Anticipating corporate emissions depending on the ambition and early action of companies

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Abstract

Anticipating future corporate greenhouse gas (GHG) emissions has tremendous potential to help develop cost-efficient long-term investment strategies and to assess climate risks for companies. Traditional projections rely mainly on global estimates broken down by sector and firm characteristics, but lack the information given by their specific decarbonization strategies. In the meantime, many companies have set climate targets that specify their intended emission reductions over different time horizons. This paper presents a methodology to integrate these pledges into firm-level emission projections by aligning them with climate scenario-consistent abatement pathways. By doing so, this method provides a clearer view of future emissions in the economy and how stringent company policies will be. To account for the extent to which firm GHG trajectories support or contradict their ambitions, we introduce a metric called "carbon credibility" that reflects the recent evolution of their emissions relative to their stated targets. This measure serves both as an early indicator of target feasibility and as an adjustment factor for forward-looking projections. Including the carbon credibility of nearly 300 companies in the STOXX 600 index results in almost a 5% increase in projected cumulative GHG emissions up to 2050. Credibility values indicate that half of the sectors in the panel fall short of the efforts required to align with their decarbonization ambition. These results imply higher expected climate risks and call for enhanced corporate actions.

Keywords: GHG emission projections, Climate scenarios, Climate targets, Carbon credibility, Carbon costs
JEL : M14, M21, Q56, Q58

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1 Introduction

Corporations have a vital role to play in the transition to a low-carbon economy. Among the 24,000 companies (2/3 of the global market capitalization) that answered the environmental disclosure questionnaire from the Carbon Disclosure Project (CDP) in 2024, over 5,000 have defined decarbonization plans aligned with a Net Zero horizon, corresponding to long-term global warming about 1.5°C above pre-industrial levels (according to the CDP Press Release, 2024). There are various incentives to develop such plans, ranging from climate risk mitigation to stakeholder pressure (Cadez et al., 2019 and Kaesehage et al., 2019). Research suggests severe effects on the economy and on companies themselves due to large greenhouse gas (GHG) emissions, such as the risk of stranded assets mentioned by Caldecott et al. (2016) on an increase in sovereign risk as stipulated by Chaudhry et al. (2020). In a context where the goals of the Paris Agreement (2015) are threatened by insufficient ambition and policies from global actors, many firms now rely on science-based targets, which are emission reduction objectives consistent with the level of decarbonization required to meet the goals of the Paris Agreement. Obtaining validation by the voluntary framework known as the Science Based Targets initiative (SBTi) is a way to publicly promise that the company will reach zero net emissions in 2050, thanks to a concrete path and guidance from SBTi. In the SBTi trend tracker (2025), the initiative mentions that 11,000 companies representing more than 40% of the world market capitalization have registered science-based targets, highlighting an accelerating global climate ambition.

Yet, hurdles are expected in the upcoming years. Not all companies have enough ambition to meet Net Zero requirements, and may set targets that are less demanding by not adhering to SBTi - Freiberg et al. (2021) find that alignment with science-based standards raises the target magnitude by up to 25% on average, highlighting the level of requirement behind science-based targets. Moreover, these pledges are made well in advance and often require assumptions about future tools for the transition, such as the development of carbon removal tools or new decarbonized technologies (Carton et al., 2023). Firms often include the emissions they offset in their carbon footprint assessments, thus possibly misleading about how low their actual emissions are. Hale et al. (2022) conclude that Net Zero targets increase in quantity but lack in robustness. Criteria for credible Net Zero targets are rarely met, including transparency regarding the use of offsets or the coverage of the different greenhouse gases. As a result, the anticipation of future corporate emissions is a challenging issue given the uncertainty surrounding the achievement of their targets. To alleviate these problems, this paper makes use of climate scenarios to classify the ambitions of companies. These scenarios outline various pathways for macroeconomic and regulatory variables, as well as projections for climate variables such as GHG emissions and average temperatures. These models place companies on coherent emissions trajectories, depending on how much reduction they plan to achieve, and result in a general assessment of the collective ambition of industries. Recognizing that blind faith in corporate pledges may lead to overestimating their performance, we assess their recent behavior to evaluate firms credibility. Following Brunner et al. (2012), we define being credible as having others believe you will do what you commit to. We then distinguish between firms demonstrating credible decarbonization strategies, where observed emissions at least align with stated targets, and non-credible firms exhibiting under-performance relative to their targets. We finally provide estimates for corporate GHG emissions up to 2050 that balance both their announced ambition but also this credibility factor.

Initial work on corporate emission pathways focused on the interactions between global climate goals and more granular decarbonization trajectories, in order to set targets for individual entities. The introduction of the Sectoral Decarbonization Approach (SDA) by Krabbe et al. (2015) represented a major step forward in improving the attribution of decarbonization efforts given each sector's unique possibilities and constraints. In a synthetic work, Bjørn et al. (2021) review the different methods (SDA and six older methods that differ by their allocation principle, company variables, and emission scenarios) to set corporate science-based climate targets, while evaluating how the corresponding emission allocation principles can affect global emissions with respect to definite budgets. Several pathways are hypothesized to allow for more flexibility, with linear, exponential, and logistic trajectories that represent different ways of reaching a decarbonization target. They conclude that a gap can be observed between aggregated target-consistent emissions and the global budget depending on the methods chosen by all companies, and this gap may be impacted by the shape of the pathway and the company variables. Relying on this principle of remaining budgets, Hadziosmanovic et al. (2022) construct individual pathways aligned with a global warming of 1.5°C and well-below 2°C, instructed by corporate carbon disclosures to better fit the profile of companies. Their alternative method aims at allowing each firm to build their own trajectory depending on their capacity to abate quickly, with limited overshoot since the budget does not involve substantial carbon removal, which is an assumption of many optimistic scenarios.

With companies progressively implementing climate pledges using these techniques, subsequent analyses were required to investigate whether they collectively exhibited enough ambition. Kuramochi et al. (2020) aim at quantifying the impact that commitments should have by 2030, by studying the combined commitments of regions, cities, or businesses and comparing them both to a Current National Policies scenario and Nationally Determined Contributions from countries. Focus on specific sectors are performed reusing the SDA by Dietz et al. (2021), comparing companies' targets to scenarios based on steel production and expected demand, as well as benchmark 1.5°C scenarios (de Villafranca Casas et al., 2024), or evaluating targets using criteria from PwC's *Building blocks for net zero transformation framework*, the CDP rating system, and the SBTi approval system (Burch et al., 2025).

Another branch of literature revolves around the consequences of these targets on company performance. Dahlmann et al. (2019) calibrate a model to predict the probability that a company has a target, and regress the change in emissions from scopes 1 and 2 against this probability and the target characteristics. They differentiate between greenwashing[1] companies that set targets only to gain a better image and those that have a real decarbonization intention. Kuo and Chang (2021) try to determine whether setting science-based targets and fixing an internal carbon pricing led to a better carbon management reputation for Japanese firms, as measured by CDP disclosure scores.

Following the implementation of firms' ambitions and targets, questioning the realization of such ambitions over time became highly relevant to assess emission trajectory. Credibility is already widely used in the literature for government commitment in reducing emissions (Helm et al., 2003; Olazabal et al., 2019; Rogelj et al., 2023) following a traditional Kydland and Prescott (1977) dilemma. Applied to firms, it is first studied as an evaluation of their progress. Giesekam et al. (2021) analyze the progress made by companies against the targets they announced using at least two years of history since the target base year. For each target, they identify companies that achieved it, are on path to do so, or behind in its realization. When companies did not disclose their progress, the authors compare their emissions to an assumed linear reduction trajectory since the base year. Similar evaluations either directly measure the target percentage achieved, classify companies as aforementioned or, in the case of Hsu et al. (2020), define a progress ratio influenced by the time elapsed between the base year and the target year. To overcome the extreme numerical variability of these indicators, Bolay et al. (2024) introduce an improved indicator that also includes the time elapsed information but in a bounded way and avoiding the use of ratios. Instead of looking at the progress already made, Saleh et al. (2025) compare a forward-looking view on steel companies emissions with either sectoral references from IEA scenarios or the company targets directly. To do this, they project emissions depending on the opening and closing dates of production units, as well as scenarios-based rates of decarbonization for electricity supply. They find that for the Net Zero scenario, between 8% and 20% more emissions are expected compared to the emission levels from the IEA projections, and that emissions overshoot the corporate targets by

[1] Greenwashing is the act of using misleading marketing to make a company or product appear more environmental-friendly than it actually is.

more than 20%.

Although few papers focus on projecting company emissions depending on their ambition, Haalebos and Fouret (2022) rely on companies' targets, when available, to predict their future emissions, and use historical trends thanks to the compound growth rate adjusted for revenue in the other case. For later horizons, the pathways are expanded using RCP scenarios or extended target levels. In particular, these different sources lead to a measure of uncertainty contained in the range of possible emissions. It is used subsequently to evaluate an Implicit Temperature Rise (ITR) metric for companies and the entire portfolio. An important assumption in the target projection is that companies will attain their targets in the worst-case scenario, and the impact of this hypothesis is analyzed by comparing the ITR distribution between this method and the historical trend.

Uncertainty in climate models further arises from the sector-specific features mentioned above. Riemer et al. (2023) compare projected Net Zero pathways obtained from system-wide and sector-focused modeling tools and document substantial divergences in underlying assumptions, particularly regarding available mitigation levers. These discrepancies translate into large gaps in expected emission reductions across models. Energy demand is especially sensitive to model choice, which in turn generates wide variation in the influence of energy efficiency to sectoral decarbonization.

A recent strand of literature attempts to quantify the carbon-related costs implied by companies' projected emissions. Pastor et al. (2024) estimate the present value of the social cost associated with projected emissions of U.S. firms, extending earlier work linking stock returns and carbon emissions by incorporating emissions forecasts for a forward-looking metric. The underlying projections, produced by MSCI, also incorporate firms' stated targets. Building on this approach, Ahn et al. (2025) construct a similar present-value metric but replace the social cost of carbon with projected regulatory carbon price paths from the IEA, which are typically lower because they reflect policy prices rather than the full spectrum of damages embedded in social-cost estimates. Consistent with this methodological difference, Pastor et al. (2024) report implied carbon costs amounting to 131% of aggregate corporate equity value (USD 87 trillion), whereas Ahn et al. (2025) obtain estimates between USD 2.4 and 4.1 trillion, approximately 5% to 9% of the total market capitalization of U.S.-listed firms.

Our paper provides four contributions. First, by linking companies' pledges to climate scenarios, we assess the level of ambition among sectors and facilitate scenario planning for financial institutions. Second, to mitigate the overreliance on firms' ambitions, we create a measure of historical credibility to benchmark companies that are struggling to decarbonize and are more likely to fail their objective. Even though breakthroughs may be achieved in the future, for instance with the help of technology advances, we argue that stakeholders and market participants should trust more companies that have already been able to make significant progress towards their objectives. Since projections are made in accordance with their goals, companies with a lower ambition are not rewarded excessively for reaching their targets in the case where their target is only performative. Third, we provide an empirical assessment of emission reductions until 2050 corrected for both firms' ambitions and credibility, providing estimates relevant to both policy makers, firms and stakeholders on the current path of transition. Last, we quantify how many additional emissions could arise from the lack of credibility of the selected companies, and use carbon price trajectories from the climate scenarios to derive implicit overshoot costs.

The remainder of this article is organized as follows. Section 2 explains the methodology used to project the emissions of companies according to their ambition, the calculation of the carbon credibility, and the data used to illustrate the methodology. Section 3 presents the projections and credibility values obtained for the given company universe, at the company or sector level. Section 4 aims at quantifying overshoot costs. Section 5 divides the sample depending on the carbon credibility values to evaluate recent portfolio performance. Robustness checks are performed in Sections 6.1 and 6.2, to account respectively for the uncertainty in the scenario selection and for the impact of scope 3 emissions. Section 7 summarizes the process and findings and discusses possible improvements.

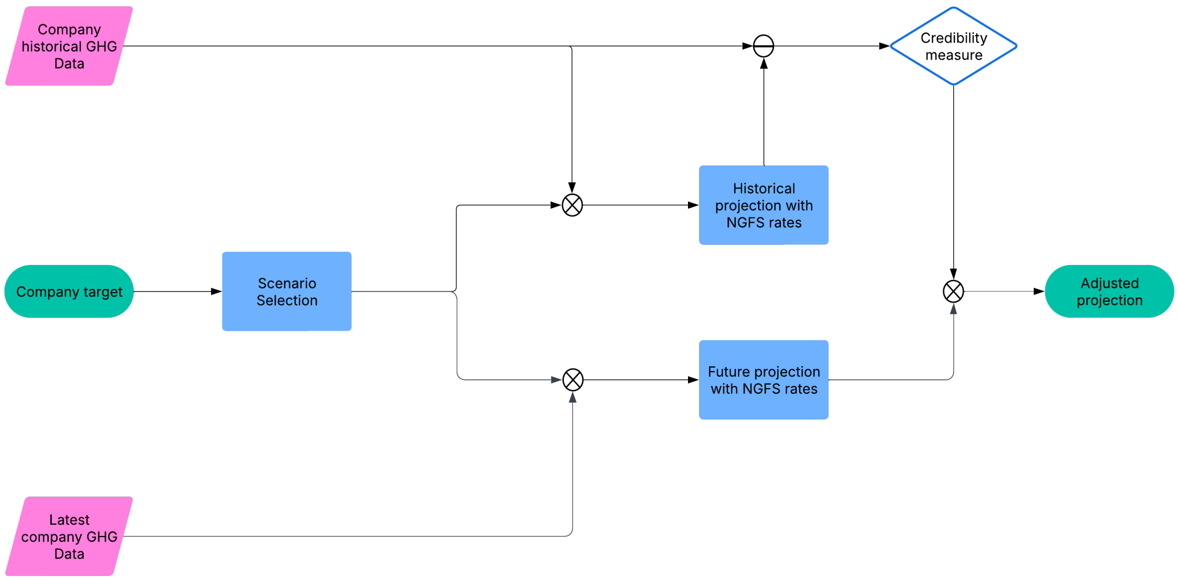
2 Methodology

2.1 Overview

We use three steps to convert a corporate target into a projected GHG emissions pathway. The announced GHG reduction from a base year to a target year is compared to the expected reduction from the NGFS climate scenarios to identify the scenario that most closely resembles the ambition of the company. Then, its historical GHG emissions are projected according to the decarbonization rates from the NGFS data, while its future trajectory is projected from the most recent reported GHG value. Finally, a measure of carbon[2] credibility shifts future projected emissions depending on the company's early action. This process is summarized in Figure 1.

[2]The term carbon is used for simplicity. The methodology presented here considers all greenhouse gases as identified in the Kyoto Protocol.

Figure 1: Projection methodology illustration



Using NGFS scenarios allows us to define a complete trajectory, as only point-in-time target values for specific years are available. The NGFS transition rates are supposed to define coherent pathways given possible dynamics of macro-economical and climate variables, instead of just assuming a linear decarbonization rate, which is likely not realistic given how companies' emissions should evolve to meet their targets. Likewise, exponential decarbonization pathways (with a compound annual rate) generate excessively steep trajectories, concentrating most emission cuts in the early years. Such profiles would imply that a Net Zero 2050 commitment is nearly achieved well ahead of the stated horizon, which is counterintuitive with respect to the date announced by the company.

Although scope 3 is necessary to obtain a complete profile of the companies, we focus only on scopes 1 and 2 in the main part of this paper, as the data uncertainties are even more important for scope 3, in accordance with the findings of Busch et al. (2022) or Klaaßen and Stoll (2021). This obviously has consequences, which are explored in Section 6.2.

2.2 NGFS scenarios

The first stage of the projection involves identifying the climate scenario whose decarbonization rate is closest to the reduction announced by the company. For a given horizon, consider a company indexed by i, with an associated reduction rate r_i between years τ_i^a and τ_i^b. As NGFS data start at 2020, it is not possible to include directly decarbonization rates for targets that have a base year anterior to 2020. In that case, the reduction already achieved between the base year and 2020 is deducted from the total reduction (or added if emissions increased) to generate a target starting from 2020.

Let $n_{j,t}$ denote the NGFS emissions at time t in scenario j.[3] The reduction rate of the NGFS scenario j between years τ_i^a and τ_i^b is denoted by

$$\rho_{j,\tau_i^a,\tau_i^b} = 100 * \frac{n_{j,\tau_b} - n_{j,\tau_a}}{|n_{j,\tau_a}|} \tag{1}$$

Here, we omit the dependence on i for simplicity, and divide by absolute emissions to account for net negative emissions in specific scenarios. The distances between the company and scenario rates are defined as $d_{ij} = |r_i - \rho_j|$. Then, the scenario with the closest reduction is chosen:[4]

$$k_i = \arg\min_j \ d_{i,j} \tag{2}$$

Since multiple targets may lead to different conclusions, a target prioritization similar to the one in the CDP-WWF temperature scoring methodology (referred to as CDP, 2024) is enforced.[5] In particular, targets are split according to three horizons : short-term (target year up to 5 years from now), mid-term (10 years from now) and long-term, with the mid-term ambition argued to be the most relevant indicator. We perform an additional step compared to CDP (2024). When a company lacks a target for a horizon of 10 or 30 years, we assume that the target emissions for the previous period (5 or 10 years) can be extended to stay at the same level. This assumption gives a lower bound for the company's ambition, provided that emissions will not increase again for later horizons, which is consistent with the evolution of global policies. This is particularly important for early Net Zero companies: when companies announce that they will reach Net Zero for scopes 1 and 2 in a horizon of 10 years, they should logically stay Net Zero in 2050.

The second stage of the ambition projection relies on the yearly NGFS rates for each scenario. Let $\rho_{j,t} = \rho_{j,t-1,t}$ denote the annual reduction rate from $t-1$ to t in scenario j. The projected growth rates are applied to corporate emissions in order to infer a pathway of emission evolution. The company's projected emissions are therefore

[3] Aggregate projections for 5-year intervals are interpolated to obtain yearly emissions.
[4] A more conservative approach is detailed in section 6.1.
[5] Prioritization steps and supplementary details are listed in the Appendix.

(dropping the dependency on j for simplicity):

$$\hat{e}_{i,t} = \hat{e}_{i,t-1} + |\hat{e}_{i,t-1}| * \frac{\rho_{k_i,t}}{100} \tag{3}$$

starting from an initial year t_0, with $\hat{e}_{i,t_0} = e_{i,t_0}$ the company's observed GHG emissions. The emissions are projected for each scope independently, then added to obtain emissions for scopes 1 and 2 combined. Two projections are computed: historical projections between 2020 and the current year, and forward-looking projections starting from the current year. Future projections are denoted $\hat{f}_{i,t}$ to distinguish them from historical reconstructions.

2.3 Credibility and uncertainty

The projections presented above reflect the stated ambition of firms, under the assumption that their emissions follow the evolution prescribed by the corresponding NGFS scenario. In practice, however, companies may deviate from these pathways, and it is possible that they fail to meet their pledges because of a slow start or because they overvalued their transition capacity, especially for shorter horizons. To overcome the emission overestimation that could arise due to these reasons, we propose adjusting the projections to add information about the effectiveness of the transition already undertaken by the company. This section introduces an indicator of carbon credibility, that is, a measure of the recent behavior of a firm compared to what its ambition implies in the early stages of the decarbonization process. The company's NGFS projected emissions can be adjusted by a measure of credibility up to the current year, thanks to the gap between its emissions pathway and the projected emissions. A proportional adjustment is chosen since the deviation should become more marginal for lower emissions, and firms should be increasingly incentivized to converge toward the benchmark over time due to regulatory pressures or cost optimization.

Call τ the current year and τ_1 the maximum year between the target base year and 2021, the starting date for NGFS projection rates. The carbon credibility corresponds to the time-averaged gap:

$$c_i = \frac{1}{\tau - \tau_1} \sum_{s=\tau_1}^{\tau} \frac{\hat{e}_{i,s} - e_{i,s}}{\hat{e}_{i,s}} = \frac{1}{\tau - \tau_1} \sum_{s=\tau_1}^{\tau} c_{i,s} \tag{4}$$

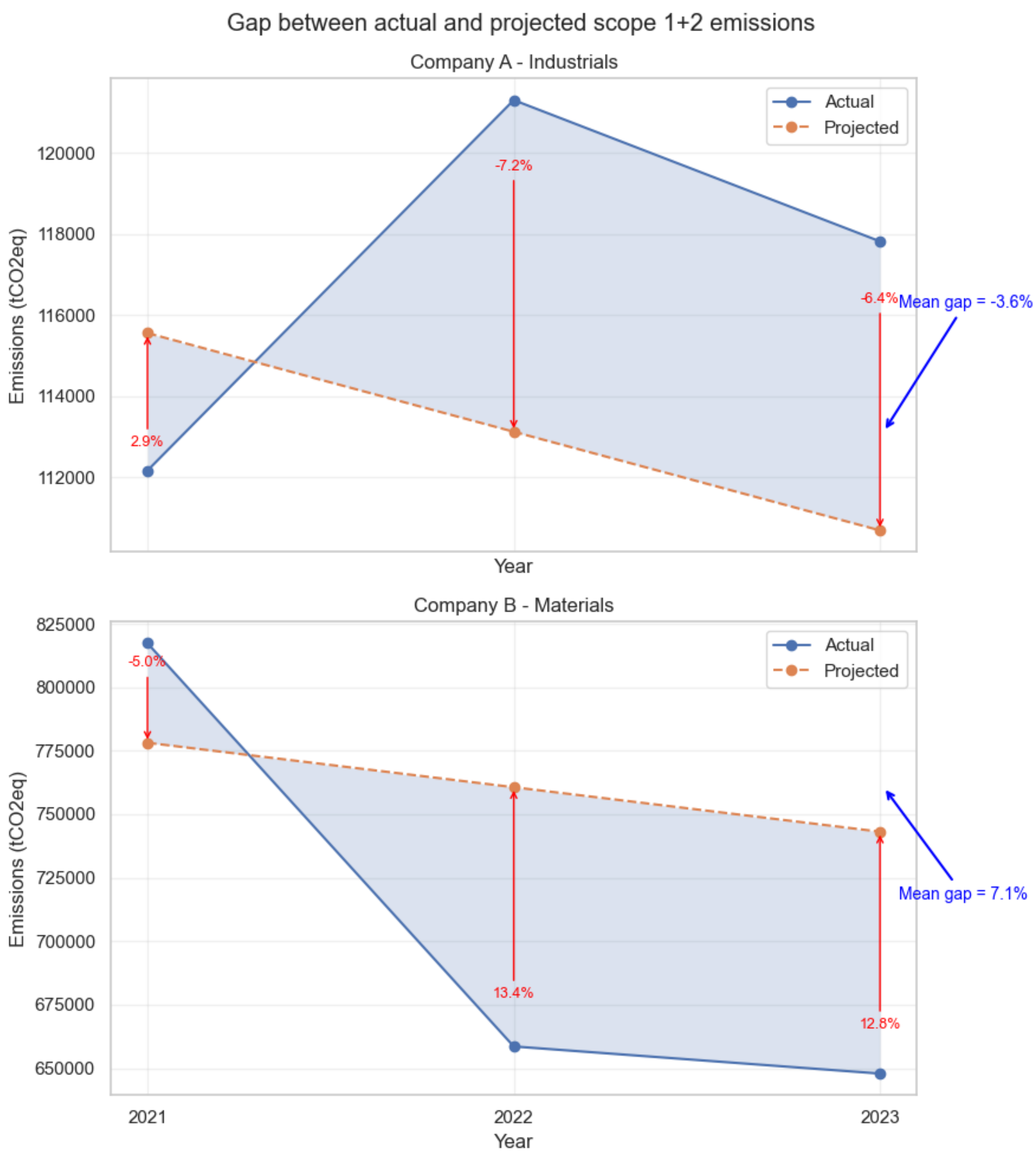
If there is a constant overshoot compared to the projected emissions, the company has been struggling to decarbonize enough. The underlying hypothesis is that "late achievers" are penalized by the model, which does not consider that postponing investments to suddenly meet targets close to the deadline is a viable strategy. This is supported by scientific theories arguing that early action is necessary to align with lower global warming, with larger reductions in GHG emissions in the initial years (Fankhauser et al., 2022 or CDP, 2024). In contrast, companies taking early action will be deemed even more credible by the model while reducing their emissions in an optimal way.

In practice, adopting this measure of credibility would lead to a reversal in the adjustment for negative emissions when companies reach Net Zero. When projections reach zero emissions, the credibility already vanishes given the proportional adjustment. Therefore, when projections are negative, no adjustment is performed. The rationale behind this choice is that companies that already have negative emissions have far fewer incentives to further decarbonize, so they are likely to refrain from investing too much effort in the process once they are Net Zero. The final adjusted GHG emissions are given by:

$$a_{i,t} = \begin{cases} \hat{f}_{i,t} * (1 - c_i), & \text{for } \hat{f}_{i,t} > 0 \\ \hat{f}_{i,t} & \text{else} \end{cases} \tag{5}$$

Figure 2 shows two examples of carbon credibilities measured over the last three years, with c_i defined as the mean gap.

Figure 2: Example of carbon credibility calculation



Adjusting the emissions yields a different amount of cumulative emissions over the whole time period. To evaluate how much overshoot (or undershoot) is created by this factor, we compute an indicator θ corresponding to the relative proportion of emissions added (respectively avoided), as defined by Equation 6.

$$\theta = \frac{\sum_{i,t}(a_{i,t} - \hat{f}_{i,t})}{\sum_{i,t}\hat{f}_{i,t}} \tag{6}$$

This indicator represents how many additional (or avoided) emissions are likely to be created by all firms as a consequence of their initial transition, as a percentage of all projected emissions.

Besides, these supplementary emissions are linked to additional costs depending on the price of a ton of carbon, which is a hypothesis of climate scenarios. Each NGFS scenario is associated with a shadow carbon price, that reflect how much emissions should cost to incentivize the abatement implied by the scenario. We multiply the differential in emissions by the yearly carbon price χ_t, and aggregate over the years and companies to obtain a global overshoot cost:

$$P = \sum_{i,t} \chi_t \big(a_{i,t} - \hat{f}_{i,t}\big)\, \mathbb{1}\Big\{a_{i,t} > \hat{f}_{i,t}\Big\} \tag{7}$$

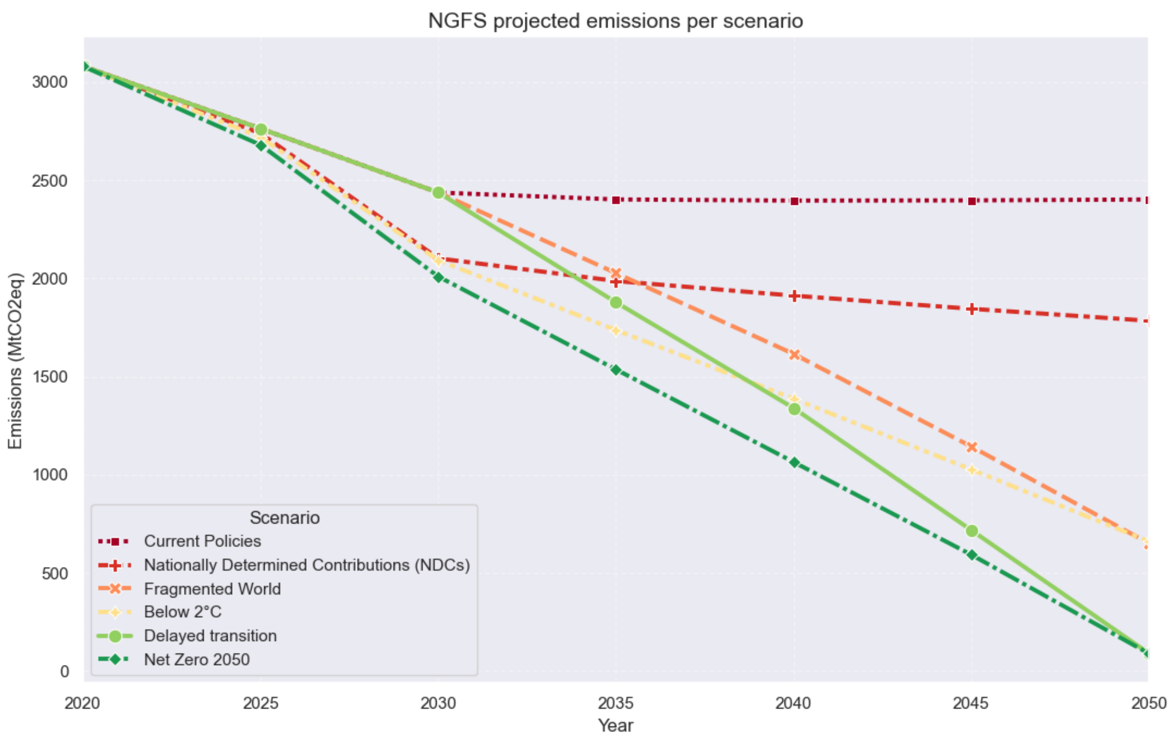
It may be interpreted as the implied cost of all emissions due to the initial lack of credibility by companies in our universe, if the economy is evolving according to a specific scenario. We choose not to include avoided emissions as they would result in negative costs, but while companies may be penalized for emitting more than allowed, it is unlikely they will be financially rewarded for reducing their emissions faster than announced.

2.4 Data

NGFS data are extracted from phase 5 of the NGFS scenarios (referenced in Richters et al., 2024). The NGFS provides projections for a wide set of variables ranging from climate impacts to macro-financial indicators, each evolving according to an internally consistent pathway that characterizes a given transition narrative. These scenarios span a broad spectrum of futures with varying levels of climate risks. In this paper, we focus specifically on projected GHG emission pathways for the NGFS Global sector. The selected pathways, representing each NGFS scenario, are illustrated in Figure 3.[6]

[6] In this method, the scenario "Low demand" is excluded. This choice was made because the other scenarios correspond to futures where ambitions and regulations drive decreases in emissions, whereas reduced emissions in Low demand are due to behavioral changes on the customer side.

Figure 3: GHG pathways up to 2050



Since data for emission reduction targets tend to be less available for smaller companies, the methodology is applied to the STOXX 600 index, made up of European companies with large capitalizations. Both targets and historical emissions for these companies as reported in the CDP questionnaire are extracted from LSEG Workspace (formerly Refinitiv Workspace); the starting year for the emissions (and thus the earliest possible base year) is 2012, and the last year available is 2024 but not for all companies. Due to various factors, the final sample is largely reduced compared to the initial index. Graph 4 shows the company losses that occur at each step of the methodology. The steps that lead to discarding companies are as follows:

1. Discard companies that do not have consistent targets (including those that do not have target data at all).

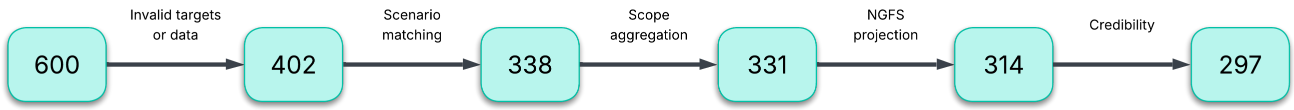
2. Assign a scenario for each scope depending on the targets and historical data.

3. Combine scenarios between scopes 1 and 2.

4. Project the company's emissions with NGFS decarbonization rates.

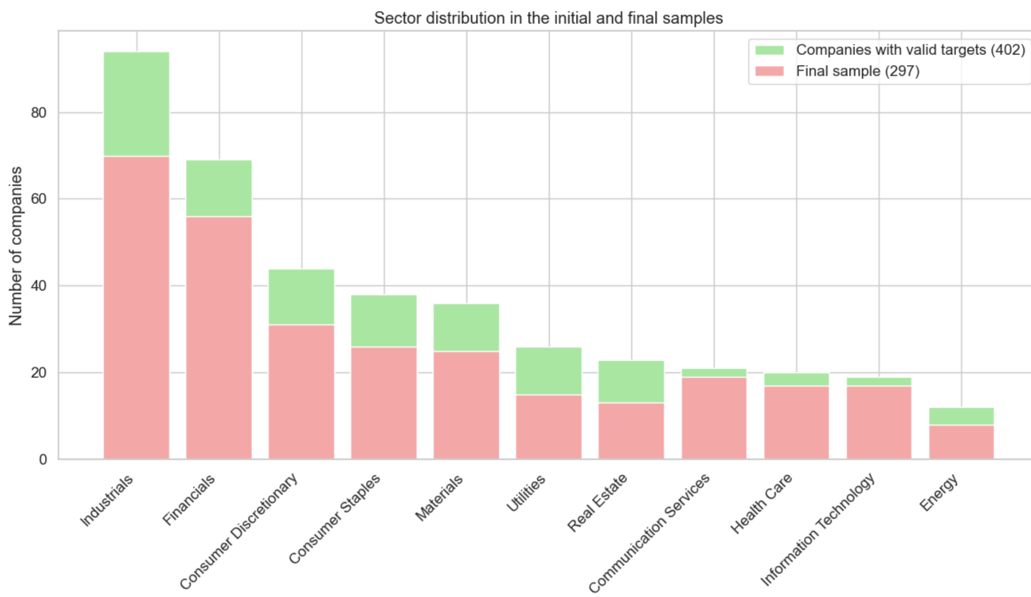
5. Compute the credibility and adjust emissions.

Figure 4: Number of companies lost at different stages of the projection.



Graph 5 shows the sector distribution for all STOXX 600 companies with valid GHG data from LSEG workspace and for the final companies that were kept in the reduced dataset.

Figure 5: Sector distribution in the initial and final samples



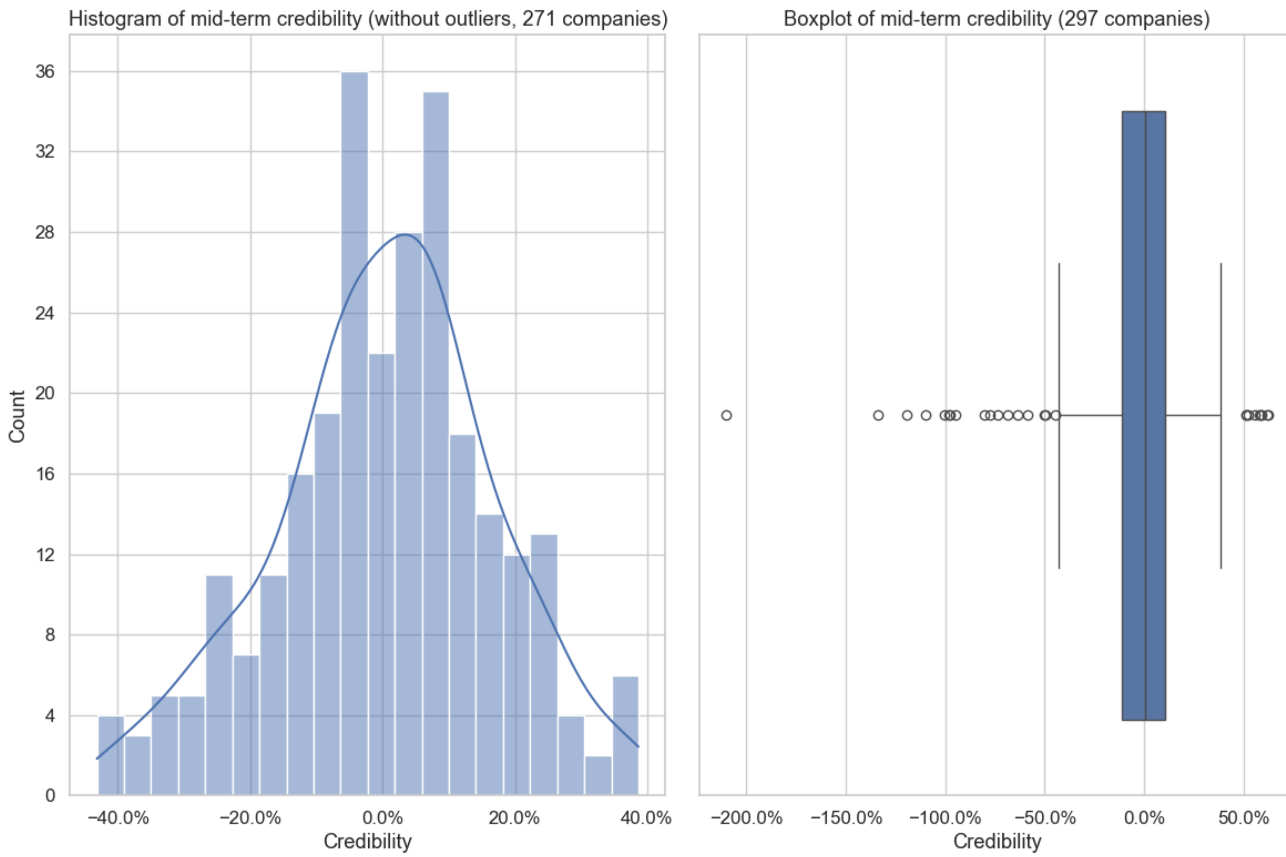
As carbon data are extremely volatile, the initial dataset was heavily processed. Further discussions about data quality and processing choices are presented in the Appendix.

3 Projections and credibilities

3.1 Individual credibilities and projections

The carbon credibility distribution, derived from Equation 4 when evaluating mid-term ambitions, is shown in Figure 6. In the histogram, points are classified as outliers and not shown if their credibility is 1.5 interquartile range (IQR) below the first quartile or 1.5 IQR above the third, while the boxplot displays every value.

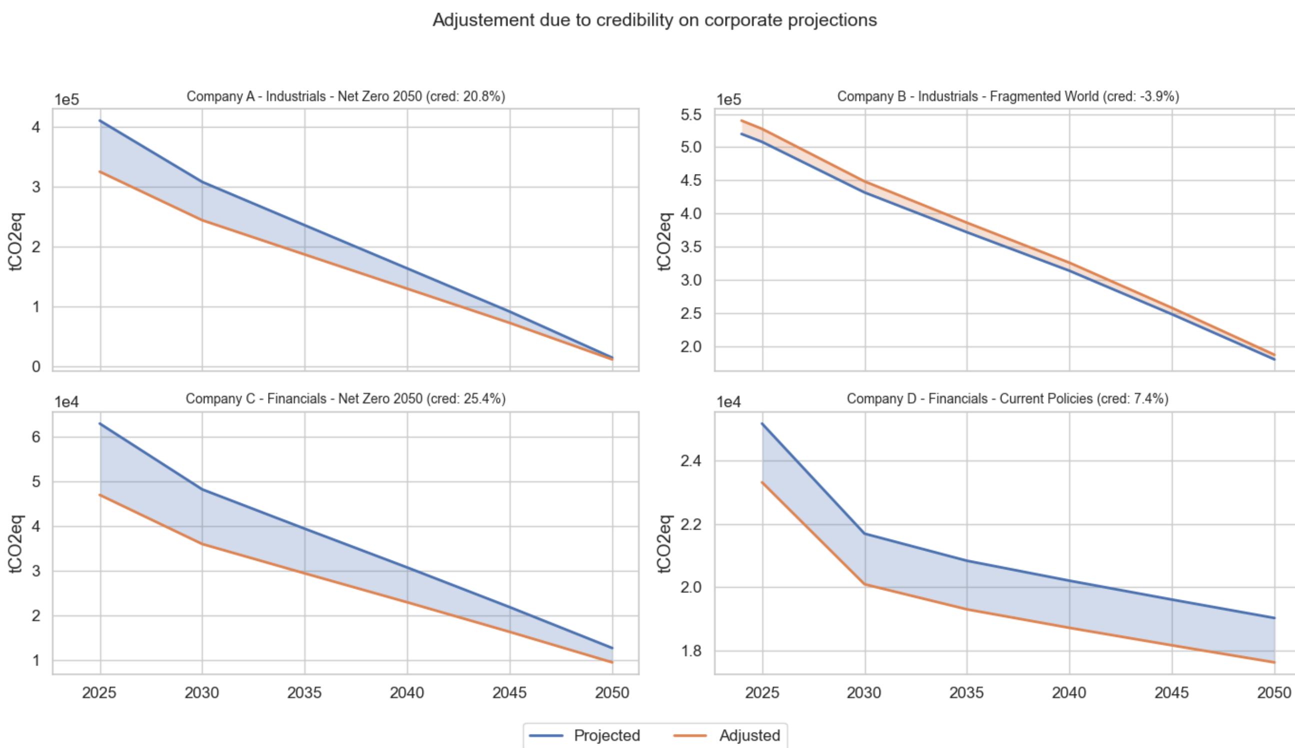
Figure 6: Distribution of carbon credibilities in the STOXX 600 (following Equation 4)



Note: The left panel displays observations within the boxplot-based range, while the right panel shows the full distribution. The credibility values are measured based on the mid-term emission reduction targets.

There are about as many companies lagging behind their objectives (negative credibility value, for 52% of our 297 companies) as companies outpacing the required reduction (48%), in line with results from Giesekam et al. (2021) and Bolay et al. (2024). For a large majority of companies with negative credibility, the gap is only a fraction of the actual emissions. It may indicate genuine efforts that have not been perfect, rather than proof that the reduction promises were deceptive. In contrast, compared to the range of values shown in the histogram, outliers present extreme values. Investigating these outliers' pathways, they are explained most of the time by companies that have low emissions but have slightly increased their emissions in recent years even though their short-term ambitions are significant, which may lead to questioning their strategy. Credibility assessments serve as adjustment factors for firm-level emission trajectories, with illustrative examples presented in Figure 7.

Figure 7: Example of projections with the credibility adjustment



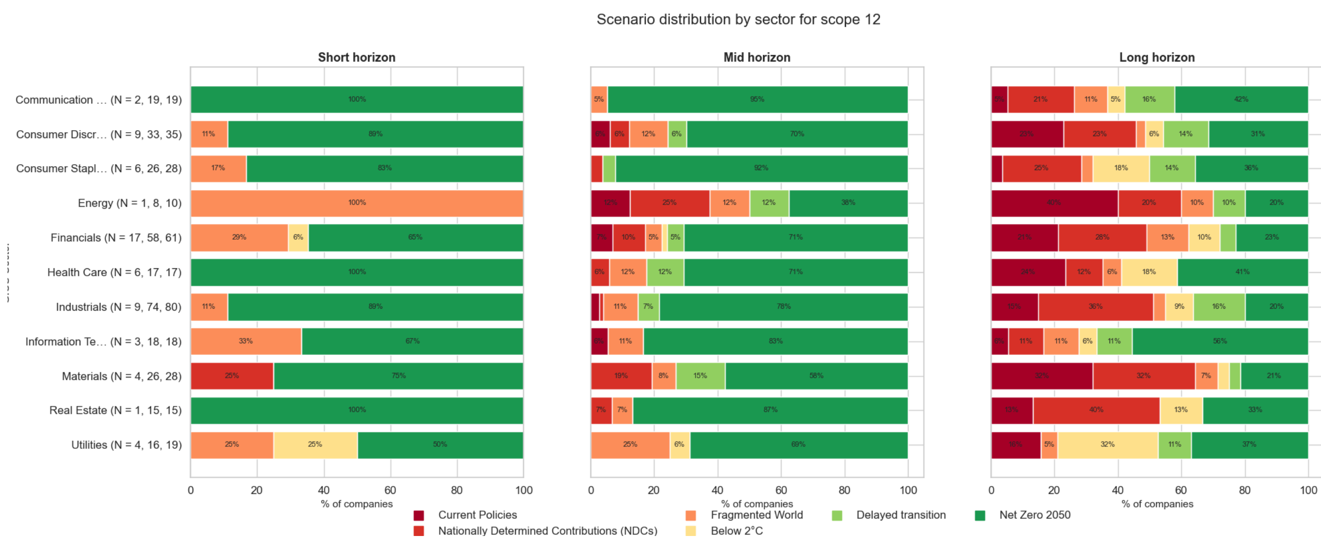
Note: For each anonymized company A, B, C, or D, this figure presents a firm initial projected tons of CO_2-equivalent emissions (tCO_2eq) in blue, compared to the projection with a proportional adjustment due to the credibility measure obtained from Equation 5 in orange. The blue (orange) area indicates that a firm is ahead (behind) the realization of its own declared targets.

Projection dynamics exhibit substantial heterogeneity across firms, driven by historical emission levels, the attributed climate scenario, and firm-specific credibility - itself a function of the former two. While the effect of credibility diminishes as the company progresses in its decarbonization process given the proportional adjustment, a negative value leads to a higher amount of cumulative emissions, since there are delays before implementing the necessary reductions, and therefore a higher level of warming. Even if the target is achieved in the end for a Net Zero scenario, this implies higher climate risks suffered during the period. For other scenarios, it also means that the target is not perfectly reached at the deadline due to slow start. Ultimately, one therefore has to consider a larger possible balance of emissions when anticipating the carbon budget of companies or investment universe.

3.2 Sectoral conclusions

The alignment between stated ambitions and climate scenarios reveals the emission pathways that sectors intend to pursue. Figure 8 presents the scenario distribution for the short-term, mid-term and long-term targets, including the scenarios linked to the extension of shorter horizons. In our sample, out of 310 mid-term reduction plans, 32 originate from an extended short-term target. For the long term, most targets were extended from the short-term or mid-term horizon (235 extended targets out of 330).

Figure 8: Scenario ambition by sector and horizon



Note: The numbers next to the sector names correspond to the number of companies in the sector that have a decarbonization target for each horizon. The scenarios correspond to ambitions from emission reduction targets for scopes 1 and 2, either for the given horizon or by extending the target reduction from earlier horizons. The total reduction is the average of each scope reduction weighted by the scope importance in total emissions

Sectors have varied ambitions, but when they define transition plans for shorter horizons, it is usually a Net Zero plan (77% for the short-term and 75% for the mid-term, all sectors combined). The shorter term is particularly strict, which is explained by the fact that climate scenarios tend to be close to each other over the first few years. However, most corporate strategies are defined only for the next decade and lack an ambitious plan for a longer horizon. The proportion of Net Zero transition plans decreases to 29% for the longer horizon, heavily due to the extended reduction levels. The change in ambition when considering the long-term is particularly significant in sectors such as Real Estate, Communication Services or Consumer Staples for which mid-term reductions do not translate to Net Zero for a longer horizon, while sectors such as Health Care or Information Technology still have more Net Zero plans than other scenarios. Companies' 10-year decarbonization levels are therefore not sufficient to ensure low-carbon transition for later stages of the century. With climate risks likely to rise substantially over the next decades, firms will have to maintain high standards after the first stages of their transition.

In addition, firm ambitions do not necessarily match closely the scenarios. Table 1 quantifies the absolute deviation between individual corporate ambitions and their associated scenario reduction rates, averaged by sectors $(S_l)_l$.[7] For a given horizon, the sector-level gap is defined as

$$\gamma_l = \frac{1}{|S_l|} \sum_{i \in S_l} d_{i,k_i} \tag{8}$$

As mentioned in 2.2, rates are adjusted whenever the company's base year precedes 2020, hence why the rate can even exceed 100% depending on the company pathway until 2020.

Table 1: Average absolute gap between time-adjusted ambitions and their most likely scenario (in %), following Equation 8

GICS Sector	Short Term Gap (%)	Mid Term Gap (%)	Long Term Gap (%)
Communication Services	69.1	31.4	15.4
Consumer Discretionary	44.3	20.2	10.3
Consumer Staples	24.9	23.6	10.5
Energy	117.4	23.9	20.4
Financials	30.0	20.8	8.7
Health Care	52.6	24.3	8.9
Industrials	23.7	20.2	8.1
Information Technology	17.7	25.2	15.1
Materials	25.1	11.5	7.3
Real Estate	89.3	21.4	8.5
Utilities	5.9	19.3	11.3

The principal finding reveals the considerable discrepancy between the level of corporate emission reduction targets and the economy-wide abatement projected by NGFS. This discrepancy suggests that companies have not systematically designed their reduction plans in accordance with existing climate scenario hypotheses. This

[7] Absolute deviations are used to prevent an overestimation of alignment that would arise from mutually canceling positive and negative gaps.

misalignment is especially pronounced at shorter horizons, as companies in our sample have sometimes envisioned an extremely fast reduction that is overly optimistic relative to the economy pathway in the NGFS models.

The NGFS also provides sector-specific GHG pathways, using the GCAM sector classification. One could expect those scenarios to reduce the gap between corporate ambitions and modeled trajectories. However, we find that average gaps are most of the time even greater when using sectoral scenarios. Table 2 reports the gaps computed against sector-specific scenarios, with the corresponding gaps against the global scenario shown in parentheses.

Table 2: Average absolute gap between time-adjusted ambitions and their most likely sectoral scenario (in %)

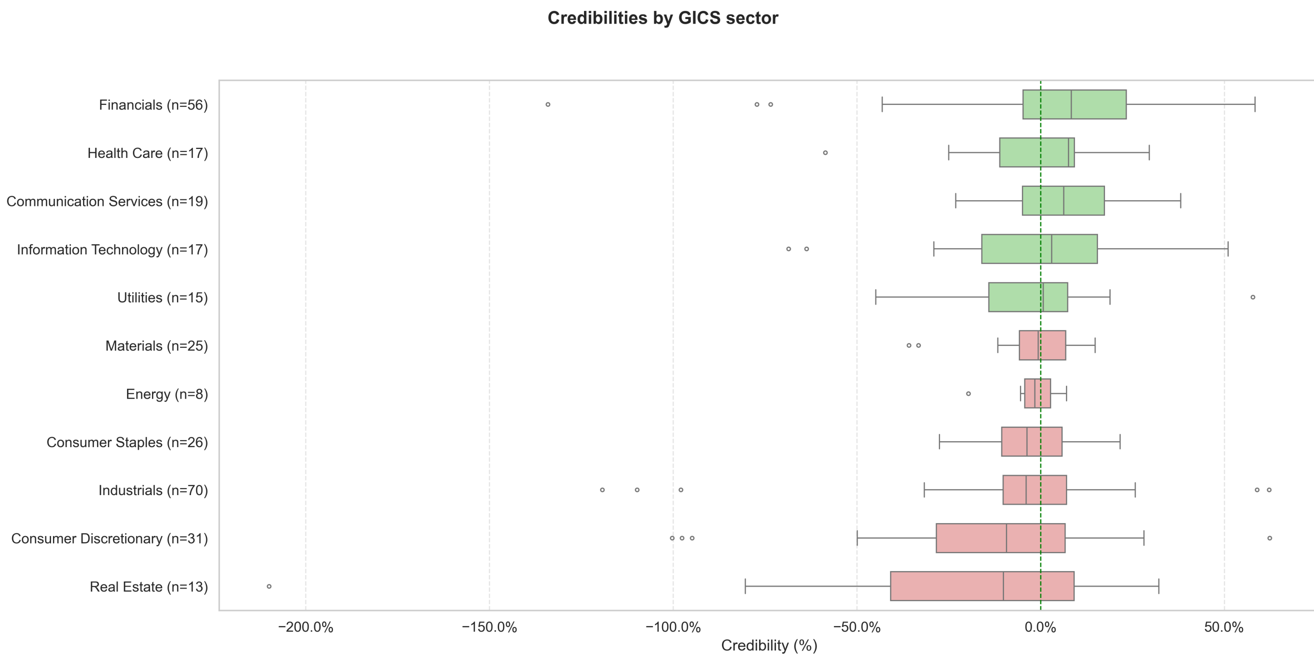
GICS Sector	Short Term Gap (%)	Mid Term Gap (%)	Long Term Gap (%)
Communication Services	69.1 (69.1)	31.4 (31.4)	15.4 (15.4)
Consumer Discretionary	44.5 (44.3)	21.3 (20.2)	13.4 (10.3)
Consumer Staples	25.7 (24.9)	28.9 (23.6)	24.5 (10.5)
Energy	117.0 (117.4)	27.4 (23.9)	23.6 (20.4)
Financials	30.0 (30.0)	20.8 (20.8)	8.7 (8.7)
Health Care	52.4 (52.6)	26.1 (24.3)	13.5 (8.9)
Industrials	25.2 (23.7)	24.0 (20.2)	13.0 (8.1)
Information Technology	17.5 (17.7)	26.8 (25.2)	18.5 (15.1)
Materials	27.6 (25.1)	17.0 (11.5)	32.5 (7.8)
Real Estate	89.3 (89.3)	21.4 (21.4)	8.5 (8.5)
Utilities	7.6 (5.9)	18.1 (19.3)	41.6 (11.3)

Note: Values from Table 1 are shown in parentheses, colored by direction of change (e.g. colored in red if the gap to the sectoral scenario is greater than the gap to the global scenario). A mapping was applied between GICS sectors and NGFS GCAM sectors.

NGFS pathways feature dramatically heterogeneous abatement profiles across sectors, but corporate targets are generally closer to global scenarios than they are to sectoral scenarios. This pattern suggests that many firms appear to anchor their ambitions to generic benchmarks such as "net zero" at the aggregate economy level, rather than to sector-consistent trajectories. Yet, the NGFS Net Zero pathway anticipates, for instance, increasing emissions in the AFOLU sector but negative emissions in almost half of the remaining sectors, highlighting that sectoral decarbonization requirements can diverge from a simple, uniform decline. This echoes findings from Riemer et al. (2023), who compare sectoral and global modeling tools and conclude that Net Zero pathways can diverge significantly in ambition and trajectory due to varying mitigation levers.

The credibility applied at the individual firm level can be systematically aggregated to examine sectoral patterns, and is shown in Figure 9.

Figure 9: Distribution of carbon credibilities by sector



The sector credibility can be interpreted as such: "In recent years, the Industrials sector in the STOXX 600 has emitted a median of 4.0% more GHG emissions than it should have to respect the scenarized ambitions announced by its underlying companies". Even with such a small sample, these results paint a concerning picture of the success of the transition for some sectors. Beyond falling short of government-mandated climate objectives, ranging from nationally determined contributions under the Paris Agreement to EU-wide commitments set out in the European Climate Law, our analysis reveals that firms from major emitting sectors such as Materials, Industrials, Consumer Staples and Discretionary are also failing to achieve their own self-determined emission reduction targets. Current actions are insufficient to align with projected 2050 pathways, requiring firms to substantially strengthen their decarbonization efforts.

To obtain a global picture of the gap between probable emissions and announced emissions, the difference in % over all emissions up to 2050 between the unadjusted projections and the ones including the credibility, is shown in Table 3 for each sector.

Table 3: Percentage of cumulative emissions added by the credibility, as defined in Equation 6

Sector	**Global**	Financials	Health Care	Consumer Staples	Communication Services	Energy
Added emissions	**4.4%**	-10.8%	-6.6%	-1.4%	-0.7%	-0.6%

Sector	Materials	Utilities	Industrials	Information Technology	Real Estate	Consumer Discretionary
Added emissions	2.4%	6.5%	8.3%	8.9%	9.7%	24.5%

Note: A negative value indicates that the early action by the sector may lead to undershoot, whereas the sectors with a positive value will emit more than forecasted by their mid-term ambition because of a slow start.

Following Figure 9, our findings highlight important heterogeneity. The largest surplus of emissions at the sector level comes from the low credibility of the Consumer Discretionary sector with 24% additional emissions, followed by the Real Estate sector with almost 10% additional emissions. Benefiting from a high credibility, the quick progress against their targets allows the Health Care and Financial sectors to reduce their projected emissions by respectively 7% and 11%. The 2.4% additional emissions of the Materials sector are smaller than what Saleh et al. (2025) find for the Iron and Steel Industry at a worldwide level. Using firms' assets, they estimate emissions, depending on the transformation of the energy supply, to be between 8 to 20% higher. Aggregating across the whole universe and considering the level of emissions of each sector, we find that firms will generate 4% supplementary emissions due to their slow transformation, and heightened risks are expected in particular for some sectors like Consumer Discretionary. This result shows important difficulties in the realization of both the 2050 and 2100 climate objectives.

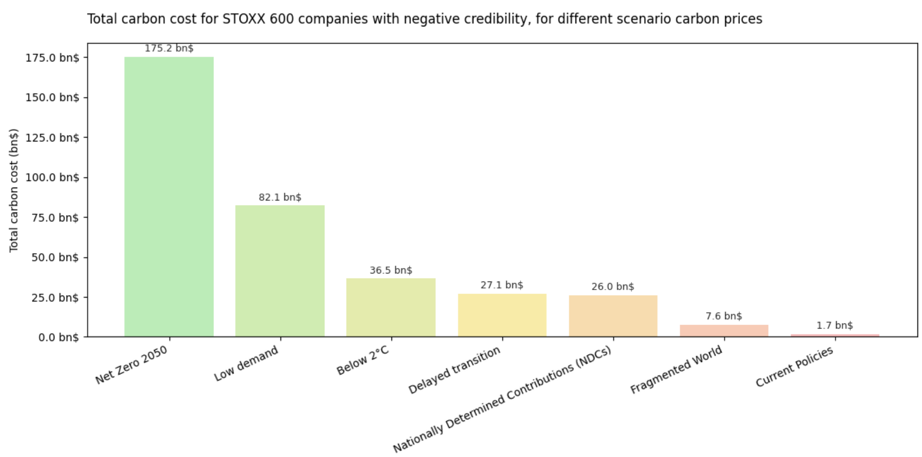
4 Projected carbon costs

Given the conclusion that a significant share of STOXX 600 companies are falling behind their stated decarbonization trajectories, we translate this credibility gap into financial terms. This section quantifies the implicit cost of the excess emissions attributable to insufficient early action, both at the aggregate level and across sectors, relying on the carbon price pathways embedded in the NGFS scenarios.

We use Equation 7 to compute the total carbon cost implied by the policy assumptions associated with each scenario. These costs originate from the credibility gap and can be aggregated at the level of the full investment universe as well as by sector. Because the carbon cost is a single measure of policy stringency that applies economy-wide, we impose the same carbon cost on all firms, regardless of their individual decarbonization ambition. This approach yields a range of plausible cost outcomes without requiring the selection of a single scenario or the specification of scenario probabilities. We also do not discount the future costs as we measure what companies could be expected to pay rather than a Net Present Value of the costs using a specific discount rate.

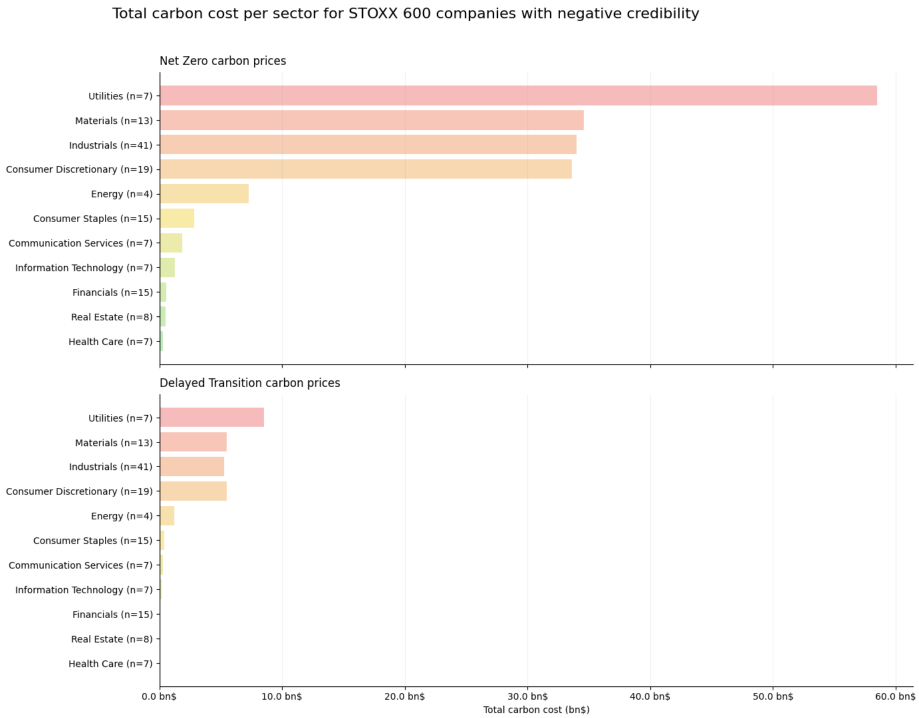
Figure 10 reports total costs for the 297 companies in the STOXX 600 with a GHG projection and credibility value, under the carbon price trajectory of each scenario. Figure 11 provides a sectoral decomposition, focusing on two scenarios characterized by comparatively high carbon prices.

Figure 10: Total credibility-related cost for the STOXX 600 companies with a carbon credibility (following Equation 7)



Note: An economy-wide annual carbon price from different NGFS scenarios is applied to the supplementary emissions due to a lack of early action by STOXX 600 companies. GHG projections are made according to the companies' ambitions.

Figure 11: Credibility-related cost per sector for the STOXX 600 companies with a carbon credibility



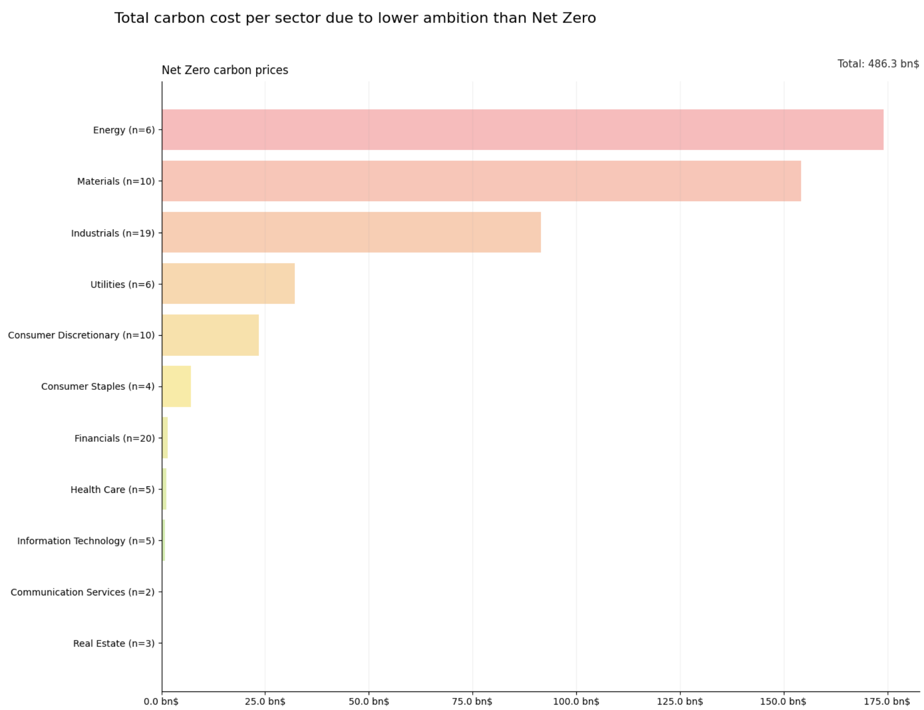
Note: The total carbon cost due to a lack of credibility is disaggregated at the sector level for two selected high-carbon price NGFS scenarios.

The substantial dispersion in carbon prices across scenarios translates into vastly different overshoot costs for firms. Under stringent climate policies, reflected by the high carbon prices in the Net Zero scenario, companies would need to significantly increase abatement efforts to avoid costs that could materially affect economic activity, reaching up to USD 175 billion. Conversely, in more pessimistic scenarios, weaker regulation implies lower policy-induced carbon costs: USD 1.7 billion (a hundred times lower than for the Net Zero economy) are expected for the Current Policies scenario since carbon prices stay comparatively low. However, these scenarios are typically associated with higher physical climate risks and, therefore, potentially larger economic damage.

Because overshoot costs scale with emissions, the largest contributions stem mostly from high-emitting sectors, such as Utilities, Materials and Industrials. In the Net Zero scenario, the Utilities sector is responsible for more than one third of the total amount (USD 58.5 billion), despite only representing a small number of firms in the sample. This concentration is consistent with the idea that delayed decarbonization under a stringent transition can generate sizable adjustment costs and may increase exposure to stranded-asset risk.

In addition to credibility-related costs, we quantify an implicit cost associated with insufficient corporate ambition using a similar approach. To do so, we compare emissions projected under each firm's stated scenario (prior to any credibility adjustment) to the corresponding Net Zero emissions pathway. We value this emissions gap using the carbon price trajectory of a Net Zero economy. Since Net Zero is the most stringent pathway considered in our framework, projected firm-level emissions are necessarily greater than or equal to the Net Zero projection. We therefore multiply this non-negative emissions differential by the Net Zero carbon cost. Figure 12 illustrates the resulting total cost by sector.

Figure 12: Cost due to the lack of ambition for the STOXX 600 companies with a carbon credibility



Note: Supplementary emissions are computed between projections matching corporate ambitions and Net Zero projections. Carbon price trajectories from the Net Zero scenario are then applied to these emissions to derive a total cost for each sector.

These ambition-related costs are substantially larger than credibility-related costs (approximately three times larger for the STOXX 600 as a whole, USD 486.3 billion compared to USD 175 billion for credibility-related costs). This difference arises because credibility adjustments typically affect only a fraction of firms' total emissions, whereas the gap between Net Zero and less ambitious pathways can be considerably larger. As a result, failure of the

STOXX 600 to fully transition to a Net Zero pathway would generate a sizeable emissions surplus, which would translate into high costs under stringent policy, as captured by the Net Zero shadow carbon price.

While Ahn et al. (2025) and Pastor et al. (2024) assess the present value of all future emissions at the firm level, our approach isolates the cost of incremental emissions attributable to insufficient ambition and limited credibility. This methodological distinction results in lower aggregate values. Nevertheless, the associated carbon costs remain economically significant. Recomputing the carbon overhang (COH) using the methodology of Ahn et al. (2025) yields results that are broadly consistent with theirs, once differences in the investment universe and necessary approximations are taken into account. Comparative results are detailed in the Appendix.

5 Portfolio allocation with the carbon credibility

Author's note: This section is still under construction

Our credibility measure provides a systematic way to distinguish firms that demonstrate early climate action from those that lag their stated commitments. If capital markets increasingly price climate performance, credible firms may exhibit different risk-return profiles. We test this hypothesis by constructing portfolios that split the STOXX 600 universe according to credibility values and evaluate their out-of-sample performance.

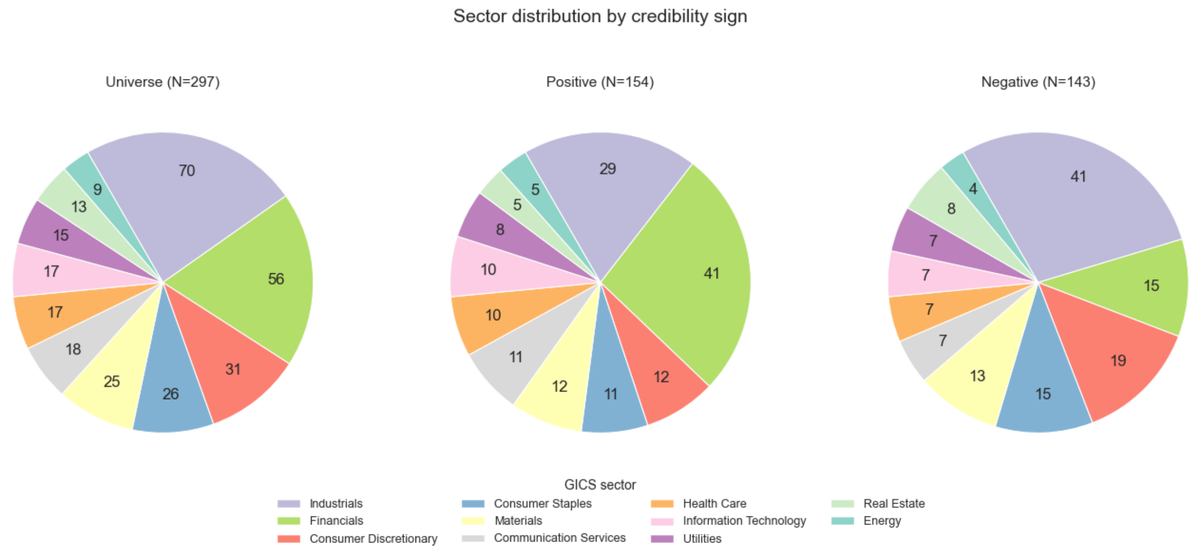
5.1 Data overlook

For the 297 companies in our final sample, we retrieve daily total returns from LSEG. We define an in-sample window from January 2020 to January 2024 to estimate expected returns and the covariance matrix, and a backtest window from February 2024 to January 2026 to evaluate portfolio performance.[8]

Sector bias is likely to influence the resulting portfolios and their performance. Figure 13 shows the sector distribution of the full sample, the positive and negative credibility universe.

[8]As a consequence, the credibility measure is computed on the historical daily returns period. GHG emissions data does not overlap the backtest period.

Figure 13: Initial sector distribution



The set of companies with either only positive or negative credibility exhibit different compositions. There are slightly more than half of the companies in the positive sample. The most noticeable differences are the higher share of Financials company in the credible universe, while the Industrials, Consumer Discretionary and Consumer Staples are more present in the non-credible universe.

5.2 Methodology

The credibility sign leads to reduced investment universes. We consider that we can only select the corresponding companies for the portfolio allocation, and estimate historical expected returns and risks only for the restricted universe (instead of having the same calibrated returns and risks no matter the universe). We estimate expected returns using the sample mean of daily returns over the in-sample window. To improve numerical stability in covariance estimation given the relatively large cross-section, we use an Oracle Approximating Shrinkage (OAS) estimator. We then compute long-only portfolio weights by maximizing the Sharpe ratio (for a risk-free rate set to zero), under the constraints of no short-selling, and a maximum asset weight of 5%. The optimization is initialized from equal weights. We evaluate the resulting buy-and-hold portfolio over the out-of-sample period and report performance and concentration metrics: Net Asset Value (NAV), average return (Re), risk (Ri), Sharpe ratio (SR), maximum drawdown (MD), maximum drawdown duration (MDD), Herfindahl-Hirschman index (HHI). We also indicate the number of possible assets in the restricted universes.

5.3 Allocation results

Figures 14 and 15 display respectively the in-sample efficient frontiers and out-of-sample NAV paths for the full, credible, and non-credible universes under the baseline specification. Table 4 summarizes the corresponding portfolio metrics.

Figure 14: Efficient frontiers depending on the credibility

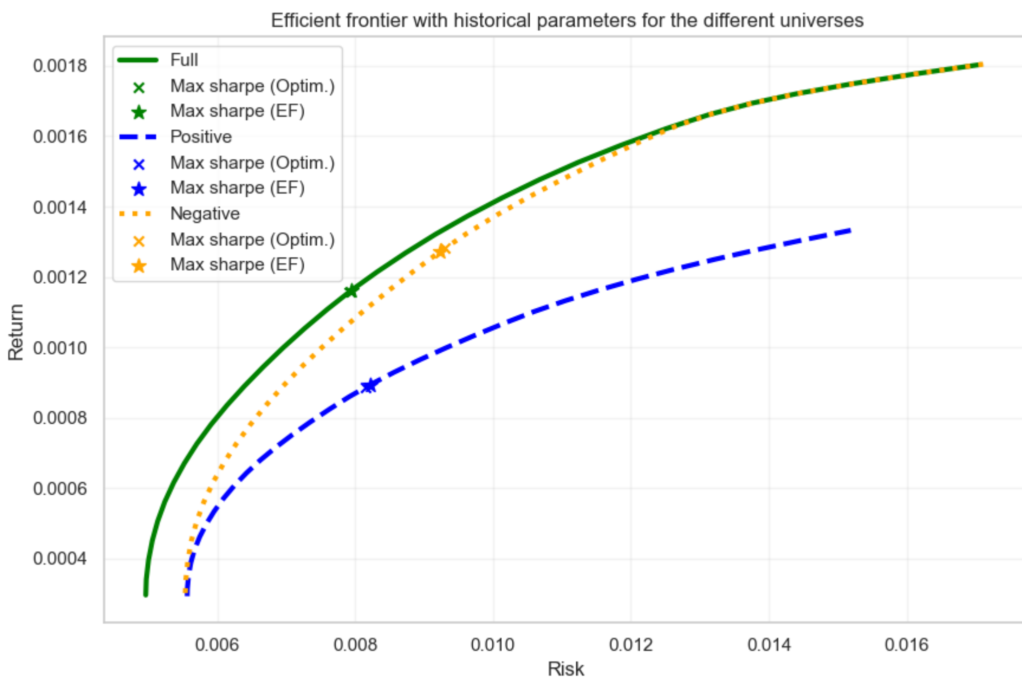


Figure 15: Evolution of Net Asset Values depending on the credibility

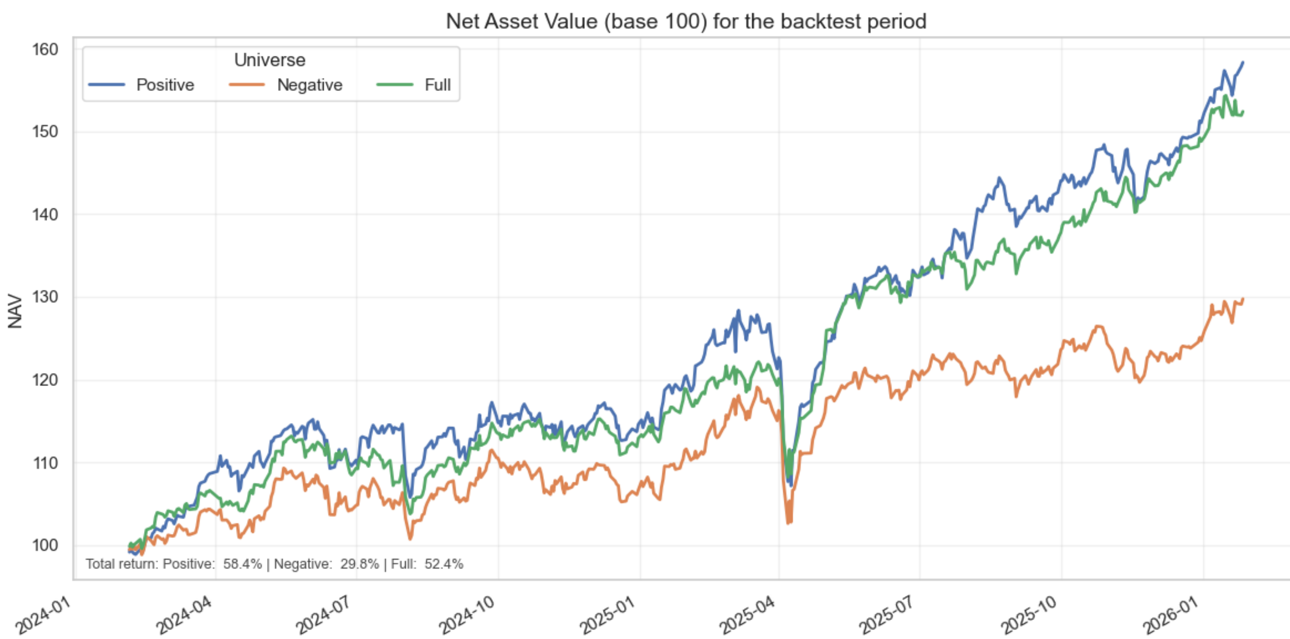


Table 4: Portfolio metrics for the baseline strategy.

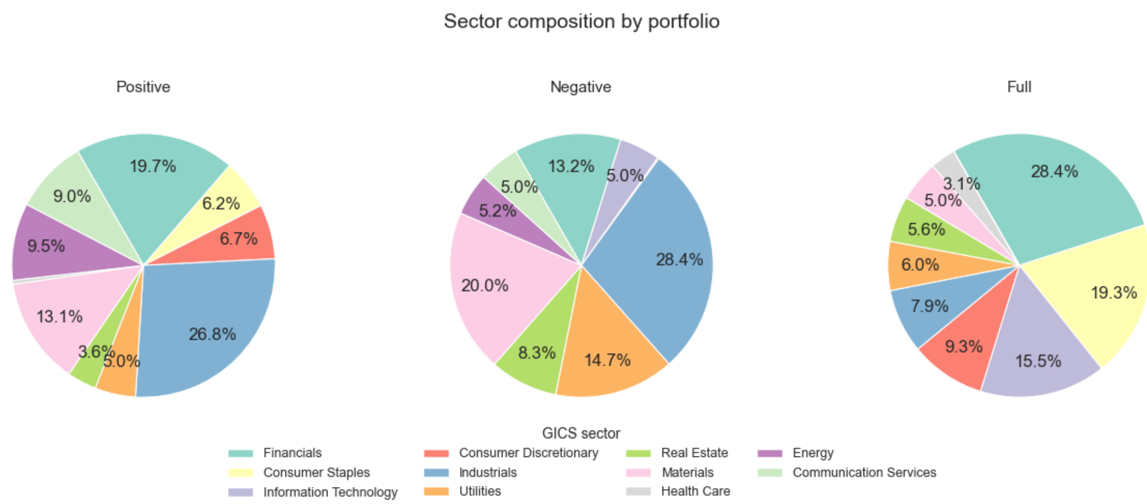
Universe	**Results**							**Parameters**			
	Final NAV	Re (%)	Ri (%)	SR (%)	MD (%)	MDD	HHI (%)	Assets	Credibility thr.(%)	Sector floor(%)	Objective
Positive	**1.58**	**0.09**	0.88	10.79	-16.54	**77**	4.53	154	0	0	SR
Negative	1.30	0.05	0.79	6.93	-13.84	93	4.62	143	0	0	SR
Full	1.52	**0.09**	**0.73**	**11.77**	**-11.42**	87	**4.03**	297	0	0	SR

Note: Best metrics are highlighted for each configuration. Maximum asset weight is 5%.

Legend: NAV: Net Asset Value, Re: Average return, Ri: Risk, SR: Sharpe ratio, MD: Maximum drawdown, MDD: Maximum drawdown duration, HHI: Herfindahl-Hirschman index, MV: Minimum variance.

Over the backtest window, the credible universe exhibits higher realized performance than the non-credible universe, despite weaker in-sample performance. Our findings parallel the "green asset premium" documented by Pástor et al. (2021). While credible firms led to efficient portfolios with lower Sharpe ratios during the calibration period, they outperformed during the backtest period. This pattern suggests that markets may have initially underpriced early climate action, leading to subsequent outperformance as climate risks are becoming more salient. However, the positive credibility portfolio exhibits higher volatility (0.88% vs 0.73% for the full universe and 0.79% for the negative portfolio) despite superior returns. This may reflect sectoral concentration effects and the fact that early decarbonizers often operate in transition-ready sectors. Figure 16 further specifies the composition of the portfolio for each universe.

Figure 16: Composition of the different portfolios



Sector weights for this strategy vary heavily depending on the credibility sign. Portfolio allocation on credible companies favours carbon-intensive sectors such as Industrials, Materials and Energy sector compared to the full sample. For non-credible companies, Industrials and Materials as well as Utilities also represent a larger share of the portfolio. The Financials sector is a particular case, always representing a large share of the portfolio (which is also the case for the original STOXX 600 index), and it is even more significant in the full sample. These results suggest that the performance of portfolios with specific carbon credibilities is also influenced by sectoral considerations.

6 Robustness

6.1 Pessimistic scenario selection

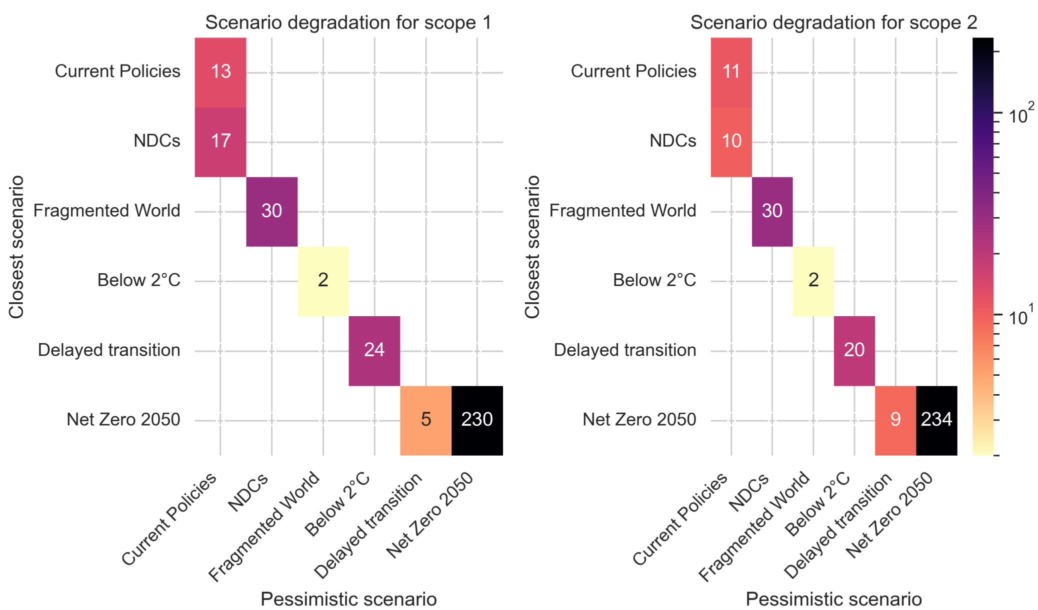
As corporate ambitions are not perfectly aligned with scenario trajectories, relying solely on the closest scenario may lead to an underestimation of future emissions whenever corporate commitments fall systematically short of scenario requirements. To address this, we attribute a pessimistic scenario to companies whose ambition lies between

Net Zero and Current Policies.[9]

For these firms, the pessimistic scenario corresponds to the one that implies the closest higher amount of emissions for the projections. Specifically, we rank all scenarios by their cumulative emissions through 2050 and assign the next higher-emission scenario relative to the company's initially attributed scenario.[10] This represents a conservative approach ("worst-case scenario") when analyzing the transition ambition of sectors and anticipating emissions, as their ambition is always slightly better than the associated scenario.

Graph 17 shows how scenario assignments shift under this pessimistic rule for scopes 1 and 2. The reassignment is performed independently for each scope and horizon for all companies with a future projection, as scopes are projected separately (this includes companies that do not have a credibility value).

Figure 17: Effect of pessimistic scenario selection for the mid-term ambition



We then quantify the resulting increase in cumulative emissions caused by the scenario degradation, focusing on the mid-term horizon and excluding credibility adjustments. Let $\hat{g}_{i,t}$ denote future emissions projected under the

[9]Net Zero companies may still be reassigned if their target reduction is weaker than that of the NGFS Net Zero scenario, and similarly for Current Policies companies when their target is stronger.

[10]We do not compare reduction rates over the target period directly, as scenarios that have higher emissions for a shorter time frame may lead to lower emissions in the end.

pessimistic scenarios. Computed in a similar way to the indicator θ, the indicator of supplementary emissions is:

$$\phi = \frac{\sum_{i,t}(\hat{g}_{i,t} - \hat{f}_{i,t})}{\sum_{i,t}\hat{f}_{i,t}} \tag{9}$$

Table 5 reports the additional emissions across sectors.

Table 5: Percentage of cumulative emissions added by the pessimistic mid-term scenario selection, before adjusting for credibility, as given by Equation 9

Sector	**Global**	Real Estate	Communication Services	Health Care	Consumer Staples	Information Technology
Added emissions	**7.3%**	0.2%	0.5%	1.2%	1.7%	1.7%

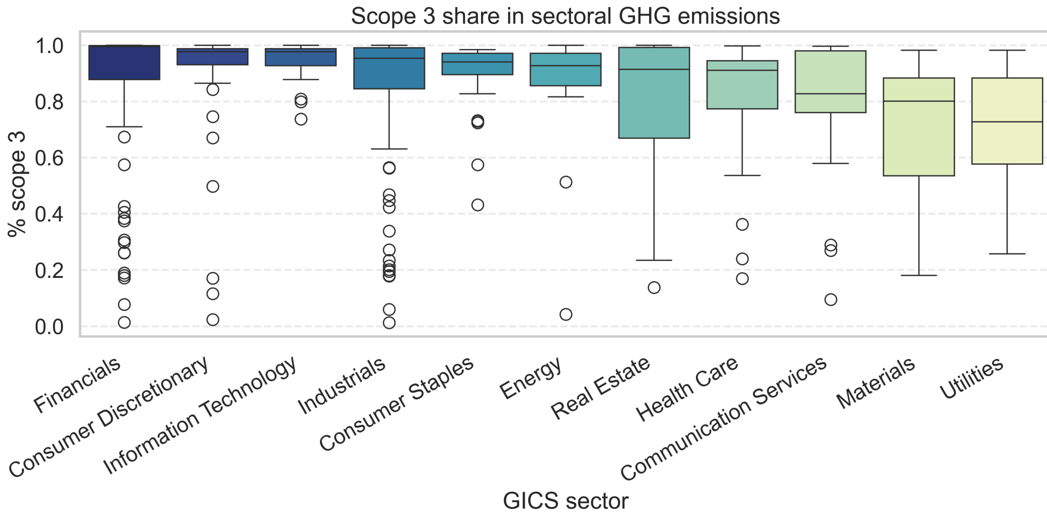
Sector	Utilities	Financials	Materials	Consumer Discretionary	Industrials	Energy
Added emissions	2.3%	4.1%	7.3%	8.1%	10.1%	14.3%

Although most firms are unaffected by the reassignment, the pessimistic approach leads to a significant difference in cumulative emissions up to 2050. Investors incorporating uncertainty in their decision-making must therefore be even more cautious with the company trajectories.

6.2 Considering Scope 3

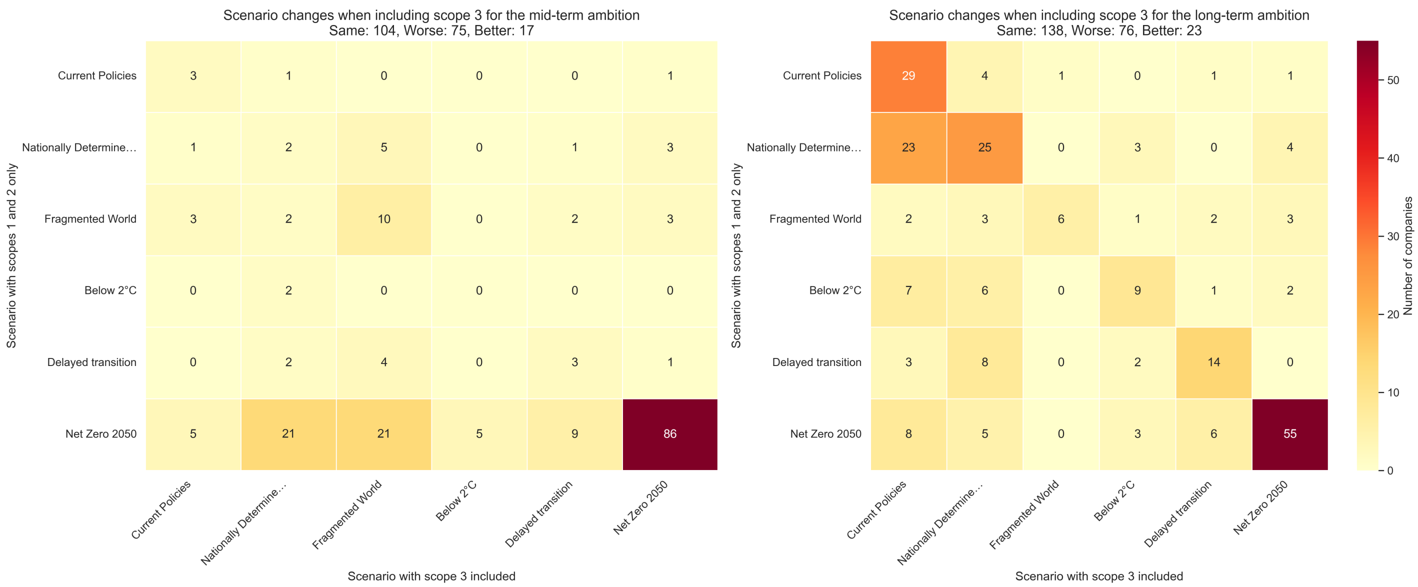
Scope 3 ambition can be included in a straightforward way when attributing the scenario, using the same approach where the reduction factor is weighted by scope importance in the emissions balance. In particular, aggregated ambitions are likely to be mostly driven by scope 3, given the high share that it represents in total emissions, as highlighted in Figure 18.

Figure 18: Share of scope 3 in total emissions by sector



Instead of looking directly at the resulting scenario distribution, we investigate the relative change in scenarios with respect to the scopes 1 and 2 ambition, only including companies with pledged that encompass all scopes. Individual scenario changes are shown in Figure 19 (the short-term horizon is not considered, as too few companies have an ambition for all their scopes in 5 years time).

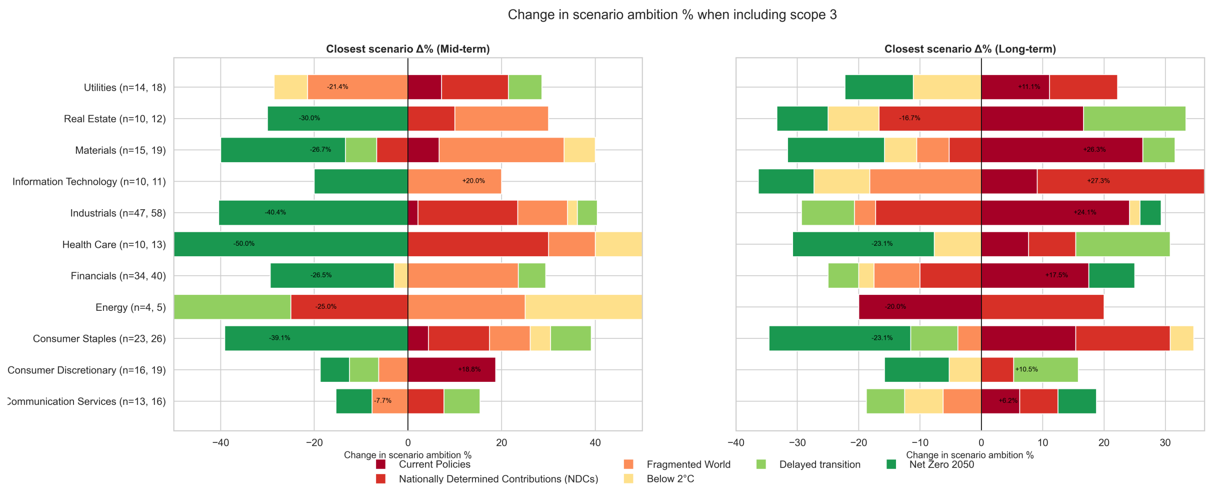
Figure 19: Changes in scenario when including scope 3, mid-term and long-term ambition



Note: The number in a matrix cell at row i and column j is the number of companies that have a reduction ambition associated to scenario i for their scopes 1 and 2 and to scenario j for their scopes 1, 2 and 3. Corporate ambitions are degraded when including value-chain emission reduction targets if they are in the lower triangular part.

More than half of the companies have a similar ambition when including scope 3 reduction targets (diagonal part). Adding companies with a worsened ambition for their whole emissions (lower triangular part, 75 out of 194 for the mid-term ambition and 76 out of 237 for the long-term), this overwhelming majority of unimproved ambition confirms the priority put in reducing scopes 1 and 2 emissions before the other value chain emissions. Only a few have set scope 3 targets so ambitious that they obtain a climate scenario with lower risks. This result is coherent with the reduced control that companies may have initially over their entire value chain compared to their own emissions. At the sector level, we can observe how much the scenario distribution is modified by the difference in ambitions that deal with the value chain (Figure 20).

Figure 20: Change in scenario ambition when including scope 3



Note: The value displayed corresponds to the scenario with the largest change for each sector.

Including the scope 3 has a serious consequence on the scenario distribution. With the mid-term horizon in particular, the landscape of sectoral ambitions is severely degraded, as transition plans are generally not demanding enough to respect the Net Zero trajectories. For the furthest horizon, a significant rise in Current Policies-aligned transition plans can be observed, as the total balance in emissions is not expected to decrease by a sufficient amount. As a result, it appears companies have not designed strategies compatible with low carbon scenarios when accounting for their whole value chain, knowing that scope 3 usually represents the highest share in their emission balance.

This result implies far higher amounts when attempting to project emissions for the scope 3 as well. However, one would need to consider double counting, as scope 3 emissions from different companies can result from the same supplier or client. If this supplier or client decreases its own emissions, both companies will have decreased scope 3 emissions. As a consequence, additional modeling would be needed to include the interactions between industries.

7 Conclusion

This paper introduces a methodology to match the ambition of a company with climate scenarios, using expected emission reduction rates. Corporate emissions are then projected using NGFS data from these scenarios to estimate a complete emission pathway. This projection is compared with the initial reduction performed by the company to derive a measure of credibility that adjusts its future emissions, under the assumption that early progress provides meaningful signals about the firm's ability to deliver on its commitments. These steps produce several key outcomes: GHG emissions estimates for the coming decades, identification of companies that are falling behind their expected trajectory, and the clustering of firms according to the climate scenarios that best characterize their transition pathways.

The application of this method to companies in the STOXX 600 leads to alarming results. Current action is insufficient to follow expected reduction pathways. Despite ambitious pledges, almost half of the firms have failed to keep up with the reduction required by their ambition. This lack of action implies higher emissions as companies struggle to make up for the delay. Up to 5% additional emissions are likely to be created for the STOXX 600, compared to what scenarios matching their ambitions imply, if companies behind schedule do not accelerate their decarbonization processes, even though there are companies ahead of time. Moreover, leading companies will probably make less efforts if they are confident that they will reach the targets. All companies must implement better processes to avoid major climate risks and meet their objectives, which may already be lower than the requirements of the Paris Agreement. Under policy assumptions of stringent climate scenarios, additional emissions would be associated with extreme costs for these firms and the economy as a whole.

These findings intensify when adopting a worst case approach in the model, with the pessimistic framework introduced earlier. By systematically assigning a less demanding scenario whenever corporate ambition lies between two NGFS pathways, we reveal how apparently small differences in scenario selection can compound over time for a reduced number of companies. Under this conservative assumption, cumulative emissions may increase by more than 7% relative to projections based on closest-scenario matching. Neglecting these dynamics could lead to systematic underestimation of transition risks and, ultimately, to suboptimal strategic decisions in portfolio construction and climate-related financial planning.

This methodology is applied to several hundred large-capitalization European firms and their scope 1 and 2 pledges. SBTi insights suggest that at least thousands of companies worldwide have now set climate commitments. Extending the analysis to a broader sample would offer a more comprehensive picture of the climate landscape of the global economy. Incorporating scope 3 data is equally essential, as any credible pathway to decarbonization requires coordinated efforts across entire value chains. The ability of a firm to meet its GHG targets ultimately depends on the participation of other sectors; as a consequence, knowledge of the future behavior of these sectors can alter its expected emissions. Accordingly, a more sophisticated model would account for relationships between entities instead of treating them as independent. Companies are likely to improve their processes when they significantly lag their peers. This notion of relative performance is determinant when using the projections to anticipate trends in ESG indicators, which usually reflect comparative assessments across companies. Finally, addressing uncertainty is a central challenge: how far from the predictions can the real emissions and ESG indicators be, given the variability in measurements and corporate actions? Quantifying this information is particularly beneficial for informed financial planning and for improving investors' understanding of the risks associated with the low-carbon transition.

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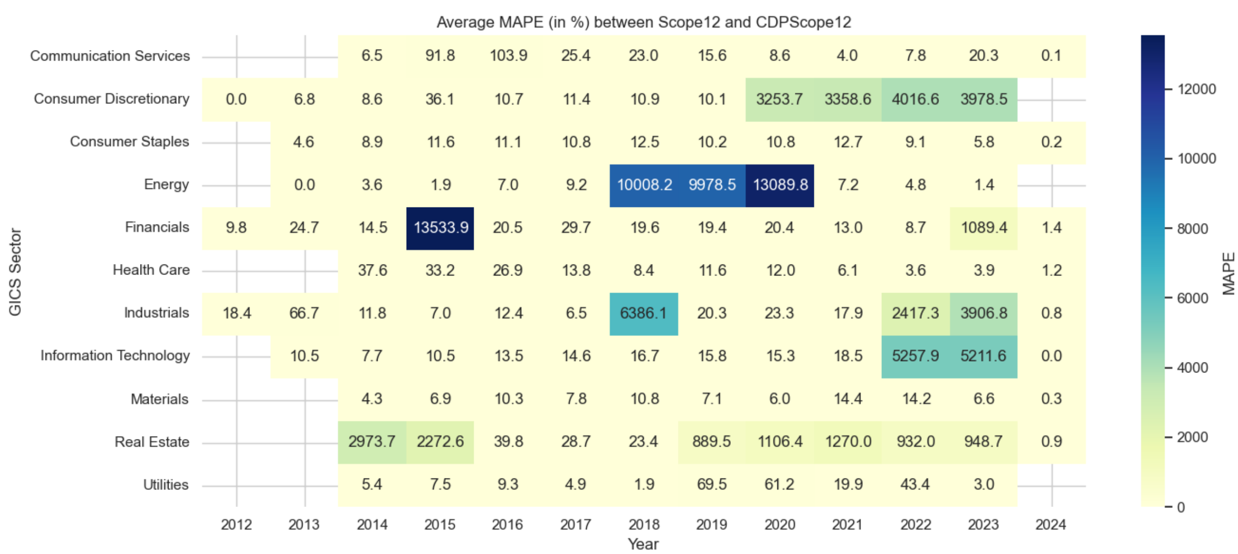
A Appendix

A.1 Discussion about GHG data

Corporate GHG-related data are highly volatile. There are many causes of uncertainties related to targets or emissions. To begin with, LSEG Workspace provides an LSEG and a CDP dataset. A private methodology is used by LSEG to harmonize the target and emission data from multiple sources (including the CDP questionnaire) to create the LSEG dataset, which may also involve estimations of company emissions when not reported. To illustrate, Figure 21 displays the average MAPE (in %) by GICS sector and by year between scopes 1 and 2 emissions data from the LSEG and CDP dataset.

Figure 21: Divergence between CDP and LSEG emissions data



There are sector-years with an unrealistic discrepancy between both datasets. Looking at the individual companies with the highest divergence, recurring patterns seem to explain the high value. For some companies, there are no data for scope 3 for LSEG, but the combined value for scopes 1 and 2 is close to the CDP combined value for scopes 1, 2 and 3, as if the datapoint was shifted (or added) from scope 3 to another. For others, there is a factor 1000 between the CDP and LSEG value, suggesting that a different unit was used.

In addition, issues are present in the data even when using only one of the databases. A process was applied to detect illogical emissions and remove them. When emissions for a year had a difference in magnitude of over 10^3 tCO_2eq compared to emissions in the former and following years, they were discarded. Similarly, when there was a jump between the two last years in the dataset, the last one was removed. Finally, manual correction on individual years was applied to three outliers that had extreme credibility values when the GHG data was publicly accessible and consistent with the rest of the company's emissions.

Inconsistencies are also found in the dataset for the targets. For example, a company in the Global sector incorrectly had short-term targets for several years in the LSEG dataset; the issue was flagged and subsequently corrected by the LSEG team. These were manually identified, but other issues may be more difficult to find if they do not cause abnormal results.

Another issue stems from the principle of carbon offsetting. Companies can specify the amount of residual emissions that will be offset while announcing targets, but it is not common practice. Kreibich and Hermwille (2021) find that almost half of the companies in their datasets are ambiguous about the use of offsets in their pledges. In the database employed here, no precise information on the offset amount is included. Using scenarios to translate reduction ambitions ensures that projected emissions are realistic, since they do not include offsets. Hence, a company may be flagged as less credible if it relies too much on offsetting in their target accomplishment. Still, this issue concerns companies that do not try to completely decarbonize their processes in the long-term, but instead plan to buy large amounts of carbon offsets. Therefore, it seems acceptable to favor those that actually avoid relying on offsets, as advocated by alliances such as the UN Race to Zero (see Hale et al., 2022).

The CDP dataset was chosen instead of the LSEG dataset for several reasons. The first is that the LSEG dataset involves additional steps to convert company data from mixed sources, whereas CDP data are given as reported in the questionnaire, which is a single source and only available since 2012 for most of the dataset. Using the LSEG dataset results in 322 companies having a carbon credibility value instead of 297. The small difference in completeness was not sufficient to outweigh the reduced transparency of the LSEG dataset, and there are even more extreme credibility values. The second is that the CDP dataset includes the datapoints "Boundary Coverage" for most targets. Boundary coverage is defined as the percentage of emissions that are covered by the target. This information is crucial to evaluate corporate ambitions, as a 90% reduction target that only concerns half of the emissions effectively corresponds to a reduction ambition of 45% (which is far from Net Zero standards). This is even more important when applying this method to scope 3 data, since companies focus their efforts on specific subcategories of their scope 3 (value chain) emissions.

Overall, these results appear to be quite problematic when using carbon data in financial strategies. A company may appear as a top performer using data from the CDP questionnaire, while its LSEG emissions would indicate a subpar performance, or vice versa. This divergence calls for accrued caution when performing GHG emissions-based decisions.

A.2 Technical details about scenario selection

Additional treatment is performed for the scenario selection process. The target preprocessing involves the following steps:

1. If the target type is both "Absolute" and "Intensity", it is replaced by "Absolute".
2. If there is a 100% reduction target with no base year, the most recent base year from other targets (if any) is used.
3. If target characteristics (scope, base year, target year, target type, percentage reduction targeted) are still missing, the target is removed.
4. If there are targets with the same characteristics apart from percentage reduction targeted, the most recent is selected, and the less ambitious if both were registered the same year.[11]
5. Remove intensity targets.

Then, a target prioritization process is applied. For each horizon (short, mid, or long term), only targets with the maximum priority score are kept. The scoring process is as such:

1. Remove targets that only concern scope 3 (as they may be more recent) for the methodology applied to the scopes 1 and 2 .

[11] This is due to some Net Zero targets registered as 100% reduction in LSEG Workspace while companies may have another definition for Net Zero.

2. Keep only the most recent targets.
3. Keep the most precise scope. If there are separate targets for scopes 1 and 2, they are both kept. Then, targets concerning both scopes 1 and 2 are selected, and finally targets for all scopes.
4. Keep targets with the latest target year.
5. Keep targets with the most recent base year.

If scopes 1 and 2 are split, there can be multiple targets for the same horizon. Otherwise, this process leads to a single target per horizon, as duplicates were removed beforehand. In the projections, scopes 1 and 2 are projected separately. A total scenario can be obtained by weighting the reduction rate proportionally to the percentage of each scope in the initial emissions (most recent base year, or in 2020).

A.3 Carbon Overhang comparison

For an alternative approach as to how high carbon costs may be according to the projections, we adapt the Carbon Overhang methodology by Ahn et al. (2025) to our NGFS scenario data and the market capitalization of our universe retrieved in LSEG. Table 6 summarizes the main assumptions and comparative results.

Table 6: Comparison of aggregate carbon-implied costs for the projections between Ahn et al. and this study, using the Carbon Overhang methodology.

Metric	**Ahn et al.**	**This paper**
Total market capitalization of the universe (USD tn)	48.24	12.14
Most recent total GHG emissions ($GtCO_2eq$)	2.28	0.493
Pass-through of carbon costs for regulated utilities	0%	0%
Carbon price trajectory	High-cost scenario (IEA, S&P)	Net Zero scenario (NGFS)
Discount rate	8.31%–9.97% (cost of equity capital)	9% (fixed)
Carbon overhang (COH) through 2050 (USD bn)	3,083.5	731.8
Share of firms with COH / Market Capitalization > 1	4.7%	4.14%