Exploring ITR scores: Framing robust company-specific benchmarks and future company-level GHG emissions ranges*

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Abstract

As investors are looking to align their portfolios with the goals of the Paris Agreement, forward-looking portfolio metrics like Implied Temperature Rise (ITR) are becoming increasingly popular. In this paper, we describe a Task Force on Climate-Related Financial Disclosures (TCFD)-aligned ITR methodology based on absolute GHG emissions, which includes two important methodological innovations: First, we introduce constituent-specific decarbonisation benchmarks that blend sectoral pathways, which account for firm diversity more effectively. Second, we take a probabilistic approach to projecting GHG emissions trajectories, which better reflects plausible future emissions reductions for individual companies. We use the results to compare ITR scores with static portfolio metrics such as carbon footprints; and explore the impacts of integrating Scope 3 emissions and voluntary corporate emission targets on ITR scores.

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1 Introduction

Financial institutions need to reduce the Greenhouse Gas (GHG) emissions linked to their investments to align with the objective of the Paris Agreement[6] of limiting global warming to well-below 2°C (ideally 1.5°C) above pre-industrial levels. A growing body of literature from both practitioners and academics as emerged to quantify reductions and measure the alignment[5],[36]. Among them, a new methodology focusing on the relation between the "climate performance" of an asset and the overall objective of limiting temperatures to well-below 2°C has emerged: Implied Temperature Rise (ITR) methodologies.

The Portfolio Alignment Team (PAT) convened by the TCFD [30] defines the ITR methodologies as a way to translate "an assessment of alignment/misalignment with a benchmark into a measure of the consequences of that alignment in the form of a temperature score that describes the most likely global warming outcome if the global economy was to exhibit the same level of ambition as the counterparty in question." [29]. It gained significant momentum over recent years[1] and offers the advantage of being a concise and easy-to-communicate indicator.

However, the sensitivity of ITR to its model inputs and the complexity of the methodology has provoked criticism from some quarters[2]. According to the Bank of England, "relatively minor methodological variations using the same portfolio produced alternative estimates ranging from < 1.75°C to 4°C." [40]. The discrepancy between models of different providers has been highlighted in a report by the Institut Louis Bachelier [13], where they found significant dispersion in degree warming results at company and portfolio level. Several initiatives are working towards creating a common framework, to increase comparability and benchmarking between methods. As a result, the PAT recently published a guide (see [29]) to build ITR scores, highlighting the three following steps: (1) translate carbon budgets into benchmarks, (2) assess company-level alignment and (3) assess portfolio-level alignment.

This new framework provides some needed structure for ITR scores but still leaves significant methodology choices open to interpretation. These choices are strongly tied to the quality, variety, availability and granularity of the input data as well as the expected overall coverage of the final metric [9]. This has deep connections with the trade-off between robustness and precision, between building an ITR score for a single or a few sectors or for a more global coverage [22]. More precisely, what remains open to interpretation is how country- and sector-level pathways are adapted at company-level and how company-level future GHG emissions, required to assess the company-level alignment, are computed. These issues have also been recently highlighted by the Glasgow Financial Alliance for Net Zero (GFANZ) as key "methodology focused barriers" for broader adoption of ITR metrics [42].

[1]According to a study by Novethic, 25 investors out of 100 measured an ITR score in 2019 against 18 in 2018: https://www.novethic.fr/fileadmin//user_upload/tx_ausynovethicetudes/pdf_complets/Novethic_2020_173-nuances-de-reporting-Ultime-saison_etude.pdf. (Accessed: 21/03/2022).

[2] See for example the comments from the Transition pathway Initiative https://www.transitionpathwayinitiative.org/publications/73.pdf?type=Publication (Accessed: 22/03/2022).

Detailed and technical descriptions of those steps are, to the best of our knowledge, sparse in the literature. This paper aims at filling this gap by providing a detailed description on (1) how country- and sector-level pathways can be adapted at company level and (2) how to build the company-level future emission pathways needed to assess company-level alignment for a global and diversified portfolio. With this exercise, we are focusing on two essential steps in computing ITR metrics and aim to provide a coherent basis allowing for future discussion and improvement.

This paper will first review the existing literature on ITR metrics. Section 3 focuses on the methods used to derive company-level benchmarks and future pathways. Section 4 describes the data used in our study. Section 5 provides results at portfolio-level allowing to uncover the specificity of our methodology. Section 6 provides a sensitivity analysis of the results and Section 7 concludes.

2 Literature review

In the last two decades, the quantification of a carbon budget associated with a potential warming temperature has been the subject of a large scientific literature [19]. Jointly, the relationship between GHG emissions and temperature increase [3][25] and the notion of a GHG emissions budget as a threshold for stabilising this increase [44] has been documented in numerous articles. Since 2014, the Intergovernmental Panel on Climate Change (IPCC) has become the scientific reference for addressing these budgets and their range to limit the temperature increase. Their recent publications has defined the global carbon budget for 2°C [15] or 1.5°C [16] temperature increases[3].

New fields of research on the global carbon budget breakdown at country- or sector-level have emerged as a result. On one hand, country-level budgets are widely covered by the academic literature [10][32][43][28][27][34][11]. On the other hand, sector-level budgets are poorly covered by academic literature [38]. To this extent, the private sector, and particularly the financial sector, has taken on the role of filling this gap by developing a large variety of scenarios covering all or part of the global economy. From the top-down scenarios (IEA[14], OECM[39], NGFS[26], Climate Technology Compass (CTC) [1]) to the bottom-up [41], there is a wide range of sector pathways and methodologies available in the public domain.

In parallel, financial sector institutions have also developed a whole research field on assessing the alignment of companies with these sector pathways. In 2015, the concept of alignment at company-level emerged in finance around assessment of targets with the Sectoral Decarbonization Approach [18][37]. While assessing targets alignment [8] brought consistency in target setting, other institutions developed subsequently scientifically backed approaches to assess if a company is on pathway or not [7][21][4], with the Transition Pathway Initiative (TPI) developed by the Grantham Research Institute at the London School of Economics being one of the main research centers in this field[4,5].

[3]The global carbon budget will be updated in the latest IPCC report, expected to be published in April 2022.
[4]All publications available: https://www.transitionpathwayinitiative.org/publications. (Accessed:25/03/2022).
[5]FTSE Russell is the TPI's data partner, https://www.transitionpathwayinitiative.org/strategic-relationships.

While literature on carbon budgets and company alignment is abundant, academic literature on portfolio alignment metrics remains limited. Indeed, there is still a debate on the scientific relevance of such an indicator, where different assumptions and their uncertainties are fused into a single metric [33].While several papers have computed carbon budgets and resulting temperature for sovereign asset classes [11][12], few have tackled this issue for corporate asset classes.

Two main research initiatives that outline an ITR score methodology are the Institut Louis Bachelier [13] and the PAT [29][31]. The former provides a systematic review of the different methodological choices and their implications made by the practitioners. The latter provides a framework to build a degree warming alignment methodology, organized around the following topics:

- Translating scenario-based carbon budgets into benchmarks
- Assessing counterparty-level alignment
- Assessing portfolio-level alignment

This framework provides a structure for ITR scores but detailed and technical descriptions of the underlying steps are sparse in the literature. This represents a main barrier to adoption by financial sector practitioners [42]. Thus, our research proposal documents a topic that is not well-referenced to date, providing a detailed view of these steps. It highlights the complexity of the key methodological choices to build a portfolio-level ITR score.

3 Methodology

Following the PAT report we build our ITR methodology using three steps: (1) compute the company-level benchmark, (2) project the company's future GHG emissions and (3) assess a portfolio-level temperature

3.1 The company-level benchmark assessment

The company-level benchmark is the theoretic GHG emissions trajectory to achieve a given temperature rise *(e.g.,* 1.5°C for Paris-aligned benchmarks). The global temperature increase being directly linked to a carbon budget, our benchmarks are expressed in absolute emissions to preserve this relation. We allocate a share of the carbon emissions resulting from the global pathway to each company in our company universe[6], while adjusting the total carbon budget to its size[7].

The company-level benchmark is derived from country- and sector- level pathways. The main challenge of this step is to reconcile top-down scenarios with bottom-up corporate data. This can be straightforward for some high-emitting sectors where the emissions mechanisms are clearly defined and limited to a constraint geographic area. An example of such a sector is power generation where its direct emissions are linked to its power mix. To date, most of the methodologies are based on a one-to-one approach and do not account for the following: companies are multisectoral and multi-regional, with complex

[6]The corporate universe is the list of the companies for which we compute an ITR score.

[7]For example, if the carbon budget in 2050 is 100 tCO2-eq, but our corporate universe only accounts for 50% of the economy, we need to adjust the carbon budget for this factor.

emissions mechanisms. This leads to the question of how to reconcile the global pathways with the corporate universe and account for its diversity.

We answer this question by creating company-specific benchmarks, that are the aggregation of all country- and sector- specific ones and where the universe is coherent with the studied corporate universe.

We consider the following time period $T = [t_0, \dots, t_h, t_f, \dots t_{N_T}]$, where t_0 is the first year the data is reported, t_h is the last year for which historical data is reported, t_f is the first year which requires projection and t_{N_T} (with N_T the number of time steps) is the last year for the data projection.

The corporate universe is called I, and each company is denoted by subscript i ($i \in I$). We define two distinct sets I_1 and I_2, with the former being our corporate universe and of size N_{I_1}. The latter is the list of companies not covered. Moreover, each country and sector is denoted by c ($c \in C$), where C is the country list of size N_C) and s ($s \in S$ where S is the sector list of size N_S) respectively. The scope of emissions is denoted by j where $j \in \{Scope_1, Scope_2\}$.

Finally, for each company $i \in I$, we adopt the following norm: time-series will be designated by vectors $X_i = [X_i, t_0, \dots, X_{i,t_{N_T}}]$, where $X_{i,t}$ is the value of that indicator for company i at time t. Table 1 defines the used vectors.

Notation	Dimension	Description
$P_{s,c,j} = \left[P_{t_0,s,c,j}, \dots, P_{t_{N_T},s,c,j}\right]$	$1 \times N_T$	The country- and sector-level GHG emission pathway, with N_1 being the last year for the data projection in sector s and country c
$E_{i,s,c,j} = \left[E_{i,t_0,s,c,j}, \dots, E_{i,t_{N_T},s,c,j}\right]$	$1 \times N_T$	The company-level GHG emissions
$R_{i,s,c} = \left[R_{i,t_0,s,c}, \dots, R_{i,t_h,s,c}\right]$	$1 \times h$	The company-level revenues, with h being the last year for which historical data is reported for company i in sector s and country c
$B_{i,s,c,j} = \left[B_{i,t_0,s,c,j}, \dots, B_{i,t_{N_T},s,c,j}\right]$	$1 \times N_T$	The company-level benchmark

Table 1: Description of the used-notation

For each country c and sector s, we have:

$$P_{t,s,c,j} = \sum_{i \in I_1} P_{i,t,s,c,j} + \sum_{i \in I_2} P_{i,t,s,c,j} \tag{1}$$

At each time t, the pathway $P_{t,s,c}$ is the sum of Scope j emissions in country c and sector s resulting from the companies inside and outside our universe[8]. To build the company-specific benchmarks for the defined universe, we only use the first part, that we call $\hat{P}$, thus

[8]Note that this is a theoretical standpoint: the pathway also includes emissions from consumers, governments, etc. For ease of understanding, our equation only mentions the corporate emissions.

$$\hat{P}_{t,s,c,j} = \sum_{i \in I} P_{i,t,s,c,j}.$$

To obtain $\hat{P}$, we compute the share of the pathway that is ascribed to our corporate universe. We start by computing the region- and sector- breakdown of GHG emission for each company i ($where\ t \in \{t_0, \dots, t_h\}$, the period for which we have historical data):

$$E_{i,t,j} = \sum_{c \in C} \sum_{s \in S} E_{i,t,s,c,j} \tag{2}$$

where $E_{i,t,s,c,j}$ are the Scope j emissions from company i at time t in country c in sector s[9]. Then, for the period where we have historical data, we compute the share of emissions from our corporate universe that are included in the pathway:

$$Ratio_{c,s,j} = median_{t \in \{t_0, \dots, t_h\}} \left(\frac{\sum_{i \in I} E_{i,t,s,c,j}}{P_{t,s,c,j}} \right) \tag{3}$$

Finally, for $t \in \{t_0, \dots, t_N\}$ we obtain:

$$\hat{P}_{t,s,c,j} = Ratio_{c,s,j} * P_{t,s,c,j} \tag{4}$$

where $\hat{P}_{t,s,c,j}$ is the pathway that will be distributed into the company-specific benchmarks.

The company-specific benchmark is obtained by summing over countries and sectors.

$$B_{i,t,j} = \sum_{c \in C} \sum_{s \in S} B_{i,t,s,c,j} \tag{5}$$

To compute each individual $B_{i,t,s,c,j}$, we start by computing the breakdown for revenues:

$$R_{i,t,j} = \sum_{c \in C} \sum_{s \in S} R_{i,t,s,c,j} \tag{6}$$

For each company, we then estimate the share of its revenues in each sector and country:

$$Share_{i,c,s,j} = median_{t \in \{t_0, \dots, t_h\}} \left(\frac{R_{i,t,c,s,j}}{\sum_{i \in I} R_{i,t,c,s,j}} \right) \tag{7}$$

The benchmark for company i at time t is given by:

$$B_{i,t,j} = \sum_{c \in C} \sum_{s \in S} Share_{i,c,s,j} * \hat{P}_{c,s,t,j} \tag{8}$$

[9]Please refer to Appendix A for more details about the methodology used to distribute the company-level emissions into countries and sectors.

This approach allows us to obtain a unique benchmark for each company, depending on its revenue breakdown by activity and by country and using a fair-share approach. Figure 1 highlights how this can already provide insightful information, when put in perspective with historical data:

- Company A has higher absolute emissions but its current emissions are lower than its benchmark. However, its activity requires a quicker decarbonization and its benchmark has to reach a higher rate of reduction over time.
- Company B has lower absolute emissions but they are higher than its current benchmark. The yearly rate-of-reduction of its benchmark is lower and it may be easier for this company to attain its benchmark by 2050.

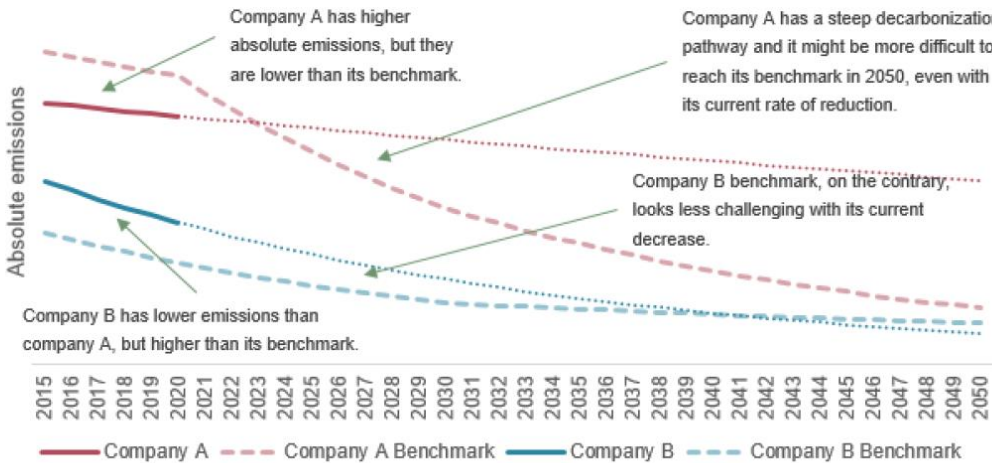

Figure 1: Illustration of the alignment of companies' GHG emissions pathways and their benchmarks.

Source: London Stock Exchange Group, Sustainable Investment Research.
Note: The company's emission trend is based on the historical year-on-year variation.

3.2 The company-level future GHG emissions assessment

The company future GHG emissions are an assessment on how, given current information, its GHG emissions might evolve until 2050. Usually, the main source of information used is the self-reported targets of the companies. While a company is not legally compelled to attain its target, it constitutes a reasonable proxy of the company's ambition. Nevertheless, target reporting is not standardized yet and doubts exists about the credibility of certain targets [17].

In addition, the majority of companies still do not publish targets and the future emissions have to be assessed with other information. This can be done using the company's current assets and their associated level of emissions. While this constitutes a good proxy to estimate a short-term forecast for high-emitting sectors, this is less suited for long-term forecasts or service sector companies. Another method relies on the past evolution of the company's emissions (see [21]), assuming that the long-term trend will follow past decarbonization pace, an assumption rarely met.

Our methodology builds upon these findings, by combining both approaches:

- If the company publishes a target, we build a future emissions assessment using the target;
- If the company does not publish a target, we build a future emissions assessment based on a projection of current emissions.

3.2.1 Case 1: The company publishes a target

The target expresses the level of ambition of a company. Due to the different reporting horizons, parts of the future emission pathway may have to be estimated. We use a conservative approach, by estimating a range of probable emissions beyond the target's time horizon. This range of possible emissions is built using the following steps:

- First, we take a company's target as granted. We do not conduct additional analysis on a company's chance or ability to reach its target[10];
- Second, we estimate a range of probable emissions beyond the target's time horizon.
  - Step 1: the upper pathway is the value of the target, as it is unlikely that a company having attained its target will further increase its emissions[11];
  - Step 2: the lower pathway is the pathway derived from the IPCC scenario RCP 2.6.

Figure 2 details this methodology, where the company target is set in 2030. The emission pathway is thus projected until 2030. Between 2030 and 2050, the company final pathway is sampled within the range.

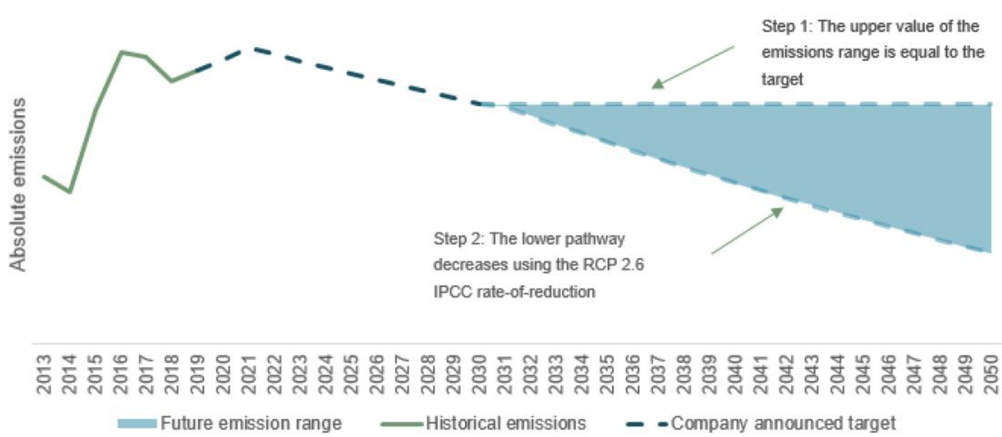

Figure 2: Illustration of the emissions pathway construction methodology.

Source: London Stock Exchange Group, Sustainable Investment Research.

[10]For a discussion on the effect of including targets, please refer to Section 6.2.

[11]We implicitly assume that companies will reach their targets while currently there is few data available to support this assumption. This will be discuss further in Section 5.2.

The steps are outlines in Algorithm 1. For a description of the Compound Annual Growth Rates (CAGR) used, see Appendix B. In the following, targets are defined in the following space:

$$\text{Target} = \left\{\left(i, j, t_1, t_2, \mathrm{R_{i,j}}(t_1, t_2)\right)\right\}$$

Where i is the company reporting the target, j is the emission's Scope, t_1 is the beginning period of the target, t_2 is the ending period of the target and $\mathrm{R_{i,j}}(t_1, t_2)$ is the carbon reduction for company i for emission j between t_1 and t_2[12].

Algorithm 1 Case 1: The company publishes a target

for $j \in \{Scope_1, Scope_2\}$ **do**
  Set $E_{i,j,t_2} = E_{i,j,t_1} * \left(1 - \mathrm{R_{i,j}}(t_1, t_2)\right)$
  Set $CAGR_{i,j}^{target} = \left(\frac{E_{i,j,t_2}}{E_{i,j,t_1}}\right)^{\frac{1}{t_2 - t_1}} - 1$
  Set $CAGR_{i,j}^{low}$[13]
  for $t \leftarrow t_p$ to t_{N_T} **do**
    if $t \leq t_2$ **then**
      $E_{i,j,t} = E_{i,j,t-1} * \left(1 + CAGR_{i,j}^{target}\right)$
    else
      $E_{i,j,t}^{high} = E_{i,j,t_2}$
      $E_{i,j,t}^{low} = E_{i,j,t-1} * \left(1 + CAGR_{i,j}^{low}\right)$
    end if
  end for
end for

We call $E_{i,j,low}^{target}(t_f, t_N)$ and $E_{i,j,high}^{target}(t_f, t_N)$ the the lower and higher future GHG emissions pathway for company i and Scope j between t_f and t_N respectively, assuming that the company publishes a target.

For each company i, Scope j and dates t_f and t_N, the future GHG emissions pathway range is defined by its upper bound and lower bound. An implicit assumption of this algorithm is that the company will, in the worst case scenario, attain its target. This assumption is debatable, and comparison of results when including the target or not is available in Section 6.2.

3.2.2 Case 2: The company does not publish a target

When the company does not publish a target, a conservative approach is used with the estimation of a plausible pathway range. It is based on the following steps:

- Step 1: historical evolution of emissions[13] are used to compute the first five years of the projection. Indeed, past data can be considered a good predictor of near-future performance.

[12]For example, Company A reports a reduction of 50% of its Scope 1 emissions by 2030 compared to 2015 levels.
[13]Definition and time frame are available in Appendix B.

- Step 2: the following 10 years are built as a range derived from IPCC's RCP 2.6 and RCP 8.5 scenarios.
- Step 3: the range is extended until 2050, where the upper bound of the range progressively decreases. Indeed, we assume that future regulation changes and potential reputational damage will make it highly unlikely that companies won't decrease their GHG emissions.

The objective is to model a possible GHG emissions range, accounting for the significant uncertainty in future emissions. The methodology works as a funnel sequence: the largest range of possible emissions for a company is generally comprised in the RCP 2.6 and RCP 8.5 scenarios from IPCC [15]. The range is then gradually refined, using first sector-level assumptions, then company-specific assumptions. As an illustration, Figure 3 highlights the separate steps used in the methodology.

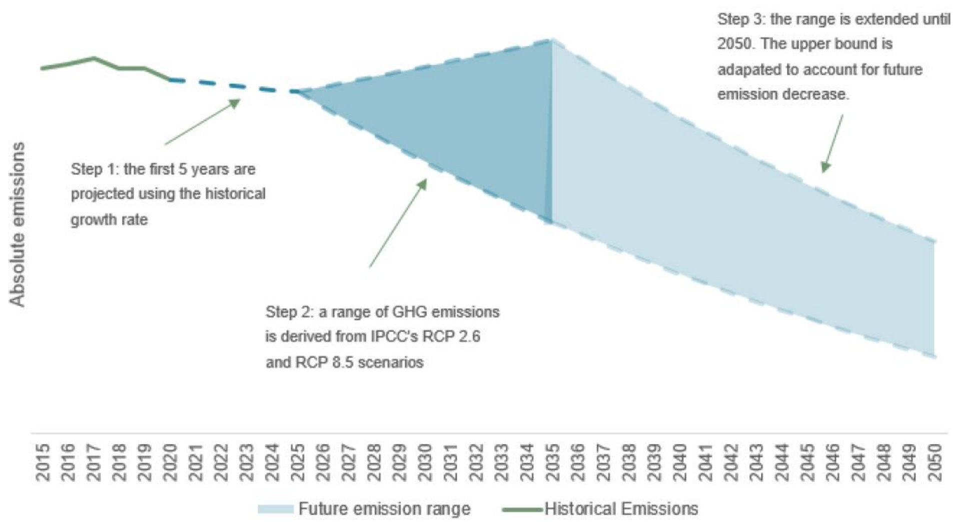

Figure 3: Description of the emission pathway construction methodology when the company does not disclose a target.

Source: London Stock Exchange Group, Sustainable Investment Research.

The extension from 2030 until 2050 of the plausible range in the last step assumes that most companies will reduce their emissions at a certain point due to regulation constraints and reputational risks. This underlying assumption is included with an upper pathway that is decreasing from 2030. As for the case when the company has a target, an individual pathway is sampled within the range, allowing to account for the uncertainty of estimating future pathways.

Algorithm 2 details the steps of this process, using notation from Section 3.1[14].

[14]Definitions for the used CAGR are available in Appendix B.

Algorithm 2 Case 2: The company does not disclose a target

for $j \in \{Scope_1, Scope_2\}$ **do**
  Set $CAGR_{i,j}^{hist}, CAGR_{i,j}^{high}$ and $CAGR_{i,j}^{low}$
  for $t \leftarrow t_p$ to t_{N_T} **do**
    if $t \leq t_p + 5$ **then**
      $E_{i,j,t} = E_{i,j,t-1} * \left(1 + CAGR_{i,j}^{hist}\right)$
    else if $t_p + 5 < t \leq t_p + 15$ **then**
      $E_{i,j,t}^{high} = E_{i,j,t-1}^{high} * \left(1 + CAGR_{i,j}^{high}\right)$
      $E_{i,j,t}^{low} = E_{i,j,t-1}^{low} * \left(1 + CAGR_{i,j}^{low}\right)$
    else
      $E_{i,j,t}^{high} = E_{i,j,t-1}^{high} * \left(1 + CAGR_{i,j}^{low}\right)$
      $E_{i,j,t}^{low} = E_{i,j,t-1}^{low} * \left(1 + CAGR_{i,j}^{low}\right)$
    end if
  end for
end for

We call $E_{i,j,low}^{\emptyset target}(t_f, t_N)$ and $E_{i,j,high}^{\emptyset target}(t_f, t_N)$ the lower and higher future GHG emissions pathway for company i and Scope j between t_f and t_N respectively, assuming that the company does not publishes a target.

Using this methodology, we obtain an upper and lower bound for future emission pathways for our corporate universe. The next step is to assess the gap between the benchmark's and the company's future estimated emissions to compute an ITR score at company level. The last step is to aggregate the ITR scores at portfolio level. These steps are outlined in the next section.

3.3 Assess a portfolio-level temperature

To compute our ITR scores, we use an equation adapted from IPCC [16] and Rogelj [35], relying on a physical relation between emissions and temperature. This equation is estimated in the scientific literature and consolidated in IPCC reports. It is mainly based on a coefficient called the "Transient Climate Response to cumulative carbon Emissions" (TCRE), or, in other words, the global temperature change per unit of CO_2 emitted.

3.3.1 Compute a company-level temperature

To calculate a global temperature variation T that would result from the carbon budget CB, the determination equation needs some adjustments in addition to the TCRE term. As a result, the following temperature equation is applied at company level in our methodology:

$$T_i = TCRE * \left(CB_i + CB_{safe}\right) + T_{hist} + T_{non-CO_2} \tag{9}$$

With:

- T_i the ITR score for company i;
- CB_i the carbon budget for company i;

- CB_{safe} the safety budget (in GtCO2) in anticipation of retroaction emissions not considered in the TCRE estimation;
- T_{hist} the historical human-induced warming to date;
- T_{nonCO_2} the non-CO2 contribution to future temperature rise.

Numerical values used to derive the results for this paper are provided in Appendix C. The carbon budget CB_i results from the gap between the company-specific benchmark and the future GHG emissions pathway. The later are sampled within the GHG emissions range allowing to build a set of various carbon budgets. Through the temperature equation, this provides a temperature distribution for each company. More details on the sampling method are available in Appendix D.

3.3.2 Aggregate at portfolio level

To aggregate at portfolio level the temperature ranges of each constituent, we use a portfolio ownership method[15] based on the Monte-Carlo algorithm. As a result, we derive a distribution of ITR scores at portfolio level. The final portfolio-level ITR score is denoted be the statistical moments of this distribution, allowing to build a probabilistic confidence interval around the median. Details of our Monte-Carlo and aggregation approach are available in Appendix E.

4 Data

For this study, we use the 2019 data set of 6,641 companies[16], which was curated by FTSE Russell for use in investment solutions. We focus on Scope 1 and Scope 2 emissions. For each company in our universe, the following covariates are available: SuperSector, Sector, SubSector, Industry and Revenue USD. All the covariates are categorical except Revenue.

The sector- and region-level breakdown of the company revenues is provided by LSEG Data & Analytics Company Fundamentals [2]. The target data is derived from FTSE Russell and TPI [7]. Because of the lack of standardisation in target data [17], we have selected only the targets[17] for the companies with the highest market capitalization, allowing us to still cover an important share of the weight at index or portfolio level. Work is currently under way to expand and harmonize the global target database in order to maximise this weight coverage. A brief description of the data is available in Table 2.

Our global pathways are derived from Climate Liabilities Assessment Integrated Methodology (CLAIM) [11], Climate Technology Compass [1] and Eora Global Supply Chain Database [23] [24]. The combination of these three data sources allows us to compute pathways for Scope 1 and Scope 2 absolute emissions at a high granularity, providing data for 181 countries and 25 sectors. By blending these three databases we ensure that the country- and sector-level pathways are, for all years, coherent with the global

[15] Please refer to [13] for more details on aggregation methods.
[16] This constitutes our corporate universe.
[17] Please note that we did not consider net-zero statement in this exercise because of the lack of information on the percentage of emissions reduction targeted in such commitments.

emission target. In particular, we obtain country-specify trajectories for low-emitting sectors that usually show less coverage with intensity benchmarks.

Data	n total	n reported	n estimated	% reported	% corporate universe covered
Scope 1	6,641	2,128	4,513	32%	100%
Scope 2	6,641	2,154	4,486	32%	100%
Revenues	6,641	6,641	0	100%	100%
GHG emissions targets	550	550	0	100%	8%

Table 2: Overview of the company-level data used.

5 Results

In this section, we present the results obtained from the application of the proposed methodology to a set of FTSE Russell indices[18]. To test our approach beyond the temperature metrics isolated, we report our results in comparison to a more common metric applied to carbon foot-printing, the Weighted Average Carbon Intensity (WACI)[19].

5.1 Application to index

Figure 3 below presents the ITR score ranges obtained for each of the FTSE Russell indices. The All Share index has, according to our methodology, the best score, while the Russell 1000 index has the worst performance. According to this metric, the results below indicate that none of these indices of that sample are aligned with the Paris Agreement objective.

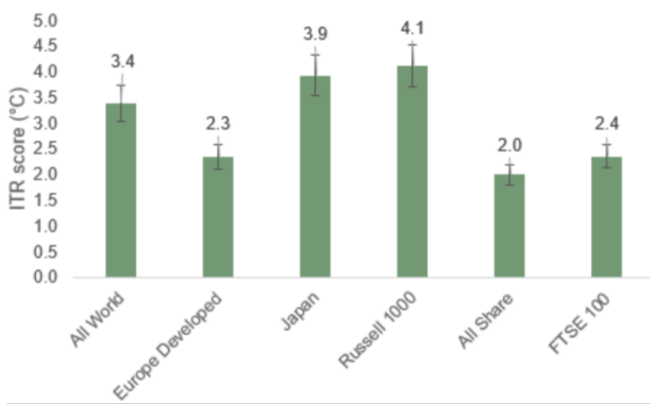

Figure 4: Estimated temperatures of different indices

Source: London Stock Exchange Group, Sustainable Investment Research.
Note: The upper and lower bar represents the estimated sensitivity to our different assumptions.

[18] Date as of 31/12/20.
[19] Definition and formula available here: https://assets.bbhub.io/company/sites/60/2020/10/FINAL-TCFD-Annex-Amended-121517.pdf, p.43.

5.2 Comparison to intensity

To illustrate the notion of complementarity for this tool, with respect to other metrics used to assess climate risk, Figure 5 presents the relationship between the WACI, based on historical data, and ITR scores, based on forward looking metrics, at index level.

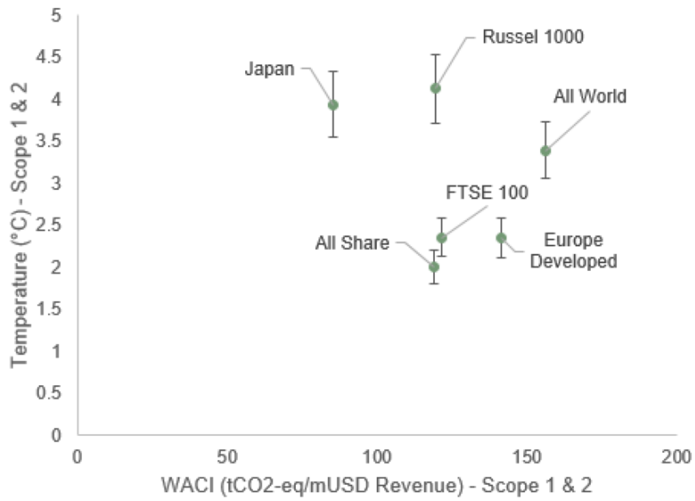

Figure 5: FTSE Indexes ITR scores and WACI

Source: London Stock Exchange Group, Sustainable Investment Research.

The relationship between these two metrics is not linear and a high ITR score is not necessarily equivalent to high current exposure to carbon risk. This can be explained by at least two reasons:

- The difference of weightings of the WACI and the temperature measure. The latter takes greater account of the contribution to a portfolio's total carbon emissions while the former only accounts for the weighting of the company within the portfolio;
- A company with a low carbon intensity compared to the world average is not necessarily low compared to the sectoral trajectory of its country. This is particularly true for countries such as the United States (Russell 1000) and Japan, where the efforts required to achieve a 2°C trajectory are more substantial given the carbon-intensive past of these countries in our fair-share scenarios [20]. Thus, their ITR score is relatively high (around 4°C), while their WACI is lower than that of the other indices shown on Figure 5.

This relationship will require additional analysis and paves the way to interesting analytical results and possible trade-offs.

6 Sensitivity analysis

6.1 Impact of including scope 3 GHG emissions

An important aspect that this section wants to address is the impact on ITR scores when including scope 3 GHG emissions. Figure 6 below shows the difference in temperature scores of three companies in the automotive sector with and without inclusion of Use of Sold Products (UoSP) Scope 3 GHG emissions[20].

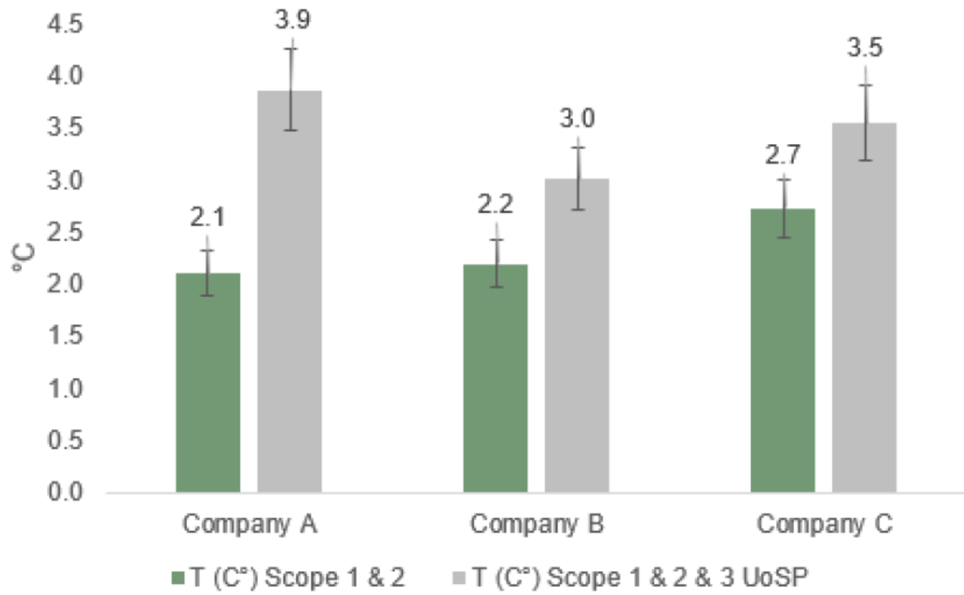

Figure 6: Temperature scores (°C) of the Automotive sector with and without inclusion of Use of Sold Products (UoSP) Scope 3 emissions.

Source: London Stock Exchange Group, Sustainable Investment Research.
Note: To compute an ITR score with Scope 3 UoSP emissions, the benchmark is adjusted accordingly. To avoid any misleading message, the company names are anonymized.

There are two immediate consequences of the inclusion of UoSP scope 3 GHG emissions: The significant increase in the temperature scores as well as the change in the ranking, from most aligned to least aligned, of the companies among themselves. Company A, which was close to 2°C on Scope 1 & 2, was one of the best performers in its sector. Following the inclusion of UoSP scope 3 emissions, it now finds itself with a temperature approaching 4°C and is one of the companies with the highest temperature in its sector. More broadly, the temperature range of the Automotive sector is [1.9°C; 3.1°C] by capturing only Scope 1 & 2, while including UoSP Scope 3 emissions raise the temperature range to [2.5°C; 4.5°C]. This focus on the Automotive sector demonstrates that a temperature based only on Scope 1 & 2 could give a misleading message on the impact of this sector, while including Scope 3 emissions gives a more representative picture.

[20]The Scope 3 emissions are derived from internal research using geographical breakdown of units sold and geographic specific factors based on several criteria: vehicle lifecycles, type of vehicle sold, emissions or consumption intensities.

Warming degree metrics gives the public a forward-looking and easy-to-understand figure to measure the performance of a company. However, it can be misinterpreted if Scope 3 GHG emissions are not included, and potentially contradicts the general public's interpretation of a temperature. This is particularly relevant for the following sectors for which scope 3 is the most material scope of GHG emissions: Automotive, Oil & Gas, Food & Beverages or Mining.

Development is currently underway to include Scope 3 emissions and benchmarks for additional sectors where appropriate. Such developments require extensive efforts due to the challenges that Scope 3 GHG emissions in benchmark construction currently present:

- the data gap on reported Scope 3 emissions and the lack of consensus on the few existing models used for its estimation;
- the lack of appropriate Scope 3 benchmarks and their overall consistency with Scope 1 and Scope 2 benchmarks.

6.2 Impact of including companies' disclosed GHG emissions reduction targets

A second component of interest in this section is the impact of the integration of corporate GHG emission reduction targets in the model. If a company discloses a GHG emission reduction target, its future emissions estimation takes the target into account, resulting in generally lower estimated future emissions than the default method.

By comparing the temperature difference for the FTSE Developed Europe with and without the integration of the companies' emissions reduction targets, one can observe a difference of around +/- 1°C between the two approaches. Please note that for the FTSE Developed Europe Index, 45% of constituents are covered by at least one Scope 1 and/or Scope 2 target of the FTSE Russell's carbon corporate target database. In addition, 75% of these targets have a targeted year before 2030. Results are available in Table 3.

	FTSE Developed Europe	
T (°C)	(with targets) [2.1°C – 2.5°C]	(without targets) [3.1°C – 3.7°C]

Table 3: Temperature scores (°C) of the FTSE Developed Index with and without the inclusion of GHG emissions reduction targets.

Source: London Stock Exchange Group, Sustainable Investment Research.

Figure 7 represents the 2°C-aligned reference GHG pathway (red) of the FTSE Developed Europe index, the future emissions range of the index with targets (yellow) and the future emissions range of the index without targets (blue). As a reminder, the upper and lower limits of the blue and yellow areas on the figure constitute the maximum and minimum pathways between which trajectories are simulated. The figure shows that the blue upper limit is equivalent to its 2013 value in 2030 while the yellow upper limit is equivalent to half of it. This shows the influence of the high proportion of 2030 emissions reduction targets on the projected future emissions range within the FTSE Developed Europe Index.

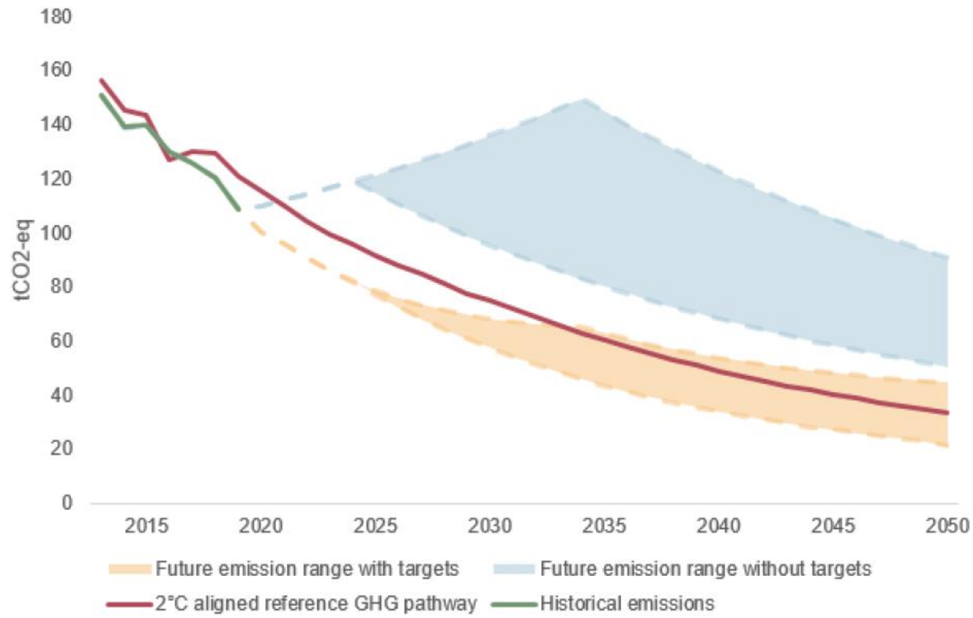

Figure 7: 2°C-aligned reference GHG pathway and the future estimated emissions with/without target for the FTSE Developed Europe Index

Source: London Stock Exchange Group, Sustainable Investment Research.

The gap between the results presented above highlights the fact that companies' commitments are a key factor to enhance temperature results at portfolio level throughout the model. However, whereas companies are willing to set GHG emissions reduction targets for investors to track in the medium- and long-term, it remains difficult today to evaluate their ability to achieve them and we have limited track records to monitor achievement of these objectives in the past. Thus, to avoid misunderstandings on the message of a temperature metric, both approaches of including the companies' commitment or not could be considered where the final ITR score is the aggregation of both methods.

7 Conclusion

In this paper, we describe an ITR methodology based on absolute GHG emissions. We include two methodological innovations:

- Company-specific benchmarks that blend sectoral pathways;
- A probabilistic approach to project emission trajectories.

ITR scores are computed at index level using an absolute emissions approach with company-specific benchmarks. The blending of the various pathways supports the construction of sector-level benchmarks coherent with a global GHG emission target and a full coverage of the corporate universe. The probabilistic approach helps to derive a temperature range for these ITR scores. This combination helps to easily compare the company benchmark with the company's future emissions or target and allows to understand the impact of companies' disclosures around their GHG emissions reduction for these type of metrics.

The results are promising though heavily impacted by the various assumptions, including the benchmark scenarios. This pleads for caution around the use of such metrics, as the methodological framework does not seem to be fully stabilized yet. Standardizing effort, led by organizations such as the TFCD and more recently GFANZ, can help foster good practices and convergence.

The final adoption of forward-looking methodologies such as alignment scores will depend on the willingness of the market to integrate methods with long-term horizons (2050) and that rely on macroeconomic and climate scenarios. Climate change raises a lot of challenges and being able to integrate long-term forward-looking metrics is one. Alignment metrics, as they propose a simple output, can lead the way to foster this adoption, but one should remain conscious about their complexity.

Appendix A: Region and sector split of company emissions

The formula used to compute the region and sector split of historical emissions is as follows (using notation from Section 3.1):

$$E_{i,t,s,c,j} = \alpha_{s,t,i} * \beta_{c,t,i} * E_{i,t,j} \tag{10}$$

With:

- $\alpha_{s,i}$ the share of total emission allocated to sector s for company i at time t;
- $\beta_{c,i}$ the share of total emission allocated to country c for company i at time t;

The share allocated to each sector is computed using the breakdown of revenues of the company and a reference carbon intensity per sector. This reference carbon intensity is computed as the average carbon intensity for company with more than 90% of their total revenues in that sector. The formula used is:

$$\alpha_{s,t,i} = \frac{R_{i,t,s} * \bar{I}_s}{\sum_{s \in S} R_{i,t,s} * \bar{I}_s} \tag{11}$$

With $\bar{I}_s$ the reference carbon intensity for sector s. With this formula, the weight of each sector is adjusted by its intensity[21]. The share allocated to each country is computed using the regional breakdown of the revenues, with the following formula:

$$\beta_{c,t,i} = \frac{R_{i,t,s}}{\sum_{s \in S} R_{i,t,s}} \tag{12}$$

Two assumptions are made here:

- For a company, the geographic breakdown of emission is estimated using the geographic breakdown of revenues. The underlying assumption is that companies report their emissions in the same countries they report their revenues. While this assumption holds for most companies, it can introduce bias for some companies/sectors, where emission location is unrelated to revenue location;
- For a company, the sector-level breakdown is similar in each country.

Because of these assumptions, the country and sector emission breakdown is a proxy of the real breakdown. Further work should be implemented to use asset-level data to increase the precision of this proxy.

[21] This increases the precision of this indicator by avoiding the pitfall of attributing the majority of emission to a low emitting sector.

Appendix B: Compound growth rate calculation

Using the notation from Section 3.2.1, we have:

$$CAGR_{i,j}^{hist} = CAGR_{i,j}^{E} - CAGR_{i}^{R} \tag{13}$$

with $CAGR_{i,j}^{X} = \left(\frac{X_{t+n}}{X_t}\right)^{\frac{1}{n}} - 1$. The emissions CAGR is adjusted for past revenues variations because these could result from an external perimeter change that is not representative of the real evolution of emissions. It is computed using all the historical data available for each company. The CAGR used for the upper and lower trajectories are:

$$CAGR_{i,j}^{low} = CAGR_{i,j}^{RCP2.6} + CAGR_{i,j}^{Sector} \tag{14}$$

$$CAGR_{i,j}^{high} = CAGR_{i,j}^{RCP8.5} + CAGR_{i,j}^{Sector} \tag{15}$$

with:

- $CAGR_{i,j}^{RCP2.6} = \left[\frac{0.35*median_{l\in 1,\dots,5}\left(E_{i,j,t_h+l}\right)}{E_{i,j,t_h}+5}\right] t_{N_T-(t_h+5)} - 1$
- $CAGR_{i,j}^{RCP8.5} = \left[\frac{1.65*median_{l\in 1,\dots,5}\left(E_{i,j,t_h+l}\right)}{E_{i,j,t_h}+5}\right] t_{N_T-(t_h+5)} - 1$
- $CAGR_{i,j}^{Sector}$ is the overall growth rate of the total emissions of the ICB Sector of company i. If $j = Scope_2$, then $CAGR_{i,j}^{Sector}$ is that of the Utilities sectors.

Appendix C: Description of the numerical values

Table 4 presents the numerical value of variables used in the temperature equation.

Variable	Applied value
$TCRE$	0.000544
CB	The company-level emissions
CB_{safe}	1333 GtCO2-eq
T_{hist}	1.02°C
T_{non-CO_2}	0.2°C

Table 4: Detailed variables of the applied temperature equation.

Note: This value of T_{non-CO_2} is relevant for a value of T around 2°. Afterwards, T_{non-CO_2} increases by 0.1 for each 0.5 increase in T.

Appendix D: Methodology to compute company-level temperatures

The section hereunder details our approach to compute portfolio-level ITR scores using the company future emission range. The benefit of this approach is that it allows for a comprehensive estimation of the ITR score and its confidence interval using a Monte-Carlo approach. Using the same notation as in Section 3.3, we have:

$$T = TCRE * (CB + CB_{Safe}) + T_{hist} + T_{non-CO_2} \tag{16}$$

Where CB is the company-specific carbon budget and is computed as follows for company i:

$$CB_i = Gap_i * CB_{tot,T} \tag{17}$$

where $CB_{tot,T}$ is the total carbon budget corresponding to a T temperature increase and Gap_i is ratio between the total company future emission and it's benchmark. In practise, $CB_{tot,T}$ corresponds to a carbon budget computed in 2100 and Gap_i must account for emissions until that date. So, if t_N < 2050, we have:

$$Gap_i = \frac{\sum_{t=t_f}^{t_N} E_{i,t} * Adj_{E_i,2100}}{\sum_{t=t_f}^{t_N} B_{i,t} * Adj_{B,2100}} \tag{18}$$

The adjustment factors account for the emissions after 2050. We choose not to model them explicitly but rather to apply the following logic:

- For the benchmark, we suppose that 70% of emissions are before 2050 and the remaining 30% are emitted after 2050. Thus, $Adj_{B,2100} = \frac{30\%}{70\%}$.
- For the future emissions, $Adj_{E_i,2100}$ is randomly selected between $\frac{30\%}{70\%}$. and $\frac{50\%}{50\%}$. This assumes that the company will emit between 30% and 50% of its emissions after 2050.

Because the company's future emission are modelled as a range rather than a single pathway, this allows us to input several carbon budgets for each company and compute a temperature distribution rather than a single value. Algorithm 3 presents the method used to derive the company's temperature distribution.

Algorithm 3 Compute the company-level temperature distribution

for $k \leftarrow 1$ to n **do**
    for $j \in \{Scope1, Scope2\}$ **do**
        if the company has target **then**
            Sample a pathway: $E_{i,j,low}^{target}(t_f, t_N) < E_{i,j,k}^{target}(t_f, t_N) < E^{target_{i,j,high}}(t_f, t_N)$
            Set $Adj_{E_i,2100}$ (by random draw)
            Compute $T_{i,j,k}$ using (16)
        else
            Sample a pathway: $E_{i,j,low}^{\emptyset target}(t_f, t_N) < E_{i,j,k}^{\emptyset target}(t_f, t_N) < E^{\emptyset target_{i,j,high}}(t_f, t_N)$
            Compute $T_{i,j,k}$ using (16)
        end if

end for

Compute $T_{i,k} = \frac{T_{i,Scope1,k} * E_{i,Scope1,t_h} + T_{i,Scope2,k} * E_{i,Scope2,t_h}}{E_{i,Scope1,t_h} + E_{i,Scope2,t_h}}$

end for

Aggregate all individual results in vector $T_i = [T_{i,1,\dots} T_{i,n}]$

The output is a company-specific ITR score vector $T_i = [T_{i,1,\dots} T_{i,n}]$ mixing temperatures of both Scope 1 and Scope 2 emissions for the company i.

Appendix E: Portfolio aggregation using a Monte-Carlo approach

We aggregate at portfolio-level using the portfolio ownership method, with the following equation:

$$T_k^{ptf} = \sum_{i \in I} T_{i,k_i} \left(\frac{\frac{Current\ value\ of\ investment\ i}{Investess\ company's\ value} * E_{i,1,t_h} + E_{i,2,t_h}}{Total\ portfolio\ owned\ emmissions} \right) \quad (19)$$

With:

- T^{ptf} the ITR score of the portfolio;
- $T_{i,k}$ the k-ieth ITR score of company i, that is randomly selected in T_i;
- E_{i,j,t_h} the emissions of company i for Scope j at time t_h;

Because each company has an ITR score range, the final portfolio ITR score is given as a distribution rather than a single value. Algorithm 4 describes how the final output is computed.

Algorithm 4 Compute the portfolio-level ITR score distribution

for $l \leftarrow 1$ to m **do**
  for $i \in I$ **do**
    Perform a random draw in T_i to select $T_{i,k}$
  end for
  Compute T_l^{ptf} using (19)
end for
Aggregate all individual results in vector $T^{ptf} = [T_1^{ptf}, \dots, T_m^{ptf}]$
Compute $T^{final} = [pct_{0.01}(T^{ptf}), pct_{0.99}(T^{ptf})]$

In practise, to compute these results, we have set n and m at 100. Increasing this number would allow for more stable and robust results. The trade-off here is between computing-time and stability of the results.

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