This is the way…or is it?

The impact of climate scenario choice on stress-test outcomes across 5 climate scenarios

1 IN 1000

THEIA FINANCE LABS

OXFORD SUSTAINABLE FINANCE GROUP

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***Declaration of Interests: Jakob Thomä is Research Director at Theia Finance Labs and Project Director of the Inevitable Policy Response Programme. Jakob had no involvement or input on the model calibration for this project or any key messages related to the IPR scenario. The report does not provide recommendations for the use of one or the other scenario. IPR was not used as a reference scenario in the analysis to avoid any perceived or real conflicts of interest.**

About 1in1000

1in1000 is research collaboration between Oxford Sustainable Finance Initiative and Theia Finance Labs (Formerly 2° Investing Initiative Germany) that brings together new & existing research projects on long-termism, climate change, and (inter-)connected future risks for financial markets, the economy, and society. Its objective is to develop evidence, design tools, and build capacity to help financial institutions and supervisors to mitigate and adapt to future risks and challenges. The programme focuses on climate change (inter-) connected risks and challenges, notably risks stemming from ecosystem services, as well as risks from social cohesion and resilience.

About Theia Finance Labs

Theia Finance Labs (formerly 2° Investing Initiative Germany) is an independent, non-profit think tank incubating research solutions for the financial sector that help solve the climate crisis. The Theia Finance Labs name is inspired by the Greek goddess of sight, the light of the blue sky, and the value of gold, Theia, and by the Greek word Aletheia, which means "disclosure" or "truth", literally "the state of not being hidden". The new brand thus mirrors our goal to develop evidence-based research and tools that shed light on the intersection of finance, climate change, and long-term risks. Theia operates as a 100% non-profit organization.

INTRODUCTION

The choice of scenarios in climate stress-test are generally recognized to be a key determinant of the outcomes of stress-test models

Climate scenario variables are the 'value drivers' that determine the production profiles of products and services and the evolution of both regulatory and market costs and prices. In light of the importance of scenarios, the Network for Greening the Financial System (NGFS) has selected a set of discrete scenarios designed to form the basis of their climate scenario and stress-test exercises.

Despite their prominence of climate scenarios, there is little to no work done to date on the exact impacts of the scenario choices on stress-test outcomes and the correlation between them.

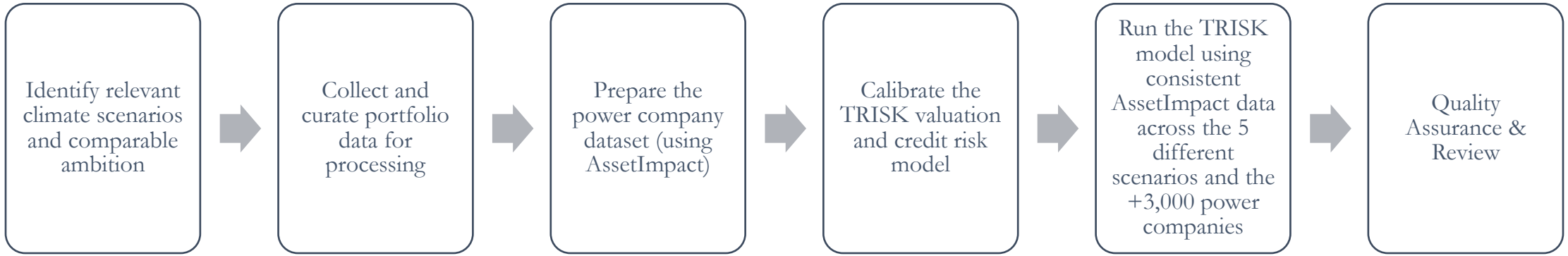
While it is intuitive to consider scenario choices important in stress-test design, the lack of analysis on the degree of importance makes it hard to gauge the overall materiality of these choices. Such analysis is of course complicated by the fact that scenarios are not the only critical choice in stress-test design.

This note is the first public exercise analyzing the comparability between stress-test model outcomes using different scenarios, with a focus on the power sector.

Using a consistent model and consistent environmental / climate data input for a universe of 3,646 companies in the power sector across two NGFS scenarios (GCAM, REMIND) and three significant other scenario providers (Inevitable Policy Response, International Energy Agency, Institute for New Economic Thinking/Oxford), the note allows users to understand both the relative impact of different scenarios on outcomes and the correlation between them. Given the extreme outliers identified in the MESSAGE scenario, it was not included in this round of analysis, but will be further analyzed at a later date.

The note provides the key findings and quantitative result in a short slide deck format and will be complemented by a more in-depth research paper to be published by Q4 2023.

Approach of the analysis



Summary of key findings

FINDING #1: Scenarios with similar ambition levels may yield significantly different financial impacts.

FINDING #2: At firm level, there is limited comparability between different scenarios in terms of financial impacts.

FINDING #3: Even when filtering those companies that have a negative shock across scenarios, the overall shock levels can be dramatically different.

FINDING #4: Similar to other providers, the NGFS scenarios also show large differences, suggesting only limited comparability between NGFS scenarios and thus the ability for NGFS scenarios to create 'standardized' outcomes.

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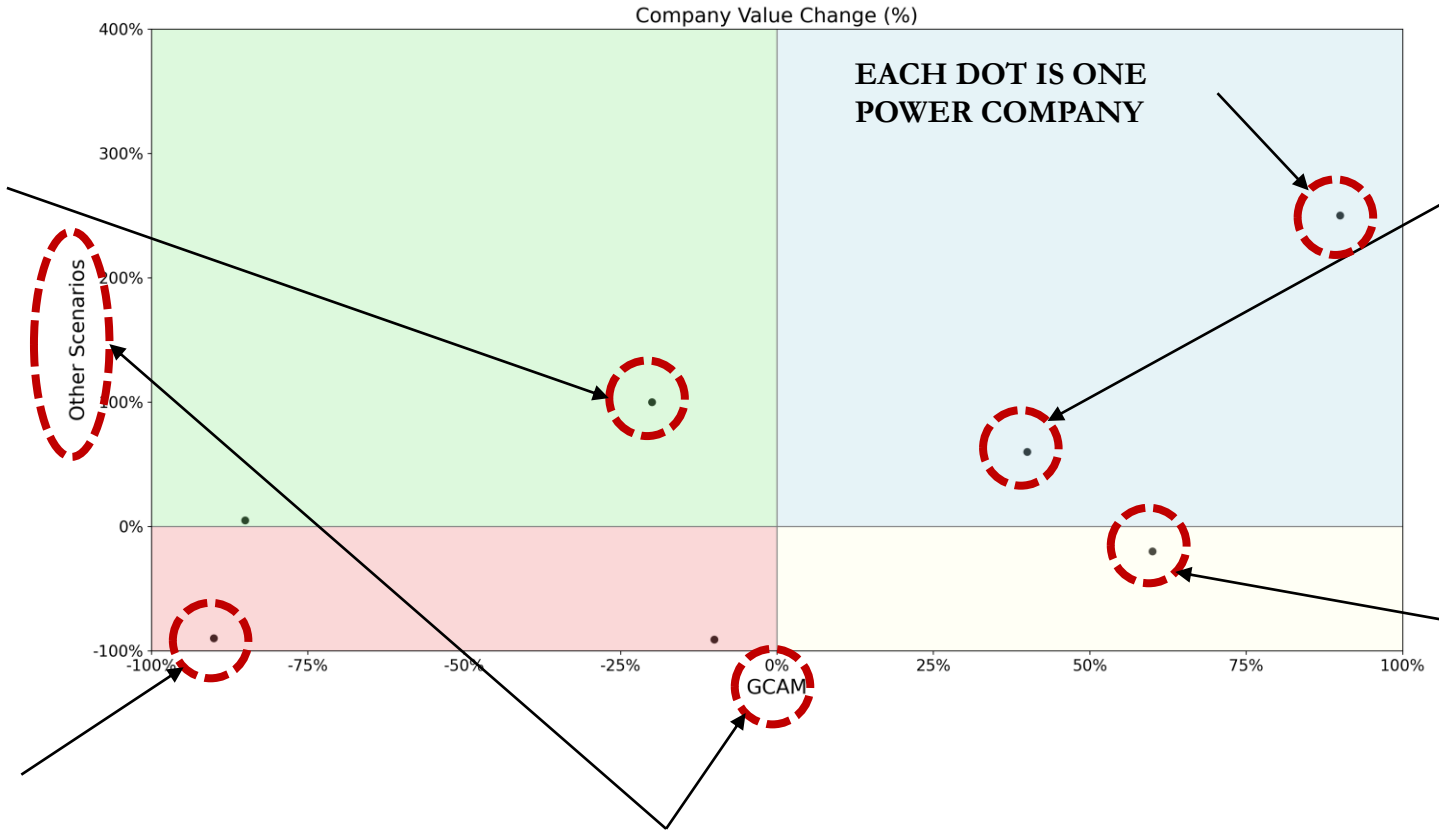
Explanatory chart to help readers follow and interpret the visuals in this note

The charts are provided for both valuation and PD losses. Note that for PD losses the charts reflect the change in probability of default and thus increased values suggest higher default probabilities (inverse to valuation shocks).

EACH DOT REPRESENTS THE FINANCIAL IMPACT OF THE CLIMATE SCENARIO ON AN INDIVIDUAL COMPANY USING THE TRISK MODEL – GCAM SCENARIO (X-AXIS) AND T-RISK MODEL – OTHER SCENARIO (Y-AXIS)

This company has a negative valuation shock in the stress-test model using the GCAM scenario and a positive shock in the stress-test model for another scenario.



This company has a positive valuation shock across both scenario inputs.

This company has a negative valuation shock across both scenarios.

This company has a positive valuation shock in GCAM and negative in another scenario. This demonstrates that the "sign" of the difference between scenarios is not constant.

The note uses a NGFS scenario (GCAM) so as to have a consistent reference point and for ease of reading. The long-form report will provide findings across all scenarios. The Y-Axis then compares the losses for the GCAM scenario to another scenario.

Quick note on methodology

The analysis is based on a universe of 3,646 power companies globally. Data for the power companies is provided by AssetImpact. The stress-test model used is the 1in1000 T-Risk model. Further information on the methodology can be found at www.1in1000.com.

We integrate a variety of scenarios with the same overall target of below 2°C from four different scenario providers – the Network for Greening the Financial System (NGFS), the International Energy Agency (IEA), the Inevitable Policy Response (IPR) and the Institute For New Economic Thinking (INET) at the University of Oxford – into one consistent climate transition stress testing framework 'TRISK' developed by Baer et al. (2022), hosted and maintained by the 1in1000 Initiative. We show the difference in financial market risk – transition-related changes in the net present valuation (NPV) - and credit risk – transition related changes in the probability of default (PD) - for a set of global energy firms in the power sector across above-mentioned scenarios. Importantly, in our exercise we keep constant all other TRISK model assumptions, to isolate the effect of the different scenario pathways. This exercise closely follows academic work by Gasparini et al. (2022), which outlines more in detail the analysis undertaken and provides an overview of the qualitative and quantitative differences across the scenarios used to help interpretability of our results.

The way in which the TRISK model is constructed allows to simulate a tail event affecting the valuation and probability of defaults of energy companies. In the model, some climate-adjusted economic parameters affect the physical production of firms, induce additional costs, and shift market shares according to the alignment of firms with decarbonisation pathways. This alters the firms' cost structure and production mix across technologies and business units (e.g., electricity produced from solar or coal power plants) and impacts their income and profitability. Asset and firm-level impacts are translated into equity valuation changes, through a discounted cash flow model and subsequently into a time-horizon adjusted Merton credit risk framework. The model takes into consideration the comparative advantage of firms throughout the transition based on stipulated forward-looking production plans and scenarios around demand and unit cost developments. We use this model to neutralise the methodological differences and focus on the scale of climate uncertainty. For a more comprehensive review of the TRISK methodology refer to Baer et al. (2022).

We focus on one key scenario variable which is the input of the TRISK model: the production decarbonisation trajectories per energy generation technology that is required in each scenario to achieve their respective climate mitigation outcomes. Loosely speaking, we analyse the impact of transition risk for each of the firms under different scenario assumptions around the associated speed and level of disruption created in the global energy mix, together with different manifestations of the evolution of energy technology costs that impact the market share and cost structure of the analysed firms. Our analysis focuses on four scenarios, namely the IEA's Sustainable Development Scenario (IEA), the NGFS Beyond 2 Degrees Scenario (NGFS), IPR Forecast Policy Scenario, and INET's Fast Transition scenario (INET). These scenarios, although all with a similar level of ambition, depict significant variation in how the energy mix is changing in the transition .For instance, the speed of technological innovation is an important driver around the deployment of renewable energy and the scale of disruption across the energy system. Some studies highlight how a faster drop in the cost of renewable energy might lead to a faster uptake of renewables in the near future (Way et al., 2021). Importantly, some energy scenarios by the IEA do not properly account for these issues and have failed to realistically forecast the speed of renewable energy technology advance (Farmer et al. 2015).

To facilitate a more convenient comparison among the scenarios, we have opted to visually represent the GCAM scenario alongside with each of the remaining scenarios in this note.

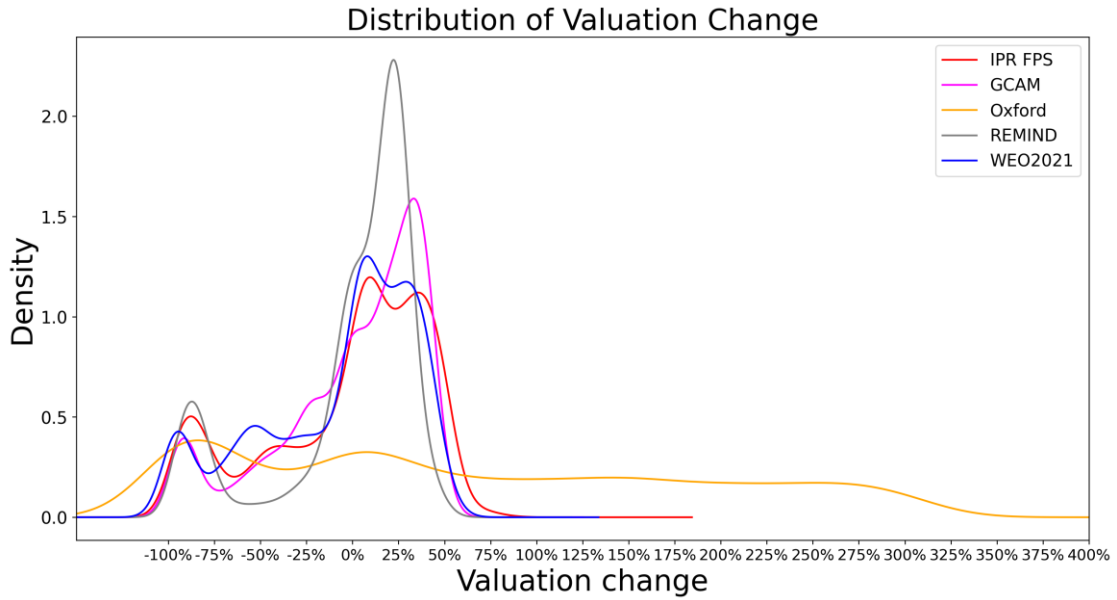
FINDING #1: Scenarios with similar ambition levels may yield significantly different financial impacts

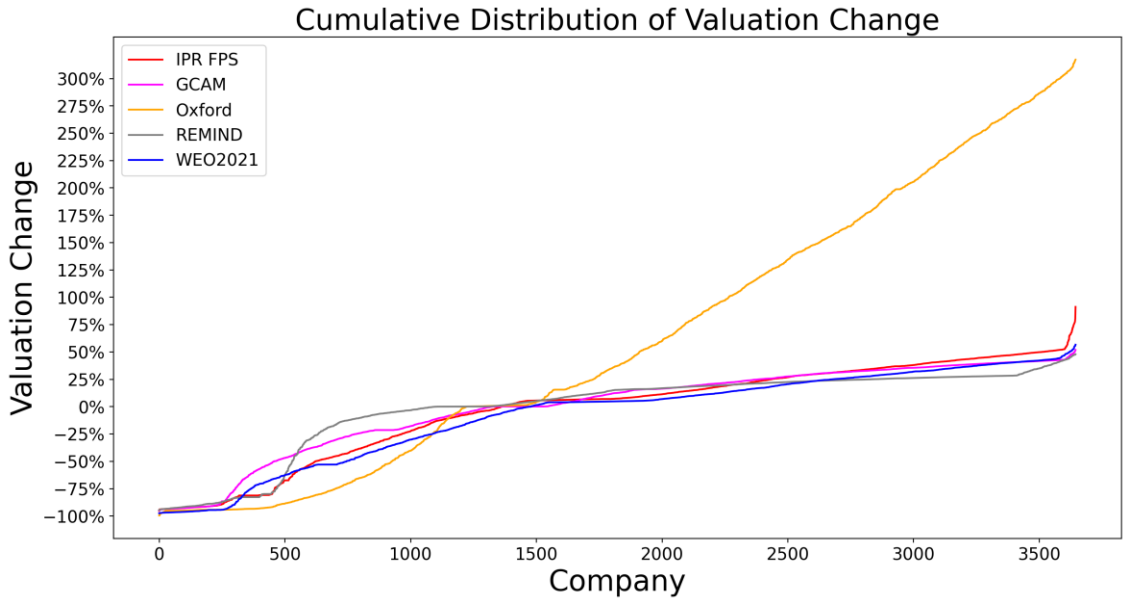
Key Finding #1: Scenarios with similar ambition levels may yield significantly different financial impacts

The figure below highlights the distribution of companies' value change across six scenarios.

The Oxford scenarios demonstrate both significantly higher down- and upside for power companies and the REMIND scenario the lowest. Whereas around 1,000 companies lose more than 20% of their value in the Oxford scenario, that number is around 500 for REMIND. One possible explanation for this outlier is the fact that the Oxford model is not a General Equilibrium Model. The analysis highlights the potential significant ramifications of scenario choice by financial supervisors. It also highlights the small but meaningful number of "winners" from the transition. Given the impact of forward-looking production and capex plans in the T-RISK model, these winners are concentrated among companies driving the transition.

The second chart on distribution further highlights the dramatic differences where in the distribution companies may sit and the "two peaks" reality of climate scenarios across "no / limited impact" and "high impact", reinforcing the non-linearity and non-normal distribution of climate losses.





FINDING #2: At firm level, there is limited comparability between different scenarios in terms of financial impacts

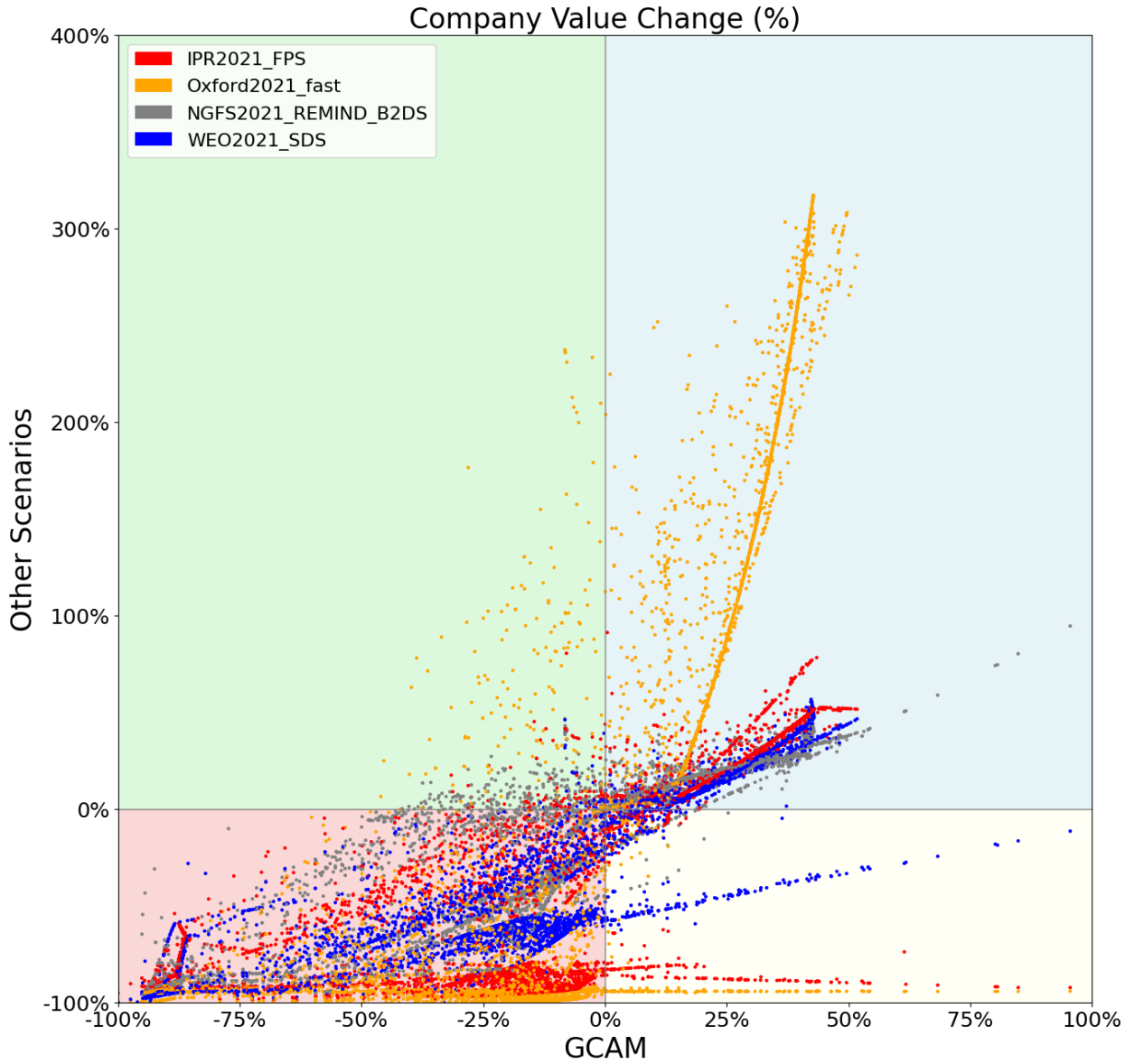
Key Finding #2: At firm level, there is limited comparability between different scenarios in terms of financial impacts

Companies find themselves in dramatically different positions on the distribution

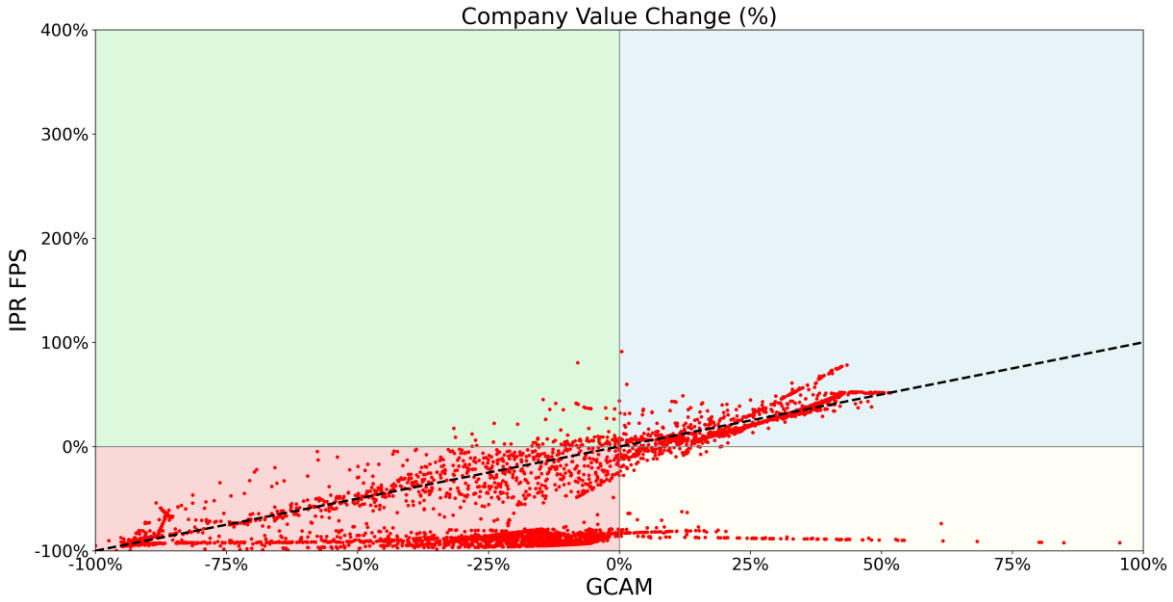
More than 10% of companies have scenario outcomes "with the wrong sign", in other words where one scenario makes them a scenario "winner" and another a scenario "loser" (see the chart on right). In a handful of cases, this is so dramatic that one scenario suggests they will lose almost 100% of their value and another suggests they will nearly double their value.

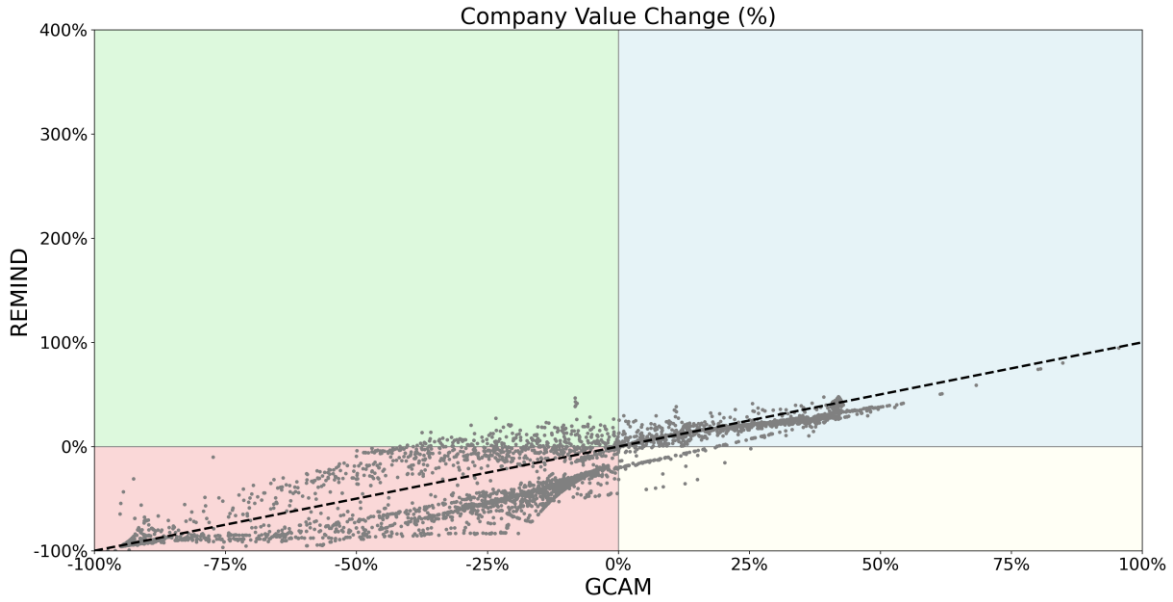
Of course, the actual company profile is consistent, but key choices about the winning technologies and the production decarbonisation trajectories per energy generation technology (renewables, hydropower, nuclear power) across the scenarios dramatically changes the picture.

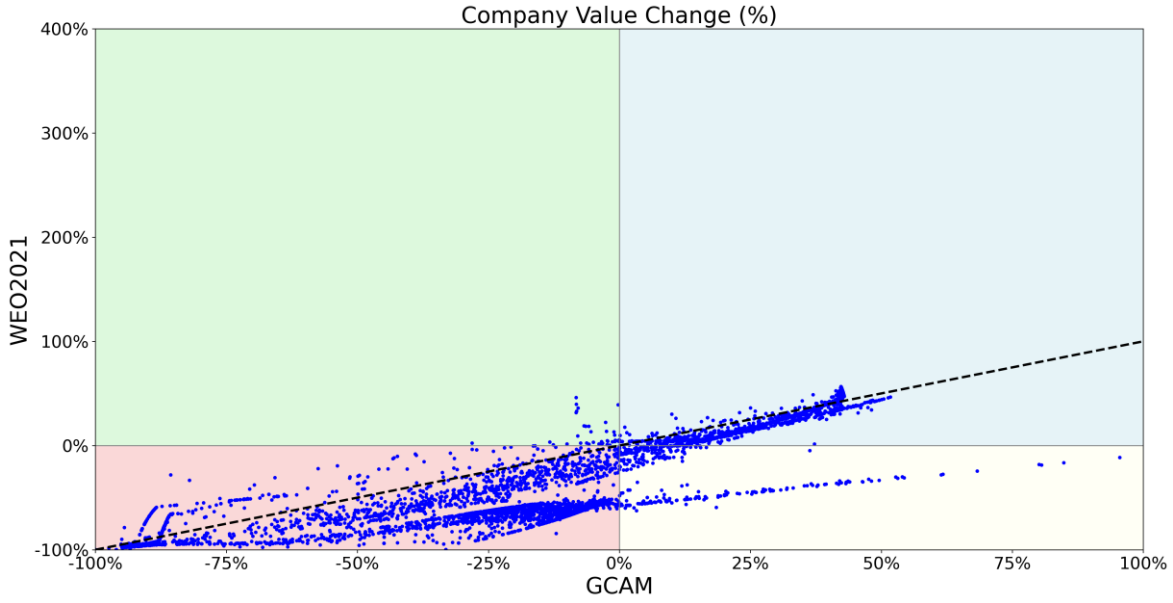
The upcoming research report will explore the core drivers behind these differences across scenarios in further detail. Preliminary analysis suggests that differences in the carbon budget allocation across sectors, slight differences in overall ambition in terms of the role of negative emissions technologies and aggregate carbon budgets, as well as assumptions around price and exact production pathways and the slope of these curves all contribute to this result. However, this is not always clear and one-directional.

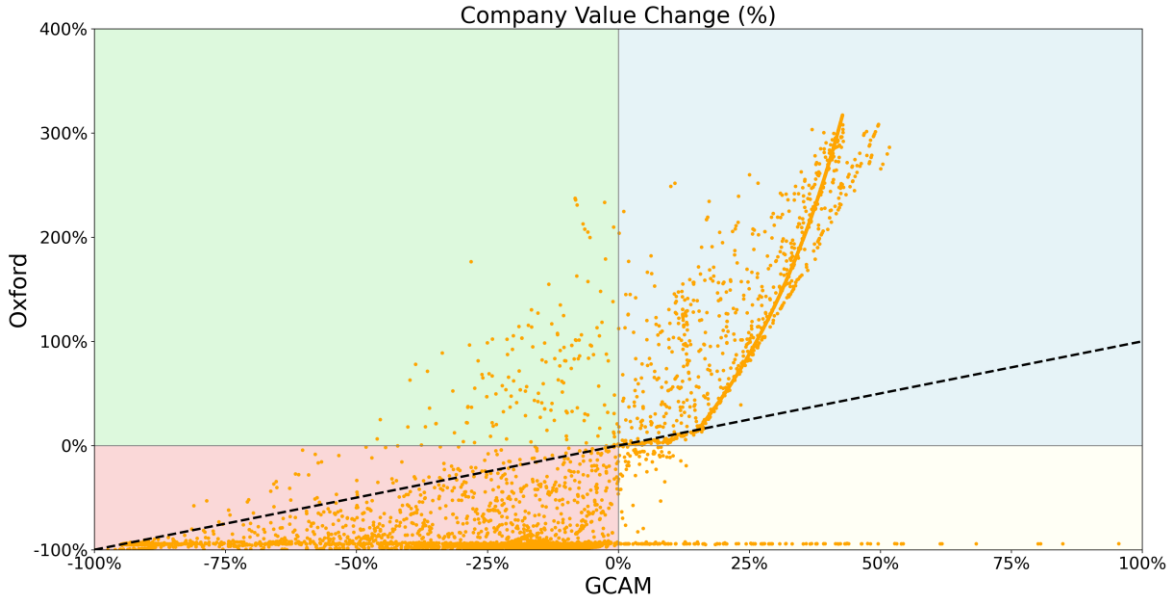


Breakdown by scenario – Valuation losses

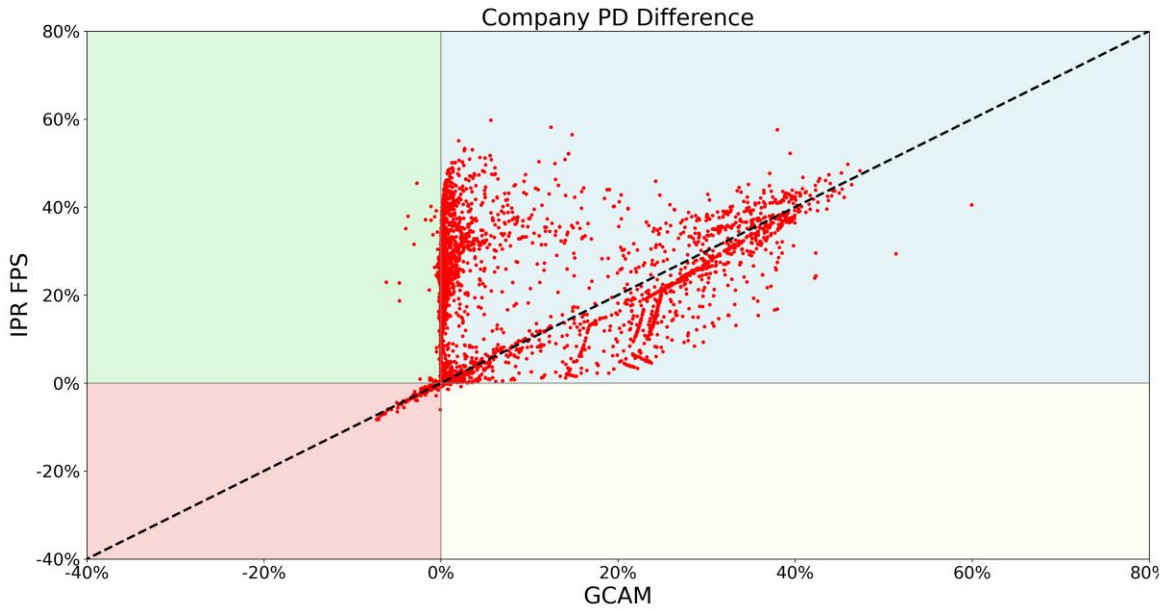


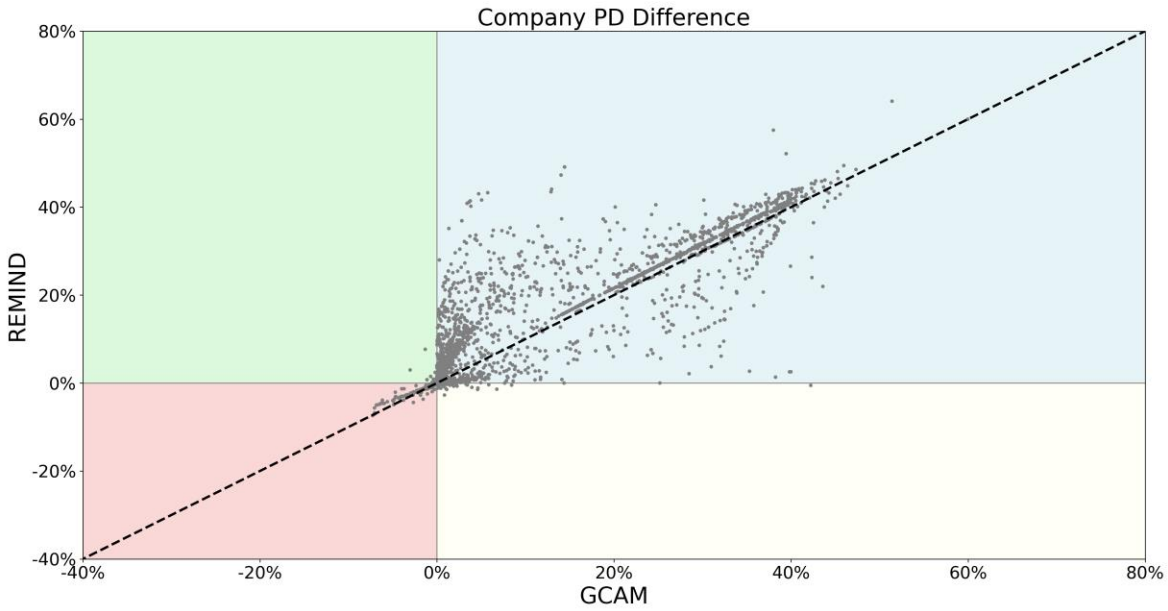


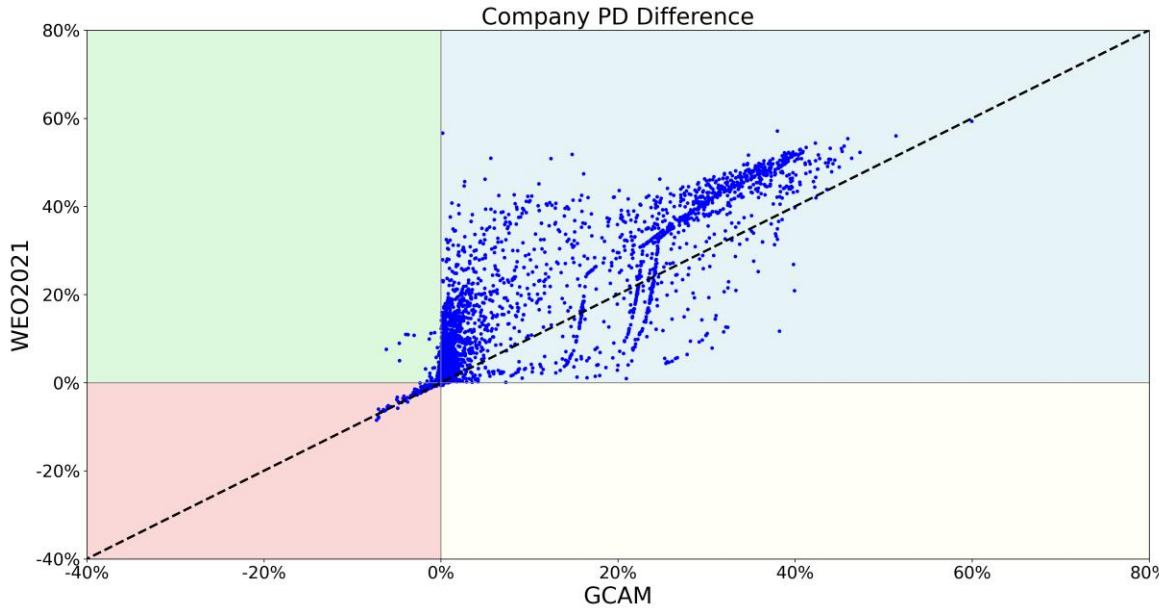


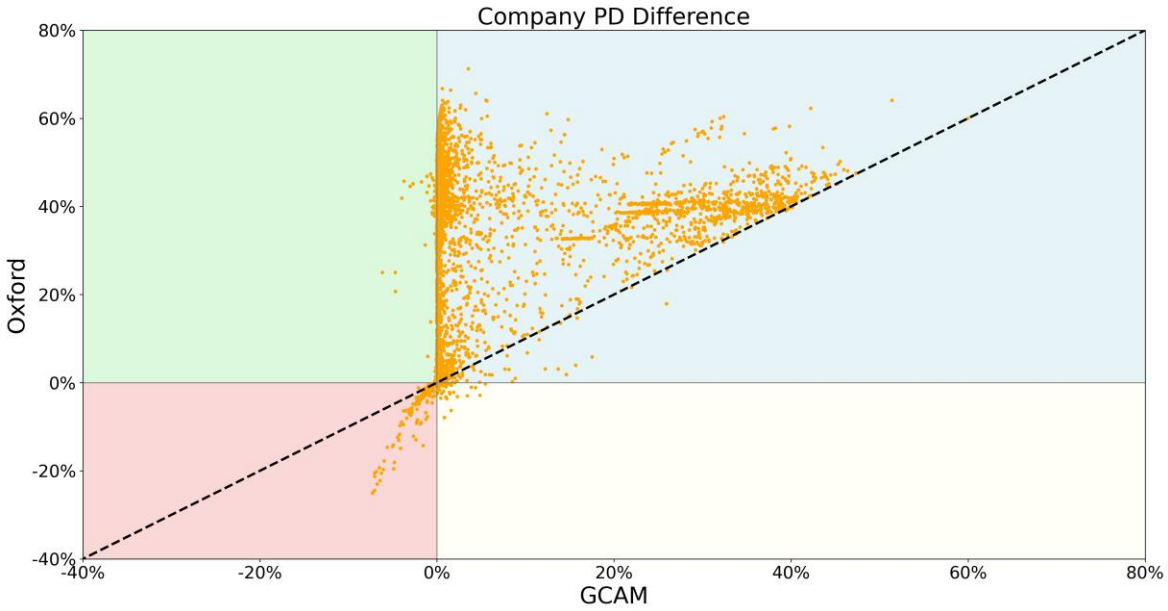


Breakdown by scenario – PD changes









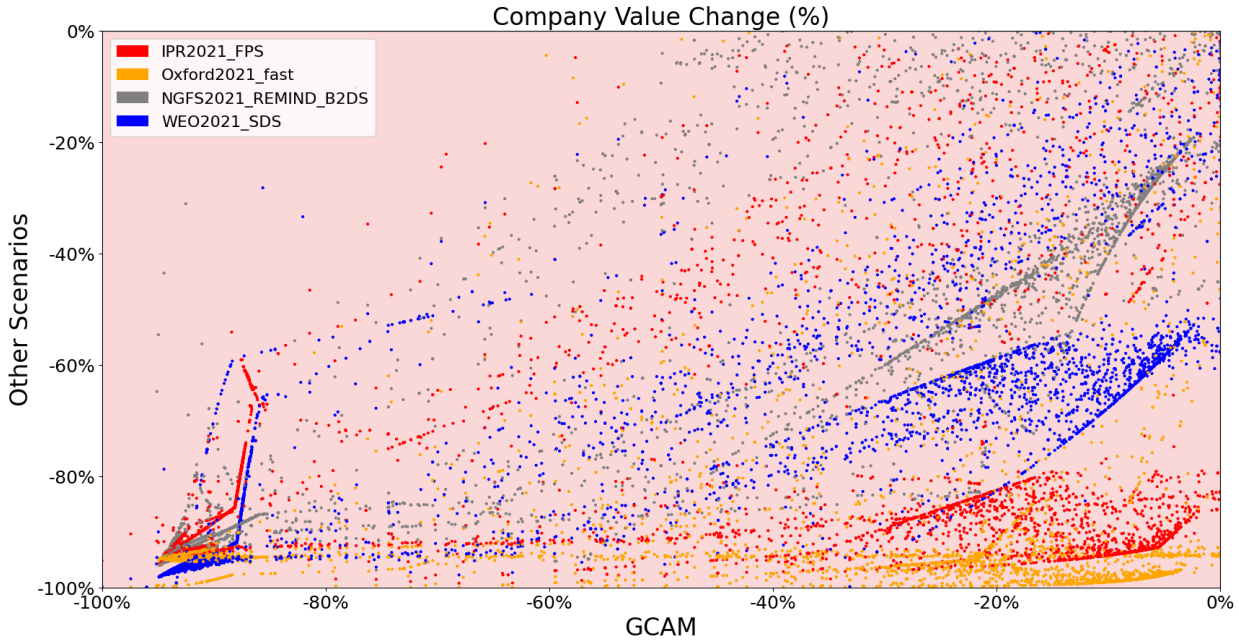
FINDING #3: Even when filtering those companies that have a negative shock across scenarios, the overall shock levels can be dramatically different

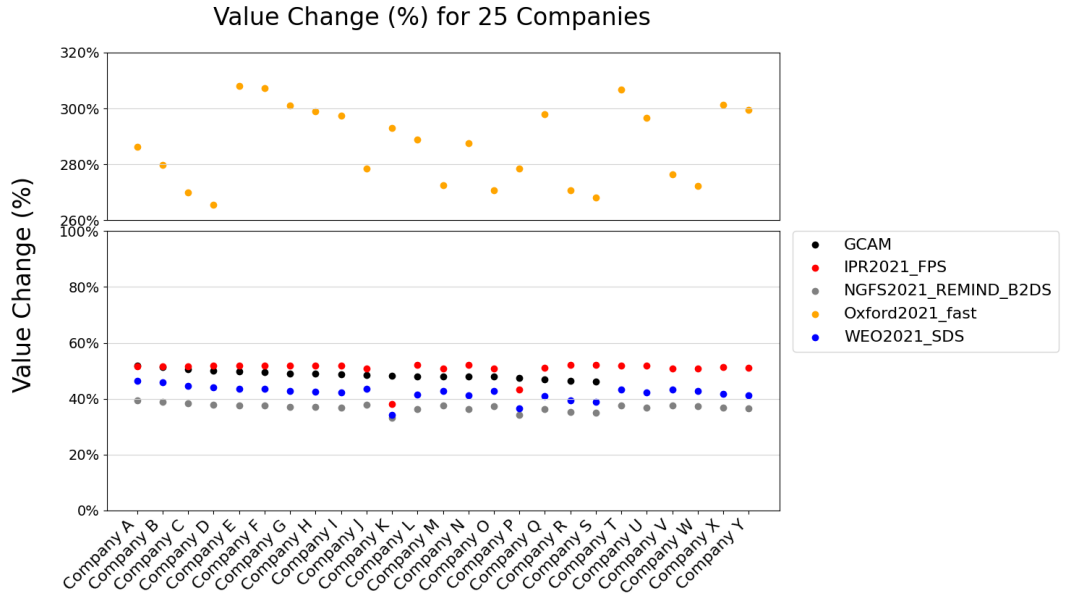
Key Finding #3: Even when filtering those companies that have a negative shock across scenarios, the overall shock levels can be dramatically different

The Figure below highlights that even when the scenarios have negative shocks for both scenarios, the actual comparability as to the size of the shock is very low.

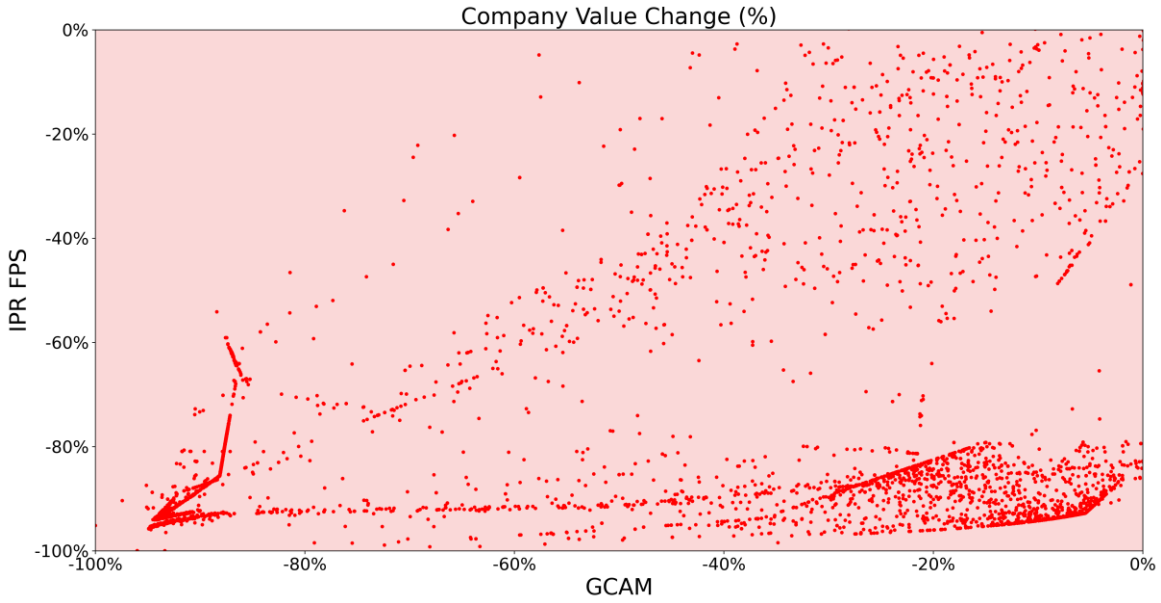
While the distribution provides some general trend, in particular insofar as there are almost no cases where the GCAM scenario has a high loss and other scenarios have a low loss, the inverse is not true. A large number of results cluster around an outcome with >80% loss in other scenarios and <20% loss for GCAM. The results also demonstrate some of the idiosyncrasies of climate stress-test models, with distributions at certain "tipping points" linear and in other places scattered randomly.

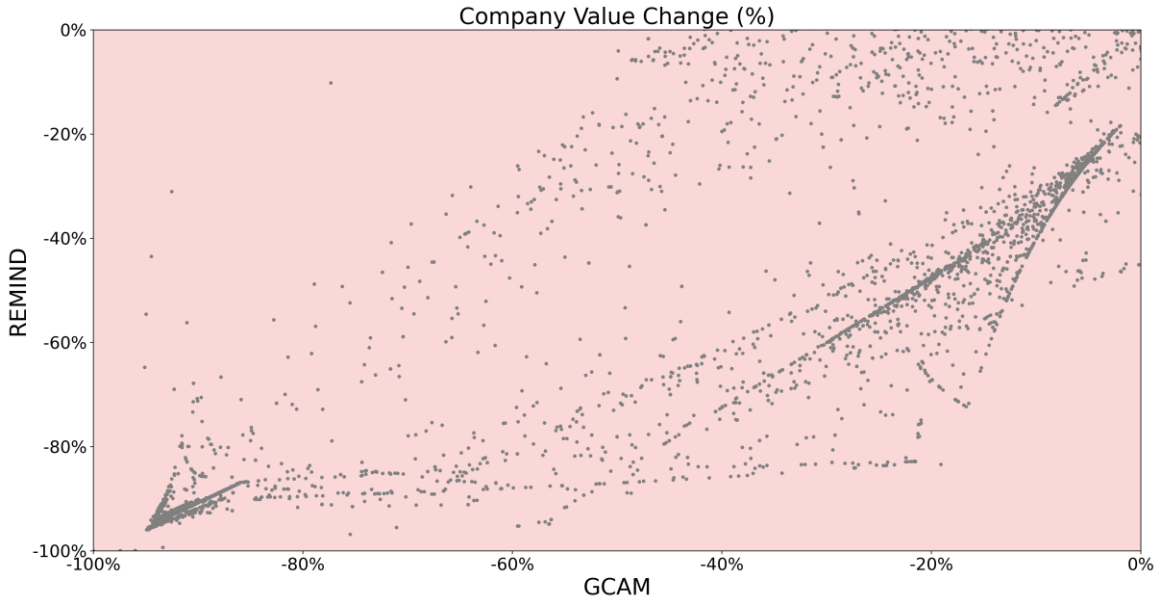
These findings are further highlighted by the dramatically different value changes of a sample of 25 companies with particularly high %-Value changes.

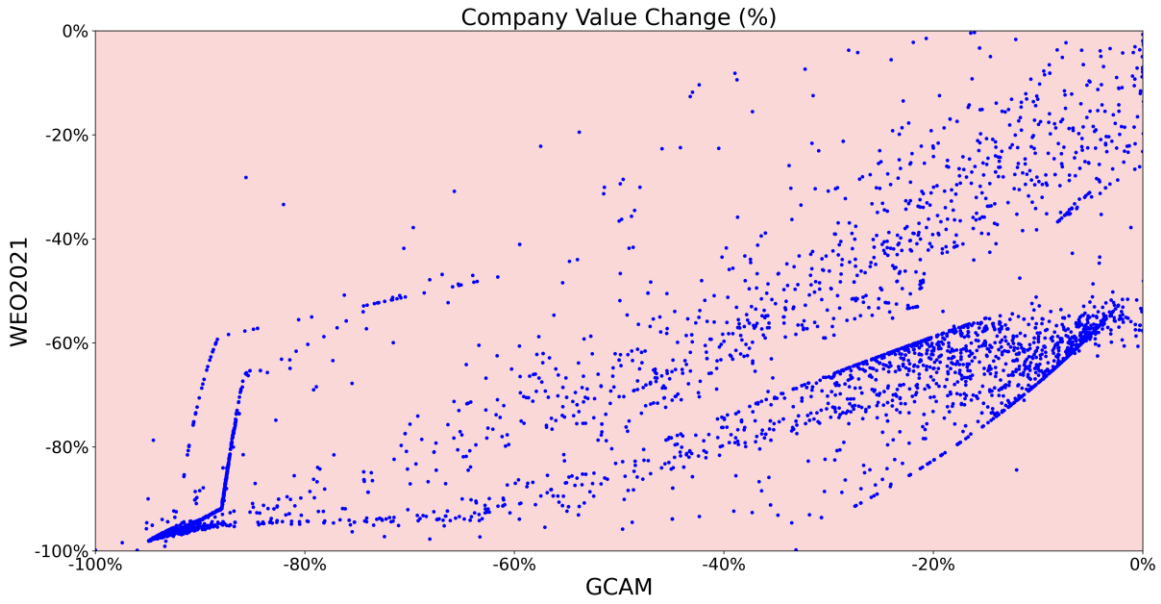


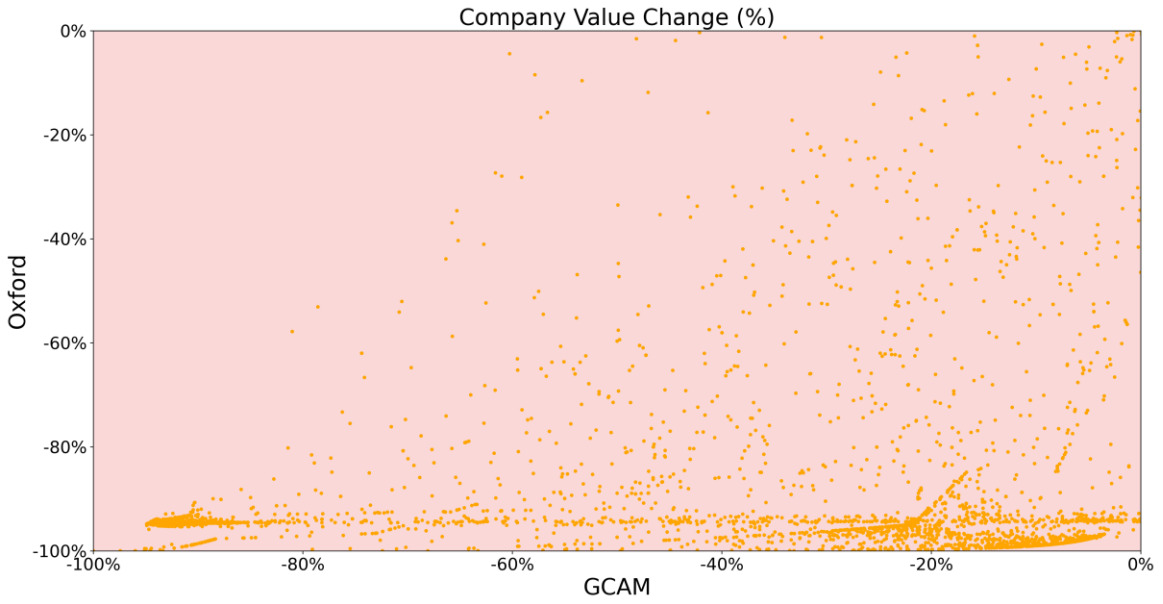


Breakdown by scenario – Valuation losses







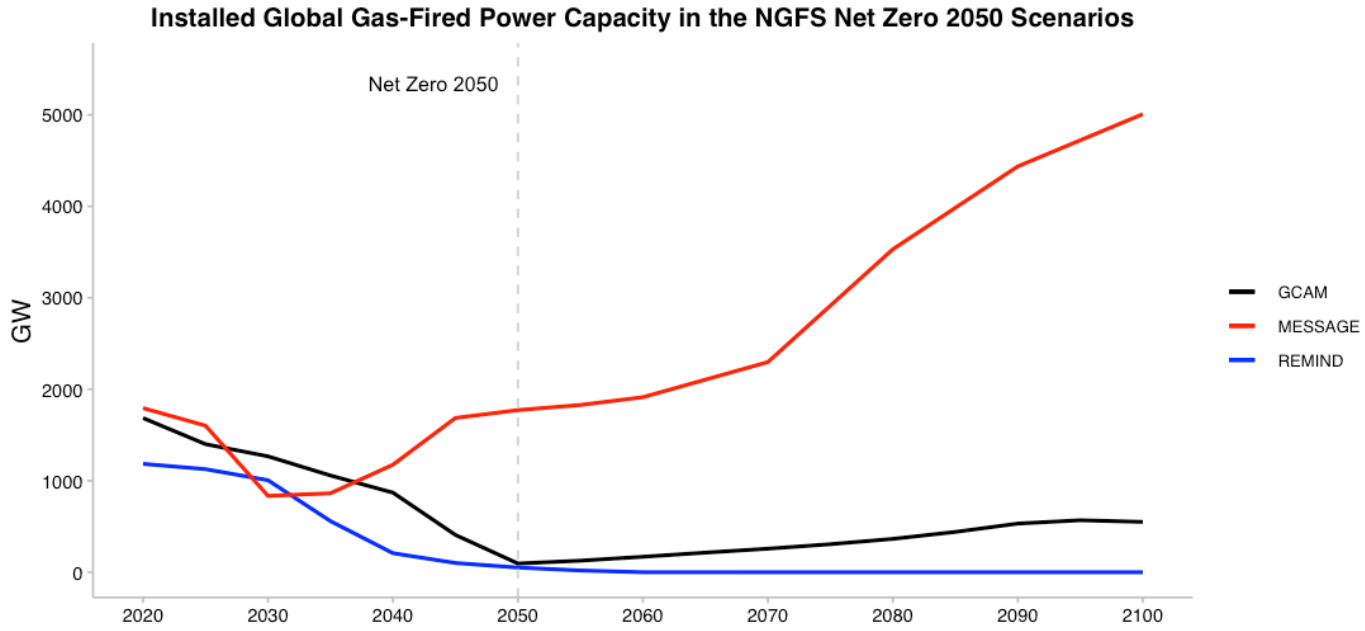


FINDING #4: Similar to other providers, the NGFS scenarios also show large differences, suggesting only limited comparability

Key Finding #4: Similar to other providers, the NGFS scenarios also show large differences, suggesting only limited comparability

It is worth highlighting the extent to which the differences described above also hold for NGFS scenarios, suggesting limited comparability and the ability for these scenarios to 'standardize' scenario analysis.

Although the two NGFS scenarios that are part of this analysis use different integrated assessment models, the NGFS advertises their scenarios as "a global, harmonised set of transition pathways." While the scenarios are surely "harmonized", this does not yield consistent outcomes in stress-test scenarios. In fact, the analysis did not consider a third NGFS scenario (MESSAGE), given its dramatically different dynamic in the power sector, with for example significant increases to gas-fired power capacity until the end of the century for even its most ambitious climate scenarios.(see Fig. below). Including MESSAGE would have further skewed the results. Thus, even users choosing only among NGFS scenarios will have a high degree of outcome sensitivity to their scenario input choice.



Implications for climate stress-tests

The analysis above highlights the high degree of sensitivity of stress-test outcomes to scenario inputs. This finding is not new intuitively, but the degree of that sensitivity even when using similar ambition level scenarios as part of a quantitative analysis is striking.

What is more, the analysis here is only limited to 5 scenarios and further scenarios would likely have also show different pictures. Crucially, this does not make the transition random. The overall results are consistently negative, even if to different degrees, and we understand key distinctions between high-carbon and low-carbon trajectories. But the underlying results of these exercises are highly sensitive to their inputs. Of course, it is also important to highlight caveats to the work. The analysis was run using one type of stress-test model and one type of data input, and thus other models and data sources may show different results and a larger degree of correlation or comparability.

There are a couple of different conclusions or implications that may be derived from this work.

a) 1in1000 has previously outlined the need for running stress-tests around core scenarios but with large number of stress-test simulations. This does not suggest using indiscriminately scenarios, but rather identifying key pathways and then simulating alternative futures around them, given the uncertainty associated with the pathways and the sensitivity of results to these choices. Technology improvements and computing capacities mean scenario simulations can now involve several 100 different scenario runs in parallel, as well as of course in parallel the capacity to assess the sensitivity to other model inputs (e.g. discount rate, terminal value).

b) The alternative perspective is to invest more time in "choosing" a scenario based on the actual beliefs / perspectives of the user. This requires moving away from looking towards a "scenario authority" but a more proactive engagement with the scenario landscape.

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