiscounted 2050 portfolio value impacts

By risk

	Below 2°C	Net Zero 1.5°C	Delayed Below 2°C
Physical risk	(0.4%)	(0.2%)	(0.4%)
Transition risk	(0.9%)	(2.2%)	(3.4%)
Total	(1.3%)	(2.4%)	(3.8%)

Table 10: Group portfolio undiscounted 2050 portfolio value impacts

By asset class

	Below 2°C	Net Zero 1.5°C	Delayed Below 2°C
Bonds	(1.1%)	(2.1%)	(3.3%)
Equities	(11.3%)	(19.4%)	(30.5%)
Total	(1.3%)	(2.4%)	(3.8%)

As expected, the transition risk impacts dominate the total impact, while the total valuation impact is heavily weighted by the bond portfolio being much larger than the equity portfolio.

4. Implications and next steps

The scenario analysis reinforces the importance of transition readiness as a financial variable. It also highlights the differential risk by asset class and transition pathway. Results are used to identify concentrations of risk and test the robustness of investment strategy under uncertain futures.

L&G plans to continue refining its approach. Future developments include enhancing data quality, expanding physical risk analysis, and incorporating nature-related scenarios where appropriate. Scenario outputs will remain a core input to long-term capital planning, product innovation, and risk oversight.

As the external environment evolves, scenario analysis will continue to serve as a key framework for testing resilience, evaluating alignment, and guiding capital decisions across Legal & General's investment portfolio.

Moody's – Impact on the Auto Industry: Credit Risk Depends on a Climate Scenario

Moody's assessed the impact of climate risks on global automotive corporate bonds across a range of scenarios, highlighting how credit outcomes shift with factors such as production mix, geographic footprint and early EV specialisation. Financial institutions can use such scenario analysis to identify which firms are more resilient across transition pathways, guide lending decisions, and capture transition opportunities within the sector. This case study is based upon a wider [Moody's publication](#).

1. Introduction

Climate change presents significant challenges to the automotive industry through both physical and transition risks that can impact financial performance and thereby credit risk. The research paper analyses how these climate-related risks affect three major automotive companies: Volkswagen, Nissan, and Tesla across different climate scenarios. The analysis demonstrates that credit risk outcomes vary significantly depending on the climate scenario and company-specific attributes, particularly production location (affecting physical risk exposure) and the mix between electric and non-electric vehicle production (affecting transition risk exposure). The findings reveal that Tesla benefits most from transition scenarios due to its focus on electric vehicles, while Volkswagen demonstrates resilience across scenarios due to its diversified production portfolio.

2. Methodology

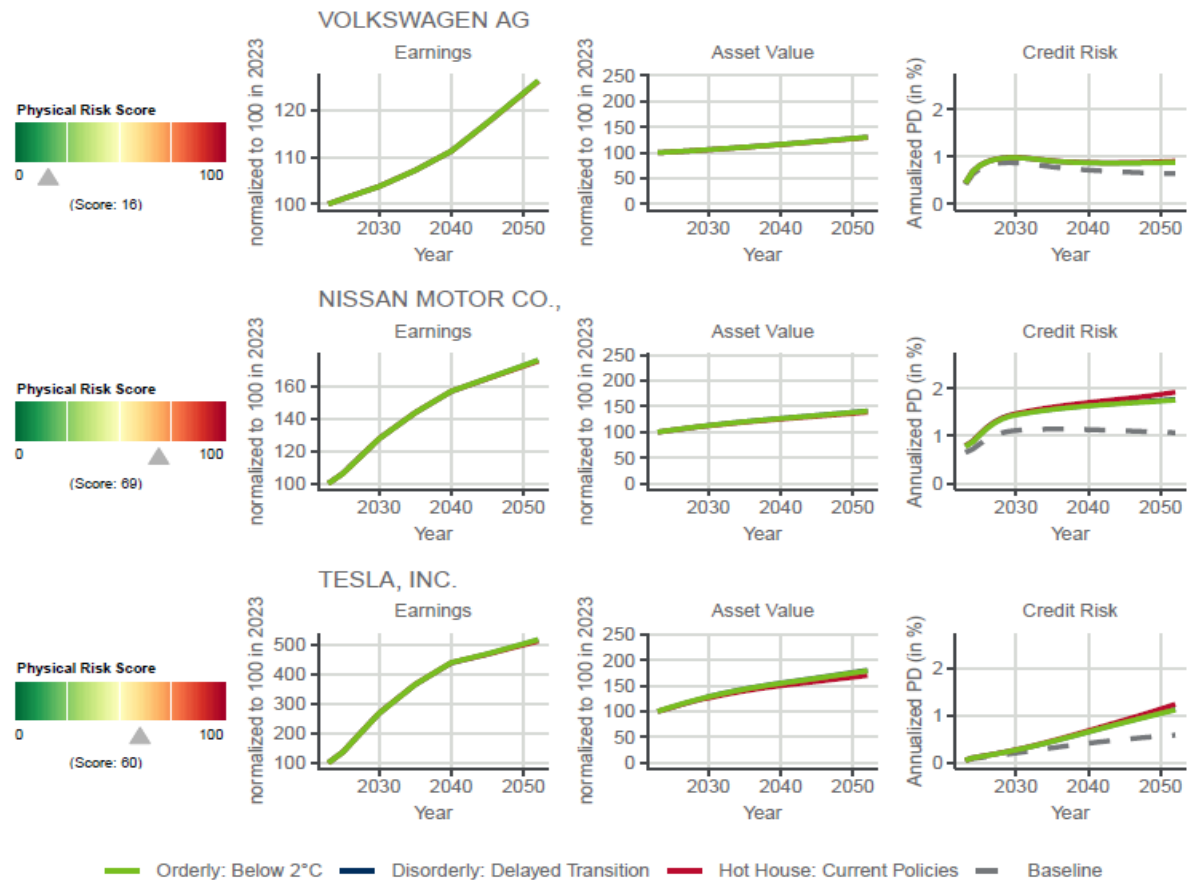
The study employs a comprehensive methodology combining firm-level risk assessment with global and sectoral dynamics to project climate-adjusted expected default frequencies. The research examines three main climate scenarios from the Network for Greening the Financial System (NGFS III): Orderly (Below 2°C), Disorderly (Delayed Transition), and Hot house (Current Policies), representing different pathways for climate policy implementation and global warming outcomes.

The core analytical framework is Moody's Climate Adjusted Expected Default Frequency (CAEDF) Model, which combines firm-level risk assessment with global and sectoral dynamics to provide a comprehensive view of climate-related financial risks. Physical risk assessment is based on Moody's physical risk scores, which evaluate companies' production facilities and physical assets across various locations, with scores ranging from 0 (low risk) to 100 (high risk). These scores are aggregated across different climate hazards and locations to provide a comprehensive view of each company's physical risk exposure. For transition risk analysis, the study employs a two-step process that first utilizes the Global Change Analysis Model (GCAM) to capture sectoral evolution in response to carbon pricing, regulations, and shifting consumer demand. The second step involves an oligopoly model to analyse how firms compete within sectors, with the automotive industry specifically disaggregated into electric vehicle (EV) and non-electric vehicle markets.

3. Physical risk analysis

Physical risk assessment reveals that all three companies in the study are negatively affected by climate-related physical hazards, though with varying degrees of impact. The analysis, based on Moody's physical risk scores, shows that Nissan and Tesla both experience a consistent increase in Expected Default Frequency (EDF) over the 30-year horizon examined in the study. Volkswagen's EDF follows a different pattern, initially increasing but then levelling off and slightly declining over the longer term.

Figure 4: Minor Differences of Chronic Physical Risk Across Scenarios

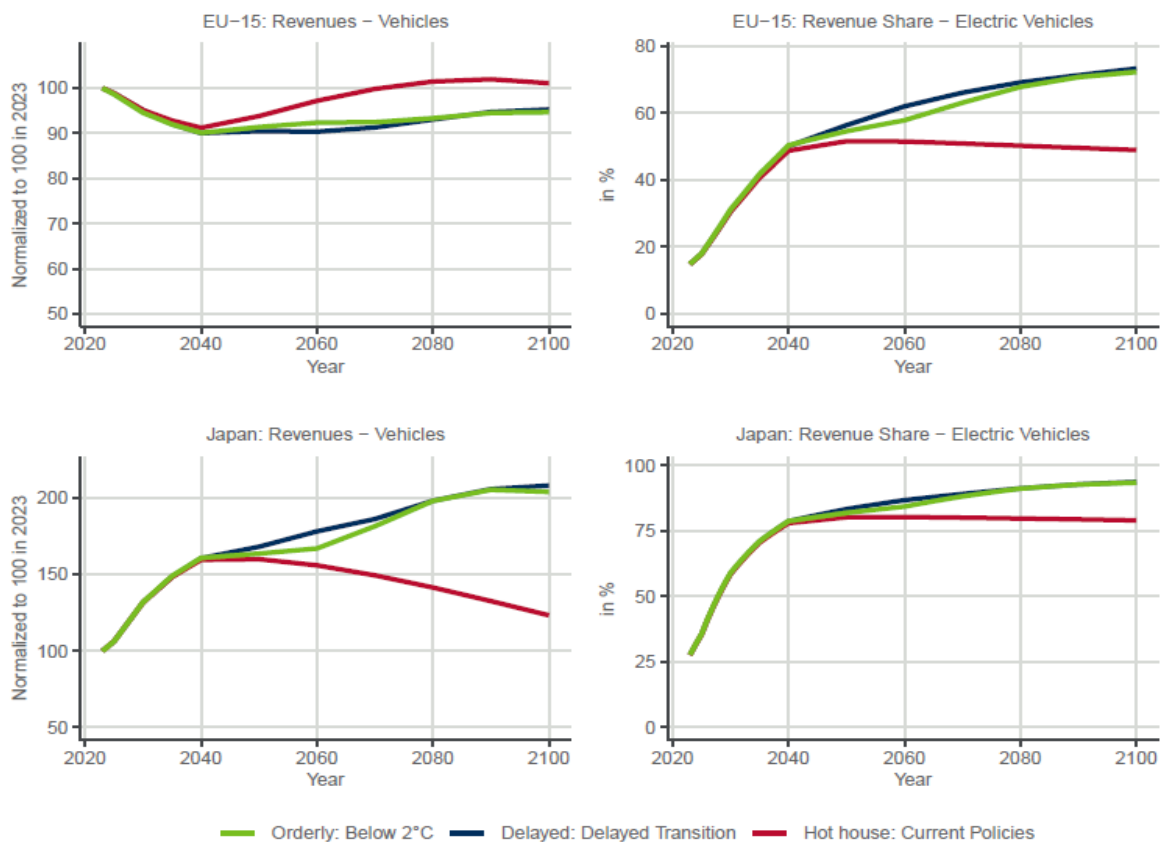


The geographic distribution of production facilities plays a crucial role in determining a company's vulnerability to physical climate risks. Companies with facilities concentrated in regions with higher exposure to climate hazards naturally face greater physical risks than those with facilities in less vulnerable areas. The assessment methodology aggregates physical risk scores across different climate hazards and locations, providing a comprehensive view of each company's exposure. The study indicates that Volkswagen's production facilities are primarily located in Europe, which has relatively lower physical risk exposure compared to some other regions. This geographic advantage contributes to Volkswagen's more favourable physical risk profile compared to Nissan and Tesla. The consistency of physical risk impacts across different climate scenarios suggests that these risks are already largely locked in due to existing greenhouse gas emissions and climate change patterns.

4. Transition risk analysis

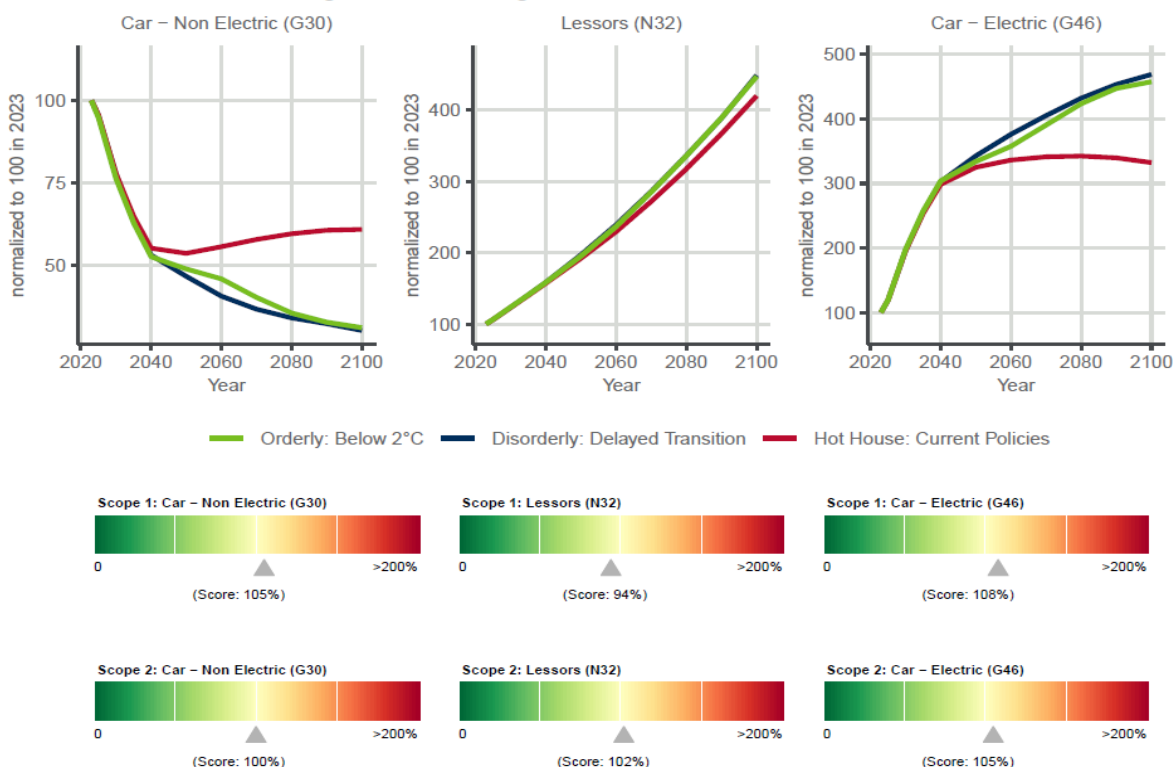
Transition risk analysis reveals significant variations in how automotive companies are affected by different climate policy scenarios. The sectoral analysis shows notable regional differences in how the automotive sector responds to various climate scenarios. Moody's would like to contrast the impact of transition risk on Volkswagen and Nissan and therefore focus on the geographic regions of the EU-15 and Japan. Figure 5 shows the GCAM-generated sum of the revenues from the two markets, and electric vehicles share of total revenue. In the EU-15 region, overall automotive sector revenue in the hot house scenario increases after an initial drop, suggesting some resilience in traditional vehicle markets under limited climate policy. In contrast, Japan's automotive sector shows a decline in revenue under the hot house scenario, indicating greater vulnerability to a business-as-usual approach to climate change.

Figure 5: Demand for Vehicles and Share for EV: EU and Japan



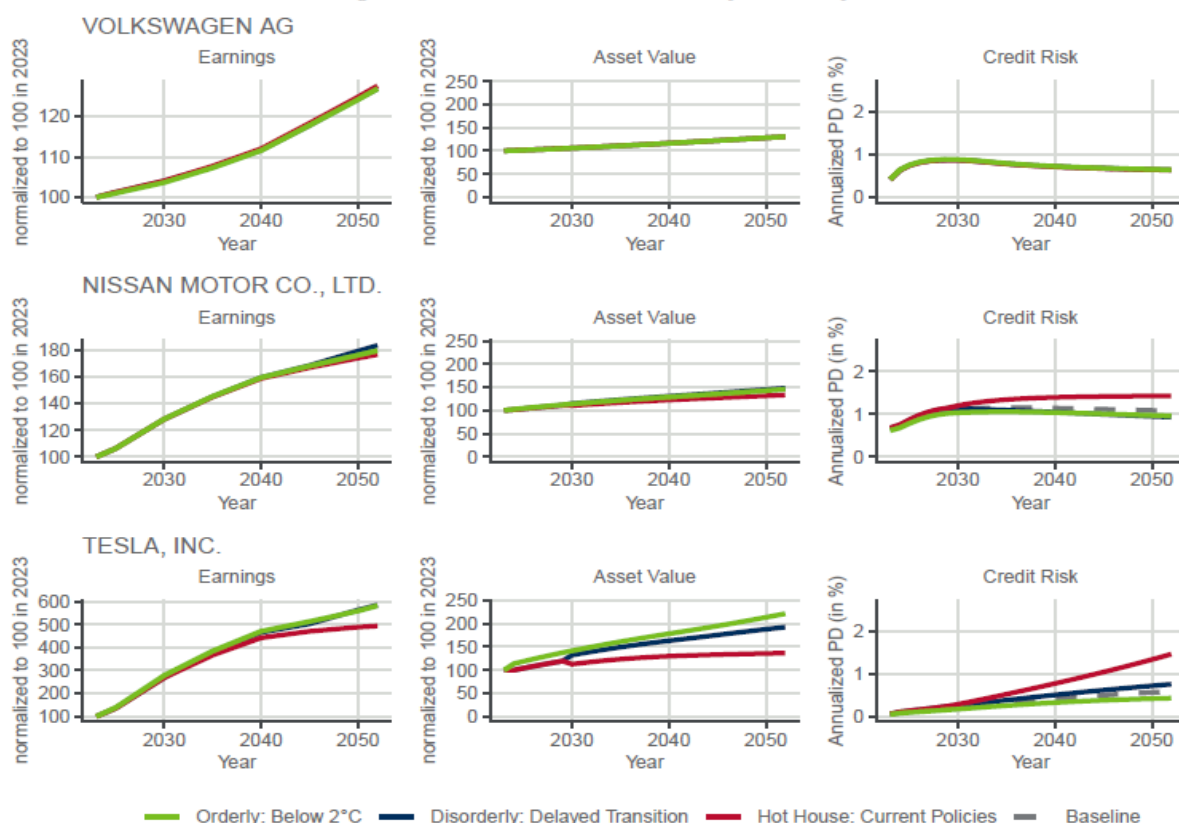
The earnings paths for the most important sectors of Volkswagen, as an example, are shown in Figure 6. It can be seen that earnings for non-electric cars are greater in the hot house world scenario as compared to the other two scenarios, while the opposite is the case for electric cars. This means Volkswagen is well hedged, doing well whether the transition occurs or not.

Figure 6: Sector Earnings Paths and Emission Intensities: VW



The firm-level results for transition risk are in Figure 7. As expected, the EDF under transition risk scenarios is lower for Tesla than for the other two car makers for the first twenty years. Then the level of EDF, and hence credit risk, due to the transition to a carbon-free economy, is actually similar. This reflects the reliance on other sectors as well as a greater portion of revenue to come from the sales of EVs. Tesla is affected more negatively in the hot house world scenario, compared to scenarios where a transition occurs, as the demand for EVs is likely to be negatively affected in scenarios with no transition. This effect is often not fully appreciated in climate scenario analyses.

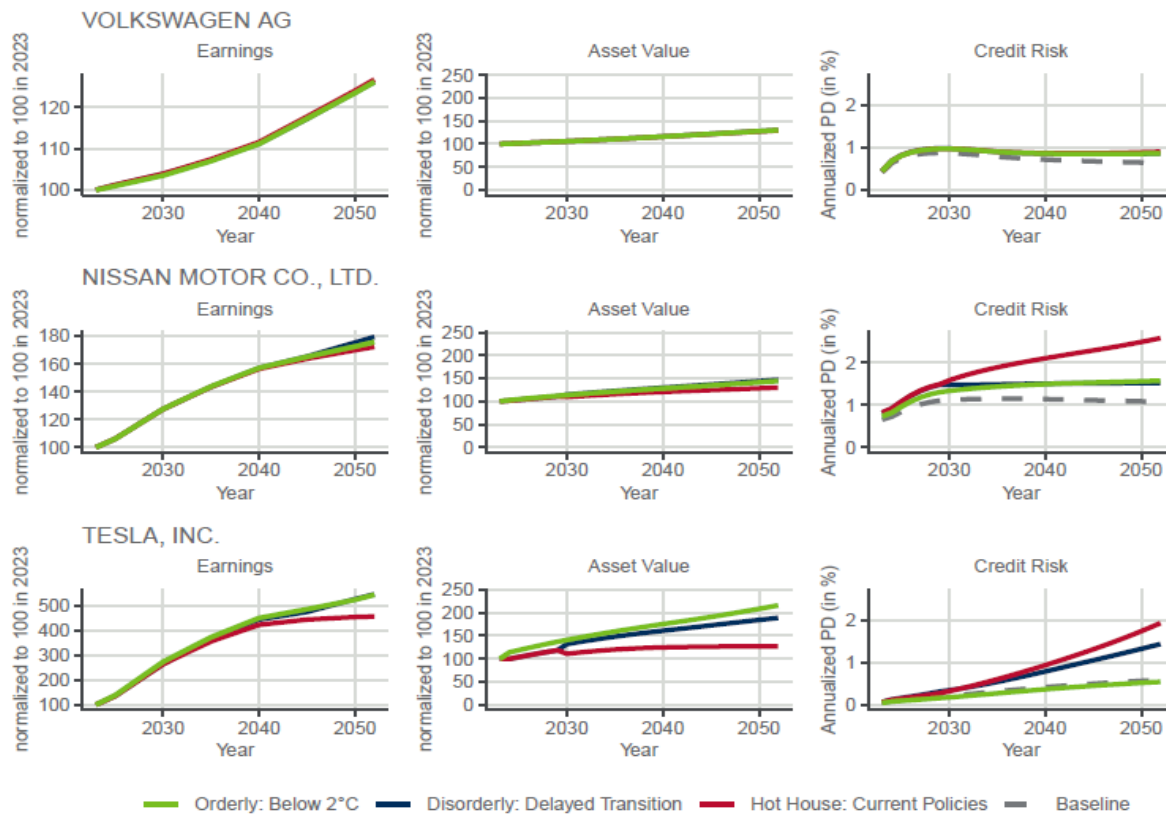
Figure 7: Transition Risk Differentiates only Moderately



5. Combined risk analysis

Figure 8 illustrates the combined risk patterns for all three companies, showing earnings, asset value, and credit risk projections across different scenarios. Tesla benefits most from transition scenarios with significantly higher earnings and asset values and lower probability of default compared to the Hot House scenario. Nissan shows a similar but less pronounced pattern, while Volkswagen remains relatively stable across scenarios, demonstrating its effective hedging strategy against climate risks.

Figure 8: Combined Risk Pattern



6. Conclusions and implications

The analysis yields several strategic implications for automotive companies and their stakeholders. First, diversification across vehicle types serves as an effective hedging strategy against climate scenario uncertainty. Volkswagen's balanced portfolio of electric and non-electric vehicles provides resilience regardless of which climate pathway materialises, demonstrating the value of a gradual transition approach that maintains flexibility.

Second, geographic distribution of production facilities significantly impacts physical risk exposure. Volkswagen's concentration of production in Europe results in lower physical risk scores compared to Nissan and Tesla, highlighting the importance of considering climate hazards in facility location decisions. Companies should assess their global production footprint and potentially reallocate resources to regions with lower physical risk exposure.

Third, early specialisation in electric vehicles provides advantages in transition scenarios but creates vulnerability if transition policies fail to materialize. Tesla's strategy of focusing almost exclusively on EVs results in superior performance under Orderly and Disorderly scenarios but underperformance in the Hot House scenario. This suggests that pure-play EV manufacturers should develop contingency plans for scenarios where climate policies are delayed or abandoned.

Fourth, the timing of transition matters significantly for credit risk trajectories. The Delayed Transition scenario shows distinct bifurcation points around 2030 when stringent policies are

suddenly implemented, creating potential financial shocks. Companies should prepare for possible policy discontinuities by stress testing their financial resilience against sudden regulatory changes.

Finally, compliance with emissions regulations increasingly affects competitive positioning within the automotive sector. Companies with lower emission intensities gain market share in scenarios with elevated carbon prices, highlighting the importance of operational efficiency and clean manufacturing processes beyond just product offerings.

MSCI – Approaches to Scenario Analysis: A Case Study on Climate Risks to UK Companies

This MSCI case study assesses the physical risk exposure of UK-listed equities from the MSCI UK IMI Index under two climate scenarios aligned with 1.5°C and 3°C pathways. The analysis, informed by NGFS and IPCC data and spanning short, medium, and long-term time horizons, focuses on the impacts of direct (i.e., 1-in-200 year flood exposure) and indirect (wider macroeconomic effects and nonlinearities) physical risks. Under the SSP3-7.0 scenario, direct revenue losses from severe fluvial flood events are projected to increase from \$0.64 billion (present day) to \$1.33 billion (2100). Losses from wider, indirect macroeconomic effects under the same scenario are estimated at \$225.1 billion (2100). If the potential for risk cascading and nonlinearities is considered, leading to total economic losses beyond 4°C, then (annual) macroeconomic-driven losses are estimated at \$915.3 billion by the end of century, representing approximately one-third of present-day MSCI UK IMI company revenues, estimated at \$2.7 trillion.

1. Introduction

The impacts of climate risk are not only recognisable today but are expected to intensify, even as the global economy moves towards a low-carbon future. Financial institutions such as banks and insurers are required to undertake climate stress tests across several jurisdictions. Now, a broader swathe of institutions across the financial sector are performing physical climate risk assessments on their investment and underwriting portfolios, recognising that climate risk represents both operational and financial risk.

Approaches to physical climate risk stress tests continue to evolve with growing access to climate models, climate scenarios and natural catastrophe-based risk frameworks. In this context, financial institutions often face the challenge of data availability, particularly for assessing public and private company exposure to physical risk. Asset location data greatly improves the accuracy of risk exposure assessments of companies and portfolios to location-specific hazards, such as flooding events.

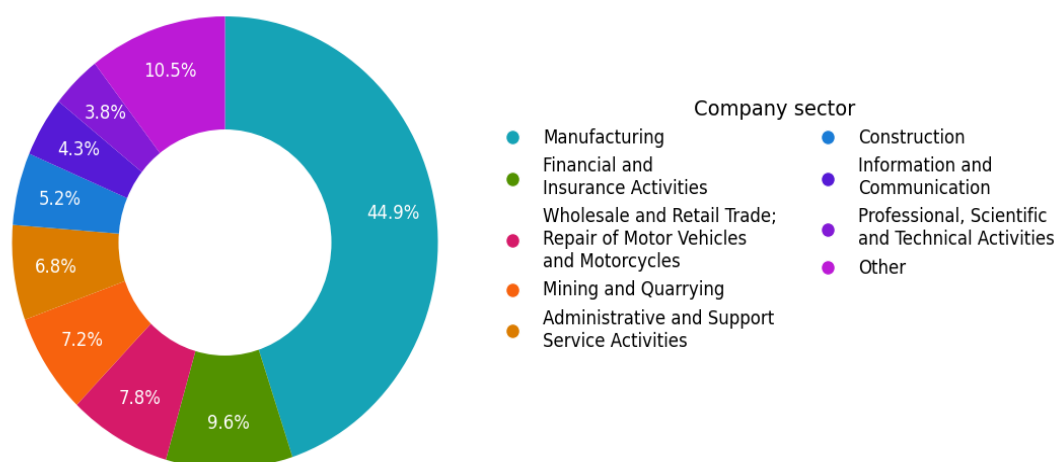
This article offers a case study of physical climate risk stress tests on public companies, leveraging an asset location database that quantifies company-level, direct physical risk exposures, and a macroeconomic physical risk model that captures additional losses from

indirect impacts and wider transmission channels. Understanding the different ways that assets and companies may incur damages and losses allows for climate risk to be translated into financial terms, including probability of default and expected loss. By translating climate risk into financial risk, finance professionals can make informed capital allocation decisions to manage risk effectively and achieve regulatory compliance.

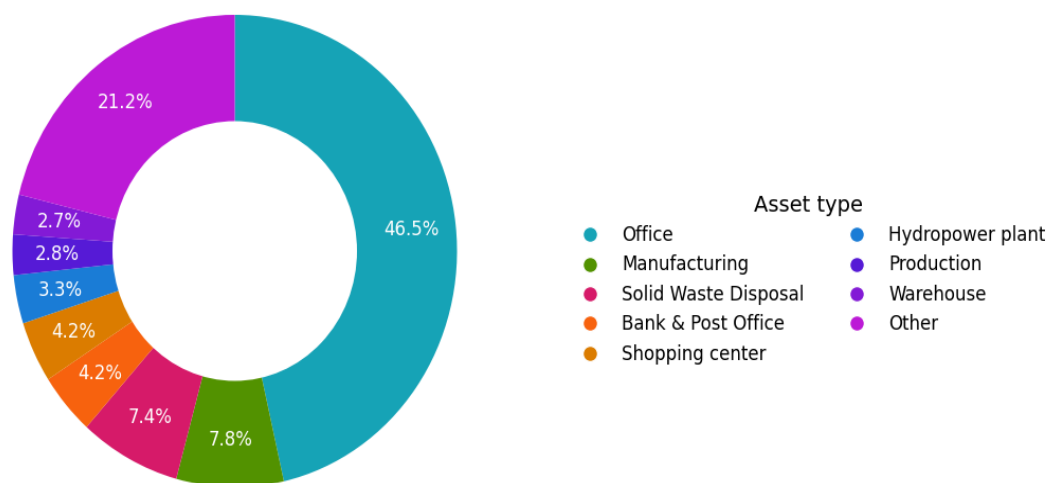
2. Data and methods

The case study focuses on three climate stress tests applied to companies within the MSCI UK Investable Market Index (IMI), representative of small-, mid-, and large-cap U.K. companies across sectors (Exhibit 1a). These companies will feature within many investment and underwriting portfolios and hold relevance to investors, lenders, and insurers. MSCI identify assets owned or operated by MSCI UK IMI companies using MSCI's GeoSpatial Asset Intelligence. The scope of the study is limited to assets located within the U.K., which represents a range of activity types at asset locations (Exhibit 1b), and to directly owned assets only (i.e., not including subsidiary assets).

Exhibit 1a: Constituents of the MSCI UK IMI by sector



Sectoral classifications (NACE, Statistical Classification of Economic Activities in the European Community) for the constituents of the MSCI UK IMI representing small-, mid-, and large-cap U.K. companies. N = 261 out of a total 282 companies, representing available asset-level and physical risk data within MSCI GeoSpatial Asset Intelligence, as of April 1, 2025. Source: MSCI ESG Research LLC.

Exhibit 1b. Activity of directly owned U.K.-based assets of MSCI UK IMI

Assets directly owned or operated by MSCI UK IMI companies and present within MSCI's GeoSpatial Asset Intelligence solution as of April 1, 2025 (n=2,171). Assets are classified by activity types at their specific locations and limited to those located in the U.K. Source: MSCI ESG Research LLC.

The first climate stress test is focused on present-day hazard exposure to flood perils. Flood exposure at asset locations is assessed using flood depths associated with 1-in-200-year events for coastal, fluvial, and pluvial flooding. Flood events are often described in terms of frequency (1-in-200-year events have a 0.5% probability of annual occurrence) and intensity (i.e., the depth of flood at a given location for a given event). A 1-in-200-year event arguably provides suitable conditions for a stress test, being representative of a low likelihood event that would generate severe losses across a portfolio. Flood depths are defined using Fathom's Global Flood Map 3.1, which underpins present-day and scenario-based flood depths for all 2 million asset locations within MSCI GeoSpatial Asset Intelligence.¹² Of the 2 million globally distributed assets, 61,500 are located in the U.K.¹³ Present-day asset damages and revenue losses from flood exposure are estimated using depth-damage functions informed by historical observations.

The second climate stress test is a climate scenario analysis that leverages MSCI's suite of climate scenarios, informed by the NGFS (Network for Greening the Financial System) and the IPCC (Intergovernmental Panel on Climate Change). The present-day flood exposure climate stress test is extended into the future using Shared Socioeconomic Pathways (SSPs) under the IPCC SSP1-2.6 and IPCC SSP3-7.0 scenarios. The scenario SSP1-2.6 is representative of a sustainable, low growth pathway respectful of environmental boundaries resulting in warming of approximately 1.5°C by end of century. The scenario SSP3-7.0 is representative of resurgent nationalism, geopolitical conflict, inequality and ununified development, resulting in approximately 3.5°C of warming by end of century. The IPCC SSP3-7.0 is not a 'worst case' scenario in terms of future emissions growth and warming.¹⁴

¹² Oliver E. J. Wing et al., "A 30 m Global Flood Inundation Model for Any Climate Scenario", *Water Resources Research*, no. 60 (2024): e2023WR036460.

¹³ Data as of April 1, 2025.

¹⁴ Keywan Riahi et al., "The Shared Socioeconomic Pathways and their energy, land use, and greenhouse gas emissions implications: An overview", *Global Environmental Change*, no. 42 (2017): 153-168.

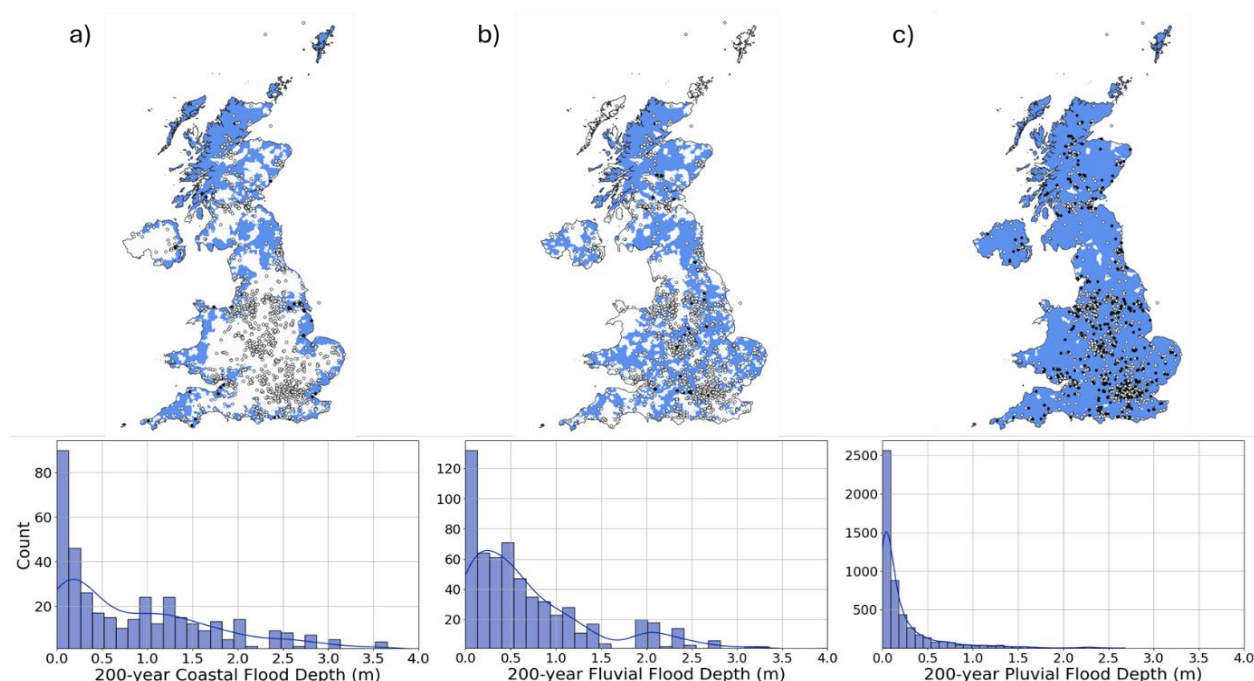
The third climate stress test is a climate scenario analysis focussed on the additional future macroeconomic impacts of wider physical risks on GDP in the UK and resulting impact on company-level revenues. The choice of scenarios (IPCC SSP1-2.6 and IPCC SSP3-7.0) is kept consistent with the flood exposure stress test for comparison. However, additional optionality is provided in the form of macroeconomic damage functions, which translate changing temperatures into economic losses. Recognising that future economic losses from rising temperatures may be underestimated because of, for example, non-linearities and tipping points in the Earth-system, choices of damage functions include NGFS-based accelerated losses that are calibrated on assumptions of total economic losses occurring at 6°C (SQ6) and at 4°C (SQ4) of mean global temperature increase.¹⁵

3. Present-day climate stress test

Present-day flood exposure can be assessed by asking a question – *which assets experience non-zero flood depths during a 1-in-200-year flood event?* For companies in the MSCI UK IMI, 2.5% of the U.K. assets identified by MSCI carry some exposure (i.e., non-zero flood depth) to coastal flooding. For fluvial flooding and pluvial flooding, the exposure is 3.8% and 33.1%, respectively (Exhibit 2). This trend highlights a common feature in physical risk assessments – a minority of assets will often carry most of the risk exposure. Considering the absolute magnitude of hazard exposure (i.e., location-specific flood depths), analysts can prioritize efforts on the most exposed assets and companies. Even though 1-in-200-year events may be uniform in occurrence probability, they will vary in terms of their magnitude and impact at different locations. Engagement and adaptation strategies will benefit from hazard exposure screening to identify at-risk assets, before undertaking financial materiality assessments and subsequent actions.

¹⁵ Sandy Trust et al., “The Emperor’s New Climate Scenarios”, *Institute and Faculty of Actuaries and University of Exeter* (2023).

Exhibit 2: Exposure of assets to coastal (a), fluvial (b) and pluvial flooding (c) associated with 1-in-200-year events



Note: Assets that carry non-zero flood depths are considered exposed to flooding and shown as black dots. The background maps show administrative areas from MSCI's Regional Hazard Metrics solution with non-zero flood depths in blue. Distributions and probability density functions of exposed assets show how flood depths vary at different locations for events of a common probability. Data as of April 1, 2025. Source: MSCI ESG Research LLC.

The financial impacts from flood events can include the direct damage to assets as well as the loss in revenues from business interruption (Exhibit 3a).¹⁶ For flood-exposed assets identified in the U.K., the value loss from direct asset damages ranged from 2.6% to 17.1%, 4.9% to 25.9%, 1.7% to 11.1% for coastal, fluvial, and pluvial flood events, respectively (interquartile ranges). Revenue losses from business interruption ranged from 0.9% to 8.2%, 2.1% to 13.2%, 0.6% to 4.3% for coastal, fluvial, and pluvial flood events, respectively (interquartile ranges).

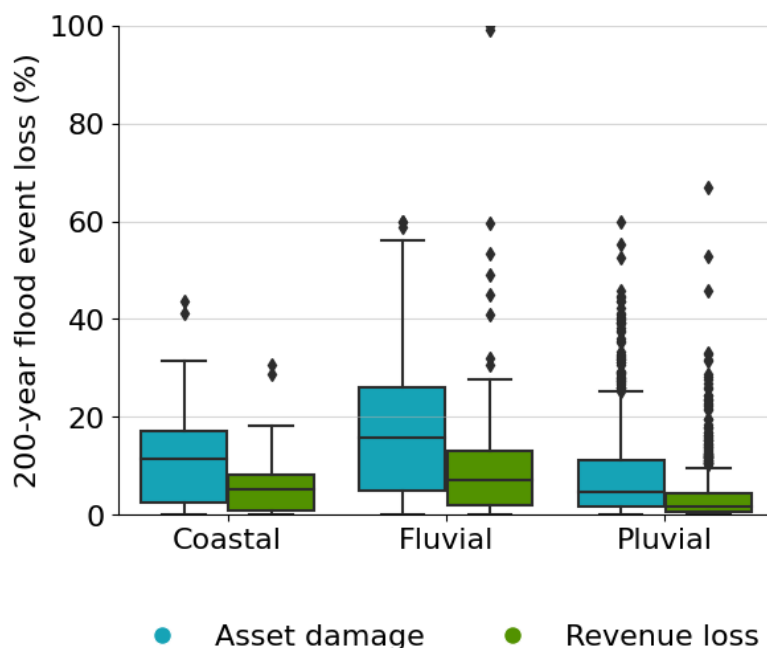
When aggregated across all flood-exposed assets and translated into dollar-loss estimates, present-day revenue-loss exposure to coastal and fluvial flooding is \$6 billion for each peril, relative to \$4.7 billion for pluvial flooding (Exhibit 3b). Whereas flood depths associated with pluvial flooding are less compared to those associated with coastal and fluvial flooding, the higher volume of asset exposure to pluvial flooding makes this peril potentially the costliest. This pattern is repeated when asset damage exposure is considered in place of revenue exposure. Financial impacts from direct asset damage and business interruption may represent material risk to MSCI UK IMI companies and the distribution of hazard exposure across those companies is non-uniform.

While climate stress tests focus on low likelihood events, they are useful tools for identifying

¹⁶ Depth-damage functions are used to translate flood depths into asset damages and revenue loss. Asset damages are defined as the percentage value loss of an asset due to direct asset damage, whereas revenue losses are defined as the percentage value loss of asset revenues due to business interruption.

concentrations of risk exposure and for quantifying the financial materiality of that risk exposure. An understanding of the financial risk exposure across portfolios, as well as the distribution of that risk, is necessary for informing management and risk strategies. For example, financial institutions can undertake targeted engagement strategies with at-risk companies to assess pre-existing resilience measures. Engagement strategies can lead to more informed decision making, such as portfolio rebalancing or seeking new opportunities of raising adaptation finance to address present and future risk exposure.

Exhibit 3a: Distributions of present-day value loss from asset damage and revenue loss from business interruption



Note: Exhibit shows lower and upper quartiles (box limits), median values (horizontal lines), 150% interquartile ranges (whiskers) and outliers (diamonds). Distributions are based on exposed assets (non-zero flood depth) from the sample of 2,171 assets of MSCI UK IMI constituents within the U.K. according to MSCI GeoSpatial Asset Intelligence as of April 1, 2025. Source: MSCI ESG Research LLC.

Exhibit 3b: Asset damage and revenue loss estimates from present day 1-in-200-year flood exposure

Loss Type	Coastal Flooding	Fluvial Flooding	Pluvial Flooding
Revenue Loss	\$0.61B	\$0.64B	\$4.70B
Asset Damage	\$0.43B	\$0.57B	\$7.18B

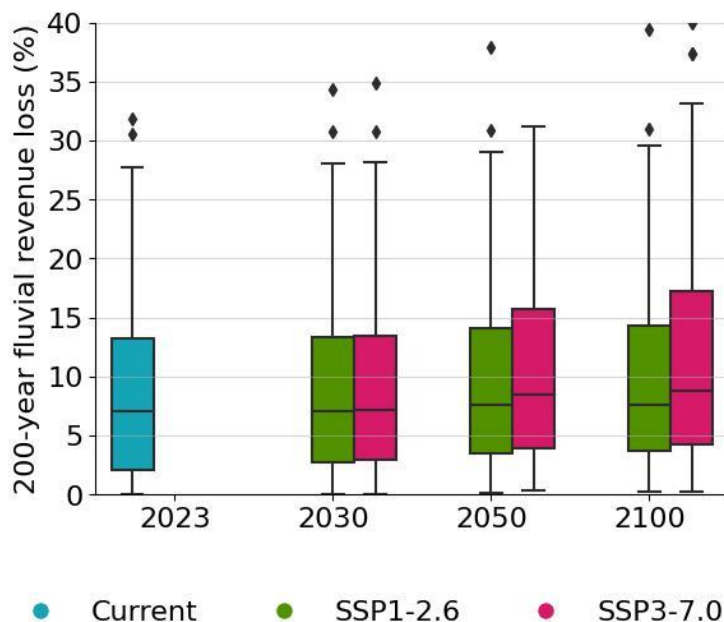
Note: Exhibit shows total estimated expected losses from present-day flood exposure to 1-in-200 year events for assets within the U.K. belonging to MSCI UK IMI constituents according to MSCI GeoSpatial Asset Intelligence as of April 1, 2025. Source: MSCI ESG Research LLC.

4. Climate scenario analysis

Climate scenario analysis allows analysts to explore how risk exposure can change under different climate futures. Here, MSCI simplify the assessment by focusing on a single peril (fluvial flooding) and loss type (revenue loss) whilst introducing complexity in terms of different climate scenarios and time horizons (Exhibit 4a). Under a low-warming scenario (SSP1-2.6) a marginal, yet sustained, increase in risk exposure and related revenue losses from 1-in-200-year fluvial flood events over time is noted, growing to 2.7% to 13.3% and 3.7% to 14.4%, for the years 2030 and 2100 respectively (interquartile ranges). Under a relatively higher warming scenario (SSP3-7.0), revenue losses increase materially to 2.9% to 13.4% and 4.3% to 17.2%, for the years 2030 and 2100 respectively (interquartile ranges). When aggregated across all assets, the stress test losses in both scenarios in 2030 are close to \$0.7 billion. Later in the century it can be seen that expected losses under the two scenarios diverge, resulting in nearly twice as much loss in the higher warming scenario (\$1.33 billion) compared to the lower warming scenario (\$0.76 billion) by 2100 (Exhibit 4b).

These trends reveal insights that can be common across climate risk assessments. Firstly, higher warming scenarios will drive increased risk - risk mitigation is best attained by limiting the magnitude of future warming. Secondly, even under low warming scenarios, climate-related risks can intensify – for some hazards (e.g., coastal flooding) risk exacerbation is already expected (e.g., due to sea-level rise). Successful resilience strategies will need to address both risk mitigation and adaptation into the future.

Exhibit 4a: Distributions of present-day and future revenue loss due to 1-in-200-year fluvial flood exposure across two climate scenarios



Note: Exhibit shows lower and upper quartiles (box limits), median values (horizontal lines), 150% interquartile ranges (whiskers) and outliers (diamonds); y-axis is truncated at 40% for clarity. Distributions are based on exposed assets (non-zero flood depth) from the sample of 2,171 assets of MSCI UK IMI constituents within the U.K. according to MSCI GeoSpatial Asset Intelligence as of April 1, 2025. Source: MSCI ESG Research LLC.

Exhibit 4b: Revenue loss estimates from future exposure to severe (1-in-200-year) fluvial flood events

Year	Present Day	SSP1-2.6 Scenario	SSP3-7.0 Scenario
2023	\$0.64B		
2030		\$0.67B	\$0.68B
2050		\$0.73B	\$0.82B
2100		\$0.76B	\$1.33B

Note: Exhibit shows total estimated expected losses from 1-in-200 year fluvial flood event under two future warming scenarios for assets within the U.K. belonging to MSCI UK IMI constituents according to MSCI GeoSpatial Asset Intelligence as of April 1, 2025. Source: MSCI ESG Research LLC.

5. Macroeconomic impacts and non-linearities

Climate stress tests that focus only on the direct exposures of assets and companies to physical risk, as demonstrated above, will fail to capture additional climate risks that may impact companies via indirect transmission channels. Climate risk assessments that do not consider macroeconomic and second-order impacts may underestimate future risk exposure by failing to capture non-linearities and tipping points in the Earth system, which become increasingly likely with higher incremental warming.¹⁷

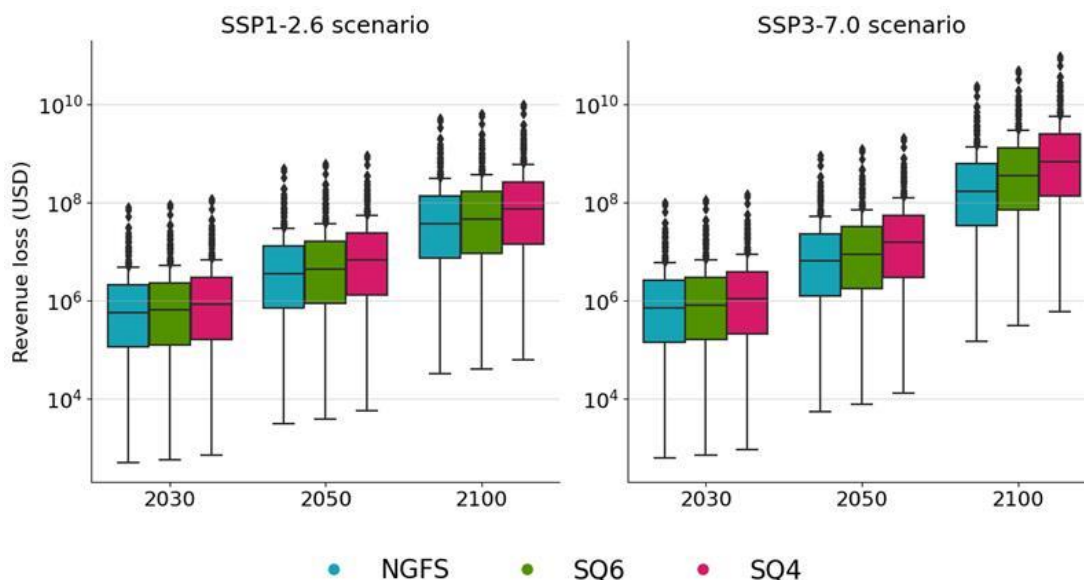
To estimate the macroeconomic impacts of future warming on MSCI UK IMI companies, MSCI translate temperature changes into GDP loss in the U.K. and subsequent revenue loss on U.K. companies using the MSCI Macroeconomic Physical Risk Climate Value-at-Risk model. Further, to account for the possibility of risk cascading from Earth system and socioeconomic nonlinearities, MSCI introduce accelerated loss damage functions that are calibrated on the assumption of total economic loss occurring at 6°C (i.e., in the distant future), and also at 4°C (i.e., potentially plausible during the 21st century under high-warming scenarios) (Exhibit 5b).

In the near term (2030, in this study) the magnitude of impacts from macroeconomic-driven losses (Exhibit 5b) are broadly comparable to those calculated for extreme weather events such as 1-in-200 yr flood events (Exhibit 4b). However, later in the century with continued warming the potential for extreme losses due to macroeconomic and second order impacts, and (implicitly modelled) cascading risk, is orders of magnitude greater compared to the potential losses from direct risk exposure alone. Within the SSP3-7.0 scenario and under the condition that nonlinearities trigger total economic losses beyond 4°C of warming, total annual losses are estimated at \$915.3 billion by the end of century. For comparison, present-day revenues for MSCI UK IMI companies are estimated at \$2.7 trillion. Analysts should consider the breadth of climate risk types that may feature in a climate stress test or in climate scenario analysis to appropriately address the research question and to capture potential losses from diverse

¹⁷ T. M. Lenton, et al. "The Global Tipping Points Report 2023" *University of Exeter, Exeter, UK*, December 6, 2023, <https://report-2023.global-tipping-points.org/>

transmission channels.

Exhibit 5a. Distributions of future physical-risk driven macroeconomic revenue losses under two climate scenarios and three tiers of damage functions.



Note: Exhibit shows annual revenue losses from macroeconomic effects due to future warming under three tiers of damage functions: lower and upper quartiles (box limits), median values (horizontal lines), 150% interquartile ranges (whiskers) and outliers (diamonds). NGFS – damage functions used by the NGFS and based on Kotz et al. (2024) ; SQ6 – accelerated losses from the addition of a quadratic coefficient to the NGFS damage functions calibrated on total economic loss at 6°C; SQ4 – accelerated losses from the addition of a quadratic coefficient to the NGFS damage functions calibrated on total economic loss at 4°C.

Exhibit 5b. MSCI UK IMI annual revenue loss estimates from forward-looking macroeconomic physical risk impacts on U.K. GDP

	SSP1-2.6 Scenario			SSP3-7.0 Scenario		
Year	NGFS	SQ6	SQ4	NGFS	SQ6	SQ4
2030	\$0.8B	\$0.9B	\$1.1B	\$1.0B	\$1.1B	\$1.4B
2050	\$4.8B	\$5.9B	\$8.8B	\$8.5B	\$11.7B	\$20.3B
2100	\$50.0B	\$61.3B	\$96.7B	\$225.1B	\$480.0B	\$915.3B

Note: Exhibit shows total estimated revenue losses to MSCI UK IMI constituents from macroeconomic physical risk impacts on U.K. GDP. For each scenario (SSP1-2.6 and SSP3-7.0) three options of damage functions used to translate physical risk impacts on U.K. GDP losses are shown: NGFS – damage functions used by the NGFS and based on Kotz et al. (2024)¹⁸; SQ6 – accelerated losses from the addition of a quadratic coefficient to the NGFS damage functions calibrated on total economic loss at 6°C; SQ4 – accelerated losses from the addition of a quadratic coefficient to the NGFS damage functions calibrated on total economic loss at 4°C.

¹⁸ Kotz, M., Levermann, A., Wenz, L. (2024). The economic commitment of climate change. Nature, 628(8008):551-557.

4°C. Losses represent the aggregated additional impact on MSCI UK IMI constituents according to MSCI Macroeconomic Physical Risk Climate Value-at-Risk as of June 26, 2025. Source: MSCI ESG Research LLC.

6. **Decision-useful data**

This case study presents an accessible view into climate stress testing focused on physical risk. The limits of the case study have been defined by design. Limiting the scope of a stress test or climate scenario analysis allows for greater focus on critical assets (here, assets belonging to companies in the MSCI UK IMI), within a defined region (the U.K.), for the most material hazards (flood-related perils). Within this data, further screening and filtering for materiality can take place (i.e., the most exposed assets, or the most important sources of damage) to identify those assets that carry much of a portfolio's risk exposure. This quantitative assessment can be a decision-useful tool for informing traditional risk management approaches (i.e., avoid, reduce, transfer, accept etc.) and subsequent engagement or action strategies.

Ensuing analyses can introduce additional data and climate risk types, such as the macroeconomic losses exemplified above, can add to the broader picture of total risk exposure. Other risk terms not included in this case study are equally relevant, such as 'average annual loss', which defines the damages an asset may be exposed to within a given year across a much broader range of event frequencies and probabilities beyond simply 1-in-200-year events, as presented here. Understanding how assets may be impacted in terms of damages and losses allows the translation of climate risk into financial risk, for example, into probability of default and expected loss terms. By translating climate risk into financial risk, finance professionals can make informed capital allocation decisions to manage risk effectively and achieve regulatory compliance. With the availability and complexity of data growing rapidly, a successful strategy often starts with the simplification of the question being asked – *of the assets within my portfolio, where are they located and how many of them are exposed to physical risk?*

NatWest and Planetrics – Constructing Decision Useful Short-term Climate Scenario Analysis

NatWest created four qualitative UK-based transition risk scenario narratives with a 10-year horizon. These act as a framework for NatWest's quantitative climate scenario analysis used in assessing expected and unexpected credit losses. In partnership with Planetrics they developed modelling capabilities required to parametrize and analyse the scenarios.

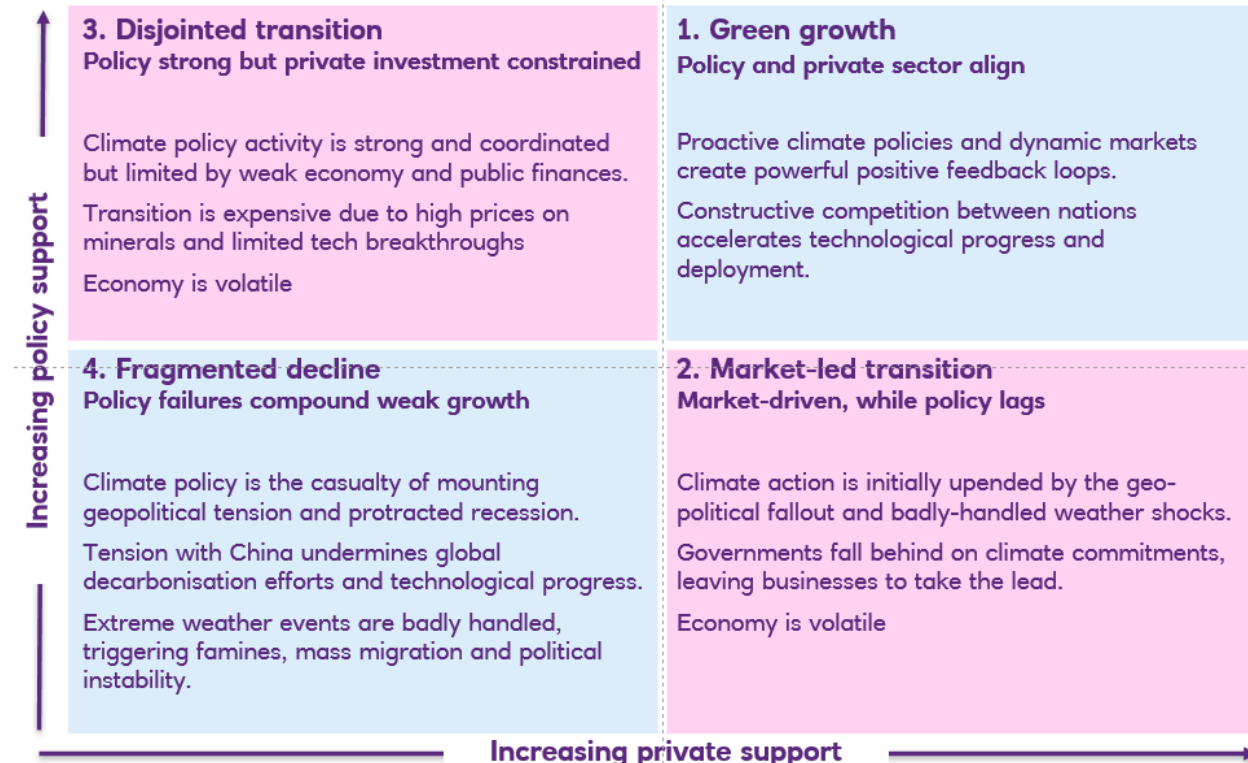
Bespoke short-term climate scenarios are an important tool that can help manage expected and unexpected climate risks. These scenarios support (i) strategic planning by providing a baseline view of climate risks and (ii) risk management by testing resilience to higher climate stress scenarios that are plausible, but have lower probability to occur.

The financial sector needs realistic and relevant short-term climate scenarios to further embed climate into decision making. To be relevant, scenarios must focus on the most material climate drivers in the sectors and regions that can directly affect an institution's financial performance within the next 5-10 years. To be realistic, scenarios must explore plausible, recognisable and specific policy, technology and physical changes. These requirements to be decision-useful run up against the limitations of the existing suite of publicly available climate scenarios typically used by the financial sector. Most scenarios explore stylised global pathways with limited sector-region policy and technology variation over long-time horizons (25+ years)¹⁹. Accordingly, this presents a challenge to the financial sector, which requires scenario customisation and construction to resolve.

In search of more decision-useful scenarios, NatWest partnered with climate experts from the University of Exeter's Global Systems Institute to create bespoke climate scenario narratives. This resulted in a framework describing four 'transition archetypes' that underpin NatWest's transition risk scenario analysis. The framework describes the transition along two dimensions: policy and private (technology/consumers) support for transition. Each archetype includes details on the following climate risk and opportunity drivers: climate policy, economic and market trends, households' attitude to the transition, technological developments, sectoral trends, and overarching geopolitical conditions. These climate risk and opportunity drivers are then considered along with the irreversible warming that will impact the climate over the next 10 years, regardless of the rate of decarbonisation. The archetypes are detailed in Figure 1.

¹⁹ Short-term NGFS scenarios which aim to address this gap are welcomed.

Figure 1: NatWest's transition risk narratives framework



To translate these narratives into quantitative insights, NatWest partnered with Planetrics²⁰ to develop the necessary modelling capabilities. The modelling framework followed a 4-step process consisting of:

- 1. Scenario pathway construction:** Leveraging scenario narratives to define quantitative climate shocks (e.g., translating the narrative into government policies and timing, such as sector specific carbon prices)
- 2. Estimation of economic shocks:** Translating climate shocks into economic terms (e.g., transforming sector specific carbon prices into changes in sector specific production costs)
- 3. Application of shocks and simulation of economic response:** Modelling the direct and indirect economic responses after the economic shock is introduced into the economy (e.g., modelling direct changes in sector output and resulting indirect (upstream and downstream) demand impacts on linked sectors)
- 4. Estimation of resulting economic impacts:** Modelling the impacts on specific economic sectors and the wider economy, which can be used as inputs into existing credit models (e.g., estimating sectoral GVAs and economy-wide GDP impacts)

²⁰ This analysis has been created by NatWest drawing on selected data provided by Planetrics, a McKinsey & Company solution (which does not include investment advice). This analysis represents NatWest's own selection of applicable scenarios and its own portfolio data. NatWest is solely responsible for such scenario selection, all assumptions underlying such selection, and all resulting findings, and conclusions and decisions. McKinsey & Company is not an investment adviser and has not provided any investment advice.

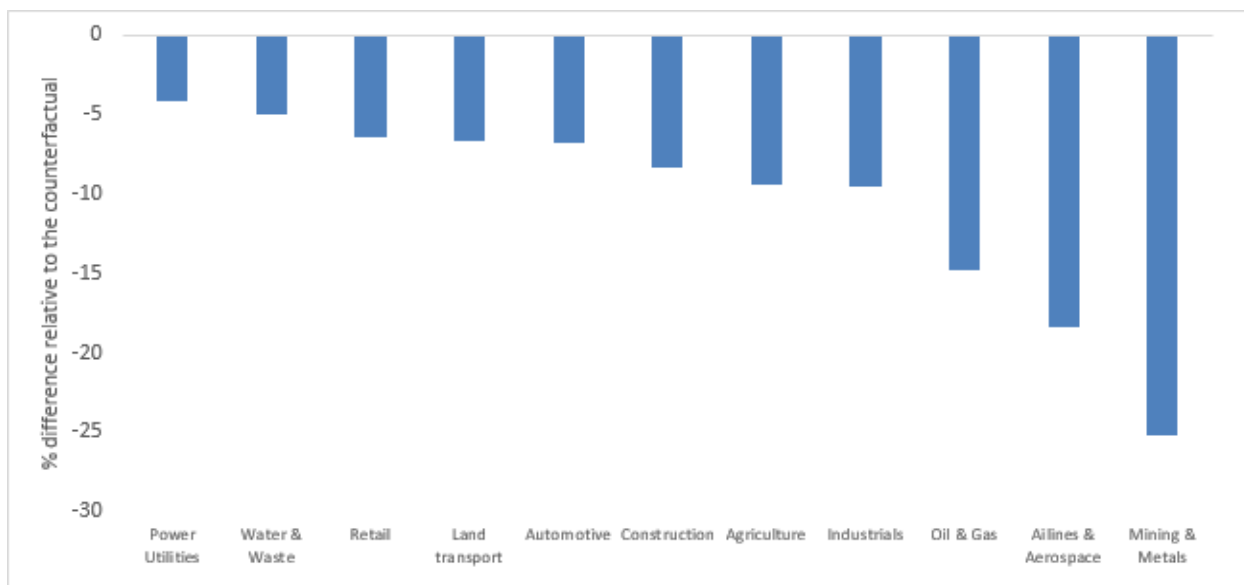
Combining these modelling capabilities with bespoke climate scenario narratives, NatWest assessed the bank's resilience to climate-driven expected (ECL) and unexpected losses (ICAAP).

NatWest estimated the expected contribution of climate transition policy to ECL within the IFRS9 exercise. First, over 100 existing and potential UK climate transition policies were assessed for materiality. Then NatWest individually assessed 46²¹ active and potential transition policies that had a significant impact on the cost of emissions and estimated the policy-specific carbon prices expressed as the cost per tonne of the emissions (CO₂e) abated as a result of each policy. The policy-specific implicit carbon prices were estimated using methods that reflect the different policy mechanisms through which price incentives are delivered, including explicit carbon taxes (UK ETS), implicit carbon taxes (fuel taxes), explicit carbon subsidies (heat pump grants), implicit carbon subsidies (contracts-for-difference) and other carbon price effects (ICE phase-out). The analysis involved calculating the effective cost imposed on emitters by each policy and relating it to the expected emissions reductions the policy would deliver. For example, under the Zero Emission Vehicle (ZEV) mandate, the implicit carbon price reflects the additional cost to consumers relative to the emissions reductions achieved. These policy-specific carbon prices were aggregated to a sector-specific carbon prices and input into NatWest's Climate Risk Macro Model (described above) to estimate an economy-wide and sector-specific base case of transition impacts. According to these estimates, the current climate transition policy contributes £8 million to the total ECL of £3.4 billion at the end of 2024.

For unexpected losses, NatWest estimated impacts from a 'disjointed transition' archetype scenario for use in ICAAP. The customised scenario was constructed by combining insights from the bespoke climate risk scenario narratives (detailed above), and adjusting a scenario developed by United Nations Environment Programme Finance Initiative (UNEP FI) and National Institute of Economic and Social Research (NIESR)²². The scenario was then fed into the Climate Risk Macro Model, which disaggregated headline UK GDP impacts to sector-specific impacts as illustrated in Figure 2. For transition policy impacts, the modelling considered emissions intensity (direct and through the supply chain), cost of abatement, ability to pass cost increases through to consumers, recycling of government carbon tax revenues and demand destruction/demand creation from changes in the energy system. This analysis ultimately supported NatWest better understanding resilience to climate driven financial stress and to further embed climate considerations into NatWest's ICAAP exercise, including using the climate impacts in one of the ICAAP scenarios.

²¹ Number of individually assessed policies was increased to 50 in 2025.

²² [UNEP-FI and NIESR scenarios](#)

Figure 2. Illustrative climate sectoral impacts, ICAAP2 scenario (%)²³

These capabilities increased the decision usefulness of climate scenario analysis by narrowing realism and relevance gaps relative to the existing suite of climate risk scenarios. Next steps to mitigate limitations include:

- **Enhanced quantification** of bespoke climate risk scenario narratives into quantitative climate shocks;
- **Improving granularity** by bringing these bespoke climate scenario capabilities into bottom-up modelling to generate counterparty level insights; and
- **Increasing comprehensiveness** by exploring additional short-term climate scenarios to test resilience to a wider range of potential climate pathways.

S&P – Physical and Transition Climate Risk: Two Sides Of the Same Coin?

S&P assessed the credit ratings of a data centre and an oil & gas platform under climate scenarios. While both showed similar exposure to transition risks, the data centre faced sharper downgrades due to extreme heat, which unlike other hazards imposes continued operational strain and higher recurring costs rather than temporary business interruptions. Financial institutions should give attention to physical risks when evaluating credit risk of asset-heavy sectors. This case study is based upon a wider [S&P publication](#).

²³ This chart shows the sector level climate impacts from the Climate Risk Macro model in NatWest Group's 2024 ICAAP2 scenario. The results are at a UK economy level and do not reflect NatWest Group's portfolio. Sector mapping to NatWest Group sectors is approximate.

Climate risk professionals are often faced with debates and discussions on the increased needs for assessing both physical and transition risk in an integrated manner. The fear of underestimating the financial impact if the risks are assessed individually is often overshadowed by the complexities and uncertainties in conducting a combined analysis.

1. Before a deeper delve into the topic, let's get the facts straight...

Physical risks are environmental events like floods or storms, whereas transition risks arise from changes in policy and new technologies, such as the growth of renewable energy.

These risks have been assessed separately by companies and financial institutions in general, whereby:

- Physical risk is evaluated on real asset exposures and considers the asset's geo-location, asset type and various impact functions associated with hazards these assets may be exposed to.
- On the other hand, transition risk is associated with the risks a company faces in its effort to reduce emissions and related abatement costs as well as carbon taxation amidst changing policies, technological advances, and the industry's price elasticity.

Highlighted by the Task Force on Climate-related Financial Disclosures (TCFD), scenario analysis is useful in assessing, quantifying, and disclosing climate-related risks and opportunities as it evaluates a range of hypothetical outcomes under a given set of assumptions and constraints. To enable comprehensive scenario analysis, several tools and methodologies have been developed over the last three-five years. However, these remain compartmentalized into those that address transition or physical or liability risks, or then more broadly environmental, social and governance (ESG) risks. In other words, these are assessed independently with separate methodologies, benchmarks and climate scenarios developed by the climate science community.

This has also been observed in several of the 40+ climate-related regulatory stress tests conducted by banking regulators to date, with the mortgage or commercial real estate portfolio requiring physical risk assessment, whereas the wholesale banking portfolio requires transition risk assessment.

2. Should physical and transition risks be simultaneously assessed?

The separation of analysis ignores the interaction between the drivers and impacts of transition and physical climate risks. This could potentially lead to larger and underestimated losses for individual companies, financial institutions, and the economy in aggregation.

Financial institutions should therefore consider the interplay of these risks to develop a full view of climate-risk exposure and evaluate the combined effects of different factors. This would enable the financial institution to develop a comprehensive climate strategy. However, this is a complex exercise as there are significant uncertainties in the magnitude and timing of each category of climate-related risks. The ability to look at the combined effects is further limited by data availability, data granularity, breadth of scenarios and quantification methodology.

3. Suggested framework for conducting an integrated climate risk assessment on corporates.

S&P Global have developed an approach that captures the effect of both physical and transition risk on companies in a granular bottom-up manner. S&P Global's solution, Climate Credit Analytics, (CCA), developed in collaboration with Oliver Wyman, provides a framework that captures integrated climate risks in a consistent, intuitive and detailed manner.

One can access a wide range of scenarios to evaluate possible climate pathways, with options for:

- Time horizons out to 2050.
- Multiple temperature targets and transition pathways, including the NGFS scenarios.
- Customization of carbon pricing levels.
- Technology transition opportunities

CCA enables comprehensive analysis for all non-financial sectors via a bottom-up approach with six distinct industry models:

- Oil & Gas
- Metals & Mining
- Power Generation
- Automotive Manufacturing
- Airlines
- Emissions-based (Generalized) approach for all other non-financial sectors

Credit scores can be generated for more than 2.2 million public and private companies that have sufficient company financial and industry data to enable bottom-up modelling. In addition, CCA provides an extrapolation module within each model to project likely impacts for companies missing the required financial data, but with some baseline credit risk information.

4. Case in example:

Using Climate Credit Analytics, you would note in Table 1 below how the interplay between physical and transition risk can affect a company that owns data centres in a significantly different manner, during the projected period, to a large oil and gas producer.

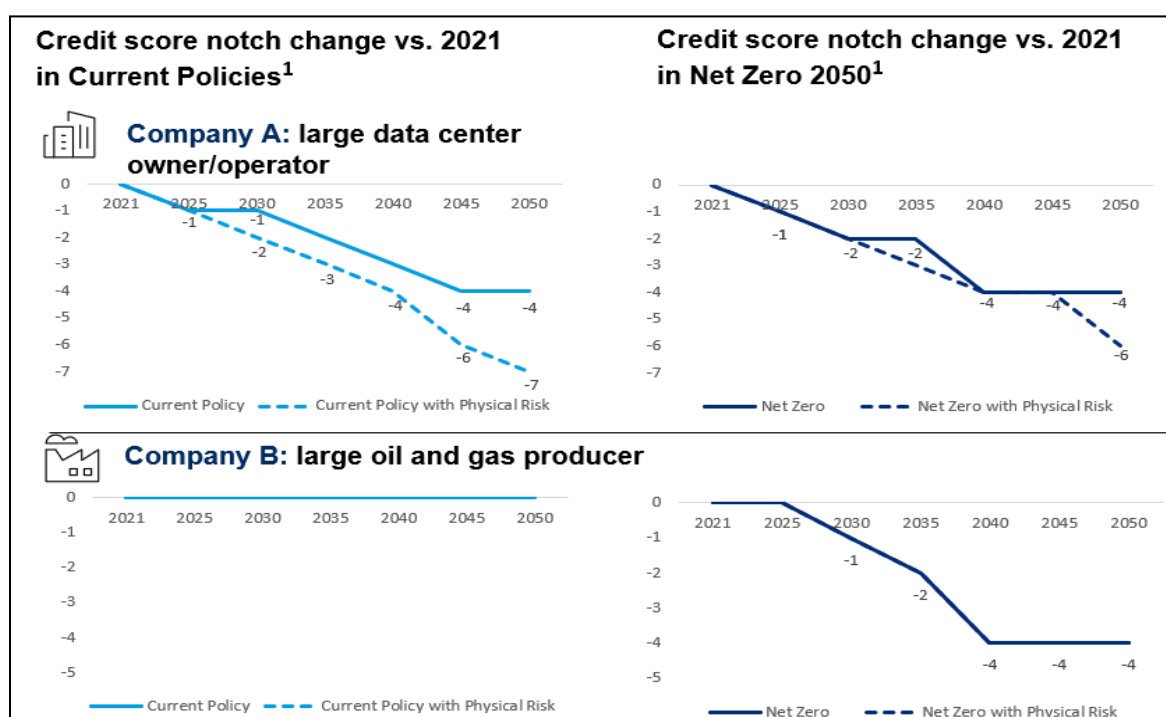
Company A

- **Asset Value:** Most of the company's assets are data centre buildings, the large amount of net Plant, Property & equipment ("PP&E") compared with revenue and total asset leads to higher overall exposure to physical risk.
- **Asset Type:** Data centres have high exposure to physical risk from extreme heat since they tend to have a higher HVAC (Heating, Ventilation, and Air Conditioning) ratio compared with other asset types, given the cooling requirement for safe operating temperature.
- **Industry:** Since extreme heat has continued impacts on data centre operations (i.e., high costs such as electricity for cooling are spent on a regular basis), the incremental impact increases over time and has a larger effect in the Current Policies¹ scenario.

Company B

- Asset Type, Asset Location: Most of the company's PP&E are onshore and offshore oil and gas platforms, which have limited exposure to various hazards include wildfire, floods, drought, and extreme heat.
- Industry: Although oil and gas platforms tend to have large exposure to tropical cyclones, tropical cyclone events are projected to be relatively stable over time with no significant incremental impact. Unlike extreme heat which has a continued impact, tropical cyclones cause temporary business interruption/repair costs that even out to smaller impact on average in each year. Thus, the company has no incremental downgrade compared with the “transition risk only” case.

Table 1: Impacts of Physical and Transition Risks on Different Sectors



For illustrative purposes only, using Climate Credit Analytics. Source: S&P Global and Oliver Wyman, as of September 2023

5. Selected scenarios

The analysis utilizes scenarios published by the Network for Greening the Financial System²⁴ (NGFS) which included three integrated assessment models that highlight the climate-related transition opportunities and risks faced by firms through a holistic lens. These quantitative models link social and economic factors (such as population growth and energy demand) with climate and environmental factors (such as CO₂ concentrations and global temperatures) within one modelling framework. For this case study, S&P Global elected REMIND, one of the three IAMs.

²⁴ <https://www.ngfs.net/ngfs-scenarios-portal/>

REMIND: The REMIND-MAgPIE model is maintained by the Potsdam Institut für Klimafolgenforschung (PIK). REMIND is a global multi-regional model incorporating the economy, the climate system, and a detailed representation of the energy sector. It allows the analysis of technology options and policy proposals for climate mitigation, and models regional energy investments and interregional trade in goods, energy carriers and emissions allowances. MAgPIE is a global land use allocation model. MAgPIE derives future projections of spatial land use patterns, yields and regional costs of agricultural production.

The physical risk financial impact (%) uses catastrophe models based on future climate change scenarios based on Intergovernmental Panel on Climate Change's ("IPCC") Representative Concentration Pathways (RCP) and Shared Socioeconomic Pathways ("SSP"), informed by the technical guidelines from the Task Force on Climate-related Financial Disclosures .

A mapping exercise by S&P Global has been conducted in order to use the best outcomes associated with both transition risk and physical risk scenarios in an integrated framework within the model.

For the purpose of the case study, the following scenarios were considered.

Scenario	Description	Mapped to IPCC
Current Policies	Hot house world	Medium-High
	A scenario in which only currently implemented policies are preserved	(SSP3-7.0 - End of century temperature increase, 2.8-4.6°C)
Net Zero 2050	Orderly	Low
	A scenario that limits warming to 1.5°C through rigorous climate policies and innovation, reaching global net zero CO ₂ emissions by 2050	(SSP1-2.6 - End of century temperature increase, 1.3-2.4°C)

6. Sector specific analysis

Transition pathways differ significantly across sectors and jurisdictions. For example, power generation as a sector has been the fastest to decarbonise and there are several renewable energy assets that utilities companies own today. However, being asset heavy, these companies may be affected if their assets are situated in locations exposed to various physical risks' hazards.

The analysis utilises tailored analysis on 'hard-to-abate' sectors, examining various sector-specific characteristics that can evolve due to energy transition technologies, as well as physical asset risk. Equally, for other sectors, the approach examines aspects such as the emissions of the business activities and impact of climate on the asset type associated with these sectors.

In the case study, Company B is from the 'hard-to-abate' oil and gas industry, while Company A is not from the typical 'hard to abate' sectors, but has an asset-heavy business model.

7. Quantifying the financial impact

The analysis begins by translating climate scenarios, sector-specific parameters, and market dynamics into drivers of financial performance tailored to each industry.

The models translate these performance drivers into changes to a company's financial statements based on expectations of how industry dynamics will impact price, volumes, cost, capital expenditures, and asset values. Income statement, balance sheet, and cash flow statement line items are estimated individually to provide a comprehensive view of how a given company's financial performance is likely to change.

It then draws on a statistical suite of credit models by S&P Global Market Intelligence that adopt a fundamentals-driven view providing a company-specific credit score assessment²⁵.

Companies with strong financials may be less affected by physical risk since they are able to absorb the additional physical risk costs and their ability to transition may also be relatively faster.

²⁵ S&P Global Ratings does not contribute to or participate in the creation of credit scores generated by S&P Global Market Intelligence. Lowercase nomenclature is used to differentiate S&P Global Market Intelligence credit model scores from the credit ratings issued by S&P Global Ratings.

University of Oxford – Impact of Physical Climate Risks on Sovereign Credit Ratings

Climate shocks could drive sovereign downgrades of up to 4 notches, but adaptation investment with strong benefit-cost ratios can materially reduce losses. Financial institutions should factor both climate risk and national adaptation capacity into sovereign credit risk assessment to estimate credit deterioration, manage portfolio risks and identify resilience-linked opportunities. This case study is based upon a wider [University of Oxford publication](#).

1. Introduction

The increasing frequency and severity of climate-related events pose significant threats to government finances and sovereign creditworthiness across the globe. Rising global temperatures and extreme weather events are putting strain on government finances, potentially increasing debt levels for climate-vulnerable countries. This research, conducted by scholars from the University of Oxford and University of Sheffield as part of the UK PACT project "Greening Thailand's Financial System" and the Oxford Martin Systemic Resilience Initiative, examines how physical climate risks and adaptation affect sovereign credit ratings. Previous research has found that climate-induced sovereign downgrades could affect nearly 60 countries by 2030, highlighting the urgency of addressing these risks. The authors argue that climate-vulnerable developing countries could fall into an "adaptation investment trap" where rising climate impacts and debt reinforce each other, creating a vicious cycle. This study introduces a methodology based on insurance catastrophe risk modelling approaches to quantify these impacts, using Thailand as a case study. The research demonstrates that the potential impacts on sovereign credit ratings are significant, but importantly, these impacts can be largely offset through strategic adaptation investments.

2. Thailand's climate vulnerability context

Thailand represents a compelling case study for examining climate risk impacts on sovereign creditworthiness due to its significant exposure to flooding and its economic importance in Southeast Asia. The country has a debt-to-GDP ratio exceeding 60%, with over half of government bonds held by banks, insurers, and contractual funds, creating potential systemic vulnerabilities in the financial system. Thailand ranks among the most flood-exposed countries globally, as dramatically demonstrated by the catastrophic 2011 flood that caused over \$45 billion in economic damages. Despite its devastating impact, the 2011 flood was not considered climatologically rare, with an estimated return period of just 10-30 years. Climate change is expected to increase flooding intensity in Thailand, making similar or worse events more likely in the future as precipitation patterns shift and intensify. The combination of high flood exposure, significant government debt, and the concentration of bond holdings in financial institutions creates a concerning scenario for Thailand's fiscal stability under climate change.

3. Detailed scenarios

The research considers 5 different combinations of climate and adaptation scenarios, focused on acute climate shocks (see Table 1). For climate, it considers three scenarios: a baseline scenario that represents the historical distribution of flood risk, and two future (2075) scenarios – one representing a low emissions (SSP126) trajectory and one representing a high emissions (SSP585) trajectory. It also considers two adaptation scenarios. The first is an existing adaptation scenario, where it assumes current river flood protection levels (see Figure 3). Existing flood protection levels at the province level are taken from Scussolini et al. (2016)²⁶. These show an average level of return-period flood protection across the 76 Thai provinces of ~18 years, with the highest level of protection (50 years) in Bangkok Metropolitan Region. The second adaptation scenario is an additional adaptation scenario where it assumes that all suburban areas in Thailand will increase river protection levels to protect against a 100-year return period flood. The cost of the additional adaptation scenario is calculated following the approach described in Tanoue et al. (2021)²⁷, which relates the increase in return-period protection and the river length to be protected to a cost of protection. The analysis finds that this additional adaptation scenario would cost \$55 billion. It only considers the additional adaptation scenario in combination with the future scenarios, assuming it will take several decades for these measures to be implemented.

Table 1. Climate and adaptation scenarios

Climate Scenario	Adaptation Scenario	Symbol
Baseline (Historical)	Existing Adaptation	B
Future Low Emission	Existing Adaptation	FL
Future High Emission	Existing Adaptation	FH
Future Low Emission	Additional Adaptation	FLA
Future High Emission	Additional Adaptation	FHA

4. Methodology

The research methodology builds upon insurance catastrophe risk modelling approaches to quantify climate impacts on Thailand's sovereign creditworthiness. This approach incorporates detailed hazard, exposure, and vulnerability data specific to Thailand's flooding risks. The researchers developed a framework that links physical climate impacts to macroeconomic outcomes and ultimately to sovereign credit rating implications. The methodology accounts for both direct damages to physical capital and indirect economic impacts through disruptions to economic activity.

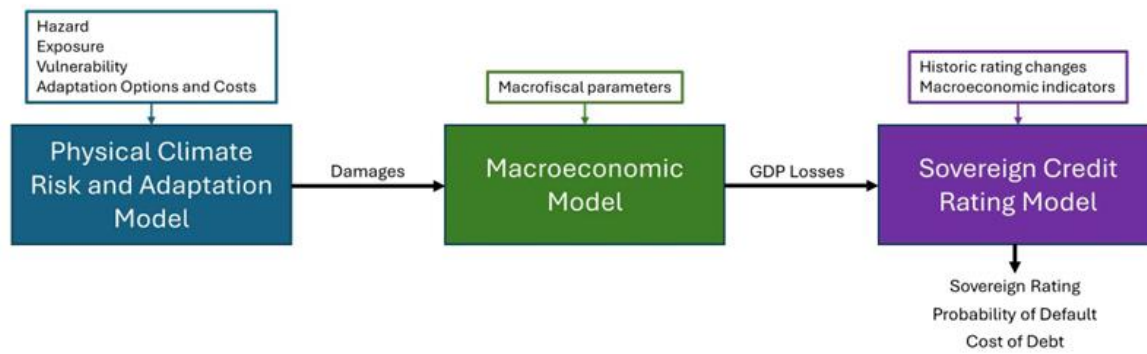
A key enhancement in this research is the explicit modelling of adaptation measures and their benefits. The researchers quantify adaptation effectiveness using a cost-benefit framework that accounts for both the upfront investment costs and the stream of future benefits in terms of avoided losses. Adaptation measures are modelled to reduce both the probability and severity

²⁶ European Geosciences Union <https://nhess.copernicus.org/articles/16/1049/2016/>

²⁷ Nature Climate Change <https://www.nature.com/articles/s41558-021-01158-8>

of damages from extreme events, with effectiveness parameters based on previous academic studies.

Figure 4. Modelling framework for estimating the impact of acute climate risk and adaptation on sovereign credit ratings.

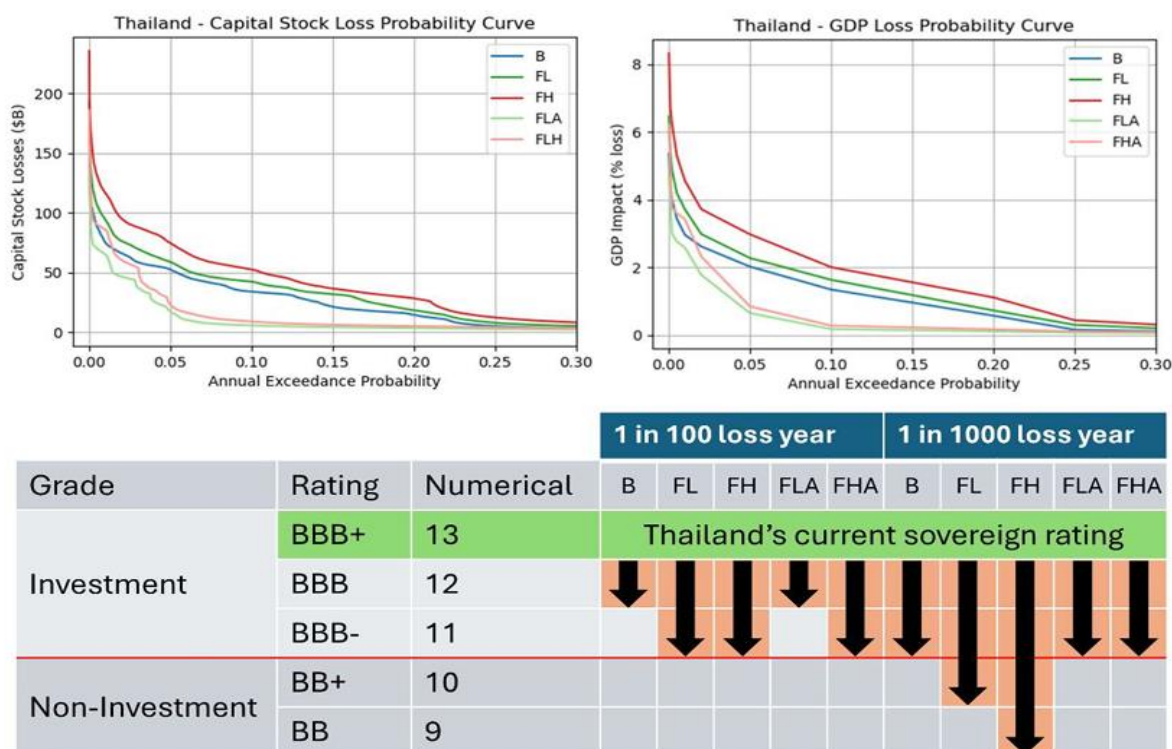


5. Case study results

The scenario analysis for Thailand reveals significant potential impacts on sovereign credit ratings from climate-induced flooding events. The research shows that flooding could lead to sovereign downgrades of up to 4 notches in extreme scenarios, specifically in a 1 in 1000-year future flooding scenario. This represents a substantial increase in sovereign risk compared with previous estimates that did not account for acute climate risk (Klusak et al, 2023)²⁸ and would translate to significantly higher borrowing costs.

²⁸ PubsOnLine <https://pubsonline.informs.org/doi/10.1287/mnsc.2023.4869>

Figure 5. Results from our climate risk and adaptation modelling. (top left) Capital stock loss-probability curve for the five scenarios (B=baseline, FL=future low emission, FH=future high emission, FLA=future low emission with additional adaptation, FHA=future high emission with additional adaptation). (top right) GDP loss-probability curve for the five scenarios. (bottom) Sovereign credit rating impacts for the 100-year flood and 1000-year flood across the five scenarios (BBB+ is Thailand's current sovereign credit rating)



However, the analysis also demonstrates that national-scale flood adaptation investments could substantially mitigate these impacts. In quantitative terms, a \$55 billion adaptation investment in Thailand could reduce average annual capital stock losses by up to \$9.5 billion (64% decrease) and lead to avoided losses of up to \$30 billion and \$48 billion for a 100-year and 1000-year flood, respectively.

The probability of Thailand's rating falling below the investment grade threshold over a 10-year period (the timeframe over which many fiscal decisions are made) is reduced from over 6% in a future high emission scenario to under 1% with additional adaptation.

When making the business case for adaptation investments, governments could include the avoided increased cost of debt as an additional benefit of adaptation. For example, the analysis shows that in the event of a 1000-year return period flood event occurring, adaptation investments that reduce a four-notch downgrade to a two-notch downgrade could prevent increases in annual interest payments of over \$2.3 billion. Incorporating these results into a cost-benefit analysis show that adaptation investments are cost-effective across all scenarios. Benefit-cost ratios range from 1.27 to 1.59 for the low emission and high emission scenario, respectively.

6. *Implications and conclusions*

The research demonstrates that physical climate risks pose significant threats to sovereign creditworthiness. However, the findings also provide a hopeful message that appropriate adaptation investments can substantially mitigate these risks. The case study of Thailand shows that flooding could lead to sovereign downgrades of up to 4 notches in extreme scenarios, but adaptation investments could reduce these impacts by up to 2 notches while delivering positive economic returns. These findings have important implications for financial institutions, investors, and the private sector. Financial institutions should incorporate climate-related risks to sovereign bond assets in stress testing and scenario analyses to identify potential vulnerabilities in their portfolios. Investors need to consider both physical climate risks and adaptation efforts when evaluating sovereign debt, as these factors will increasingly influence creditworthiness and returns. The research ultimately suggests that breaking the "adaptation investment trap" requires coordinated action across the private financial sector to ensure that climate-vulnerable countries maintain access to affordable financing for resilience building.