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Toward Paris-Aligned Sovereign Investment Portfolios: How Hot Is Your Debt?

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Abstract

Investors are increasingly adopting Paris-aligned strategies to manage climate-related risks and opportunities. Yet while sovereign bonds account for roughly half of global debt markets, credible methodologies to assess their alignment remain underdeveloped. This paper firstly advocates for Implied Temperature Rise (ITR) as a forward-looking, intuitive metric to assess sovereign Paris-alignment and embedded transition risks. It then introduces a new ITR methodology that avoids reliance on benchmark emission pathways, uses cumulative and consumption-based emissions as well as the latest global temperature data. This approach reduces volatility, enhances comparability, and improves accuracy. A worked example using a hypothetical sovereign portfolio is provided to demonstrate the methodology in practice.

Disclaimer: This policy brief is based on D. Dunlop-Barrett, "Toward Paris-Aligned Sovereign Investment Portfolios: Utilizing Implied Temperature Rise as a Measure of Alignment". Views are those of the authors and not necessarily those of De Nederlandsche Bank.

The Case for Paris-Alignment in Sovereign Portfolios

The 2015 Paris Agreement created a clear global objective: limit temperature increases to well below 2°C, ideally 1.5°C. While investors are increasingly aligning corporate portfolios with this goal, sovereign debt - representing over USD 70 trillion - has lagged behind. This poses a challenge: sovereigns are central to climate outcomes, through climate policy, infrastructure, and fiscal decisions (such as carbon tax). Those sovereigns that fail to transition away from high emitting industries may face elevated credit spreads, downgraded ratings, and restricted market access.

Yet guidance and tools to measure Paris-alignment in sovereign portfolios remain underdeveloped. Investors often default to carbon footprint, or avoid assessment of alignment altogether due to the lack of credible methodologies. The Institutional Investors Group on Climate Change (IIGCC) and others have called for more transparent, science-based tools that consider sovereign-specific dynamics. In response, this paper advocates for ITR as a tool to assess Paris-alignment, and provides a new and transparent methodology for calculating an ITR for a sovereign portfolio.

Introducing Implied Temperature Rise (ITR)

ITR estimates the global temperature increase implied if the emissions trajectories of portfolio constituents were replicated across the global economy. An ITR is a forward-looking metric that incorporates current and projected emissions based on government policies and expected technological progress. Unlike static measures like carbon footprints, it captures the anticipated impact of credible transition plans. This offers a more accurate view of sovereign climate risks and highlights opportunities that backward-looking metrics may miss. Furthermore, the output is a temperature which can be directly linked to the 1.5°C and 2°C targets set out in the Paris agreement – making communication and understandability simple. Of course, while ITR can be a powerful metric, it is advisable to always use a combination on metrics to enhance informational value.

Table 1. Comparison of Sovereign climate metrics

Metric	Forward-looking	Easy to Understand and Communicate	Robust / Agreed Methodology	Captures Transition Risk	Can be aggregated at the portfolio level
Implied Temperature Rise (ITR)	Yes	Yes	No – but this paper aims to address this shortfall	Yes	Yes
Carbon Footprint	No	Yes	Yes	Limited	Yes
Green Bond Share	No	Yes	Yes	No	Yes
Climate Policy / Ambition Score	Yes	Mixed	Partially agreed	Yes	No
Climate Value-at-Risk (VaR)	Yes	No	Model-dependent	Yes	Limited
ESG Scores	Provider-dependent	Yes	No	Provider-dependent	No
ASCOR	Yes	No	Yes	Yes	No
% of GDP derived from fossil fuels	No	Yes	Yes	Limited	Limited

Source: Subjective assessment by the author

Despite these benefits of the ITR, investors have remained understandably cautious on utilizing ITR as a metric to steer portfolio decisions. Common complaints with the ITR metric include the following:

- There is no agreement on sovereign ITR methodologies, which can complicate comparability.
- There is very little documentation to support existing methodologies. Underlying rationale behind methodologies is very rarely being provided.
- Results can be unintuitive and volatile.
- Commercial data providers can use proprietary models which lack transparency and scrutiny. Furthermore, these data providers may demand large fees, reducing accessibility.

As such, we specifically focus on addressing these concerns in this paper and our methodology.

A New Methodology: Transparent, Robust, Simpler, and uses Publicly Available Data

We propose an ITR methodology designed specifically for sovereign portfolios, addressing key limitations of existing approaches. It is:

- Benchmark-independent: Avoids reliance on Paris-aligned emission pathways, which vary widely and introduce major uncertainties.
- Consumption-based: Reflects emissions from final consumption rather than production, offering a fairer and more policy-relevant view of climate responsibility.
- Fully transparent: Uses only publicly available data and clearly documents each calculation step, enabling scrutiny, replication, and refinement.

The methodology applies the Transient Climate Response to Cumulative Emissions (TCRE), using a central estimate of 0.45°C per 1,000 $GtCO_2$, consistent with IPCC guidance. Final ITR values are rounded to the nearest 0.1°C to avoid overstating precision.

Why Not Use a Benchmark Emission Pathway in the Methodology?

In all of the ITR methodologies we reviewed, emission pathways were always compared against a benchmark "Paris-aligned" pathway. This is outlined in figure 1, whereby first a benchmark emission pathway is generated (generally aligning with 1.5°C) and the expected emissions of the sovereign (or corporate, as per the chart) are compared to this benchmark, usually via a percentage under/overshoot. The primary difference of our methodology, compared with existing methodologies, is that we do not utilize a benchmark emission pathway at all.

The primary motivation for our methodology to move away from a benchmark pathway was due to the series of complications that it introduced. The key concerns included:

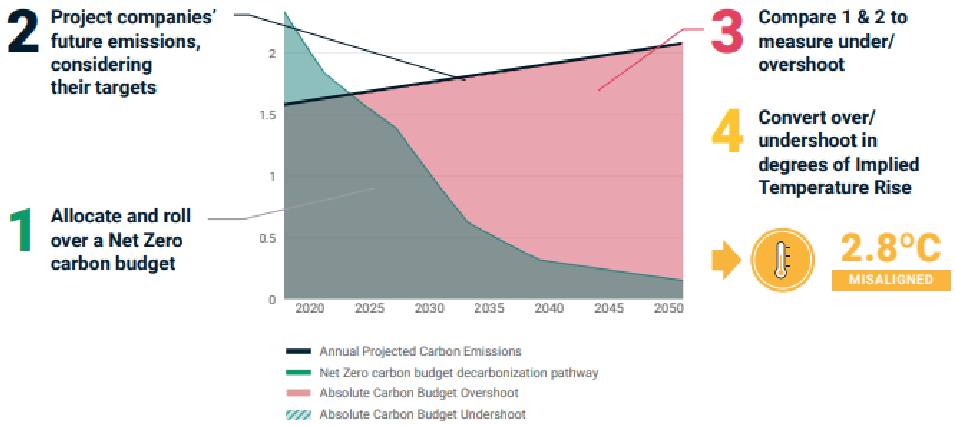
- Determining the appropriate benchmark was subjective. Whether to include or exclude a 'fair-share' approach or not in the sovereign context is difficult.
- Often benchmarks were unrealistic, for example a 1.5°C benchmark would have emissions declining from current levels at a linear pace until 2050. Given we are close to breaching the 1.5°C threshold[1], a linear benchmark pathway seemed very unrealistic.
- ITR results are highly sensitive to changes in the benchmark pathway. This introduced large variances between methodologies and data providers.
- The conversion from under/overshoot (i.e step 4 in figure 1) differed significantly between methodologies, and lacked mathematical rigor. For example, most applied a percentage emission overshoot to the remaining

[1] While 2024 temperatures did surpass the 1.5°C threshold, breaching in a single year does not mean the Paris target is officially breached.

carbon budget – but as the remaining climate budget approaches zero, the impact of overshoots become less meaningful and misleading.

Our methodology sidesteps these issues by focusing only on the cumulative emission pathway and avoids overshoot calculations entirely. Another advantage to our approach is that it gives greater flexibility in modelling the impact of different emission pathway scenarios, such as delayed transitions.

Figure 1. Most current methodologies utilize a benchmark emission pathway (step 1, 3 and 4)



Source: MSCI, Implied Temperature Rise

Step-by-Step Methodology for Calculating a Sovereign Portfolios ITR

This section outlines the key steps in the methodology, with a worked example with illustrative numbers provided in the appendix. It also sets out the underlying rationale and relevant decisions underpinning the step.

1. **Project cumulative production-based emissions to 2050**

Description – Extend each country's "current-policies" production emission pathway from the latest data point (e.g., 2030) to 2050, then sum annual emissions (LULUCF excluded for consistency).
Rationale – Using the full 2050 trajectory captures total climate impact; point-year estimates miss diverging pathways and would understate long-run warming.

2. **Convert to consumption-based emissions**

Description – Add net-imported minus exported CO_2 to every projected year to obtain a consumption pathway (e.g., +0.54 Gt CO_2 per year for the United States).
Rationale – Corrects for outsourced production, reflects scope-3-type emissions

3. **Scale to a global-equivalent total**

Description – Divide each country's cumulative consumption emissions by its share of world population to ask: "What if everyone emitted like this sovereign?"
Rationale – Produces an absolute global tonnage that can be linked to temperature without relying on subjective benchmark pathways. Using population to scale consumption emissions is in line with PCAF recommendations.

4. **Weight by portfolio holdings**

Description – Repeat Steps 1-3 for every issuer, then take the portfolio-weight-adjusted average of global-equivalent emissions.
Rationale – Aligns the calculation with the investor's actual exposure, turning disparate country data into a single portfolio figure.

5. **Add leakage for aviation and shipping**
Description – Add projected cumulative emissions until 2050 from international aviation and maritime transport (~50 Gt in the example).
Rationale – Ensures emissions that fall outside national accounts are captured; omitting them would bias the portfolio ITR downward.

6. **Convert tonnes to an ITR uplift using TCRE**
Description – Multiply total cumulative tonnes by the Transient Climate Response to Cumulative Emissions (0.45 °C per 1000 Gt CO_2).
Rationale – Applies the IPCC-endorsed linear link between cumulative CO_2 and temperature, translating emissions into warming.

7. Add the uplift to the latest observed baseline temperature
Description – Add the uplift to the average warming over the last 3 years (≈ 1.27 °C) and round the result to the nearest 0.1 °C.
Rationale – Incorporates up-to-date climate data (rather than a fixed 1.5 °C benchmark) and avoids spurious precision; the example portfolio yields ≈ 2.4 °C.

With the rationale, structure, and application of this new ITR approach established, the remaining question is how it can evolve to support a broader, more practical alignment of sovereign portfolios with climate goals. Further methodological improvements and investor adoption are integral steps towards embedding climate alignment into mainstream sovereign debt investing.

Conclusion and Next Steps

This policy brief advocates for the use of Implied Temperature Rise (ITR) as a transparent, forward-looking metric to assess Paris-alignment in sovereign bond portfolios. ITR is simple to communicate and captures the embedded emissions and government policies of sovereign issuers. The methodology introduced in this paper addresses key limitations of existing approaches by:

- Using cumulative emissions to 2050 rather than point-year estimates
- Eliminating reliance on benchmark emission pathways, which vary and create inconsistencies
- Adopting a consumption-based lens, providing a more equitable view of climate responsibility
- Incorporating the latest temperature data, ensuring timeliness and relevance

Looking ahead, further refinements can strengthen the approach. Expanding the methodology to include sub-sovereign, supranational, agency, and corporate bonds would increase its applicability across fixed income portfolios. Additionally, incorporating avoided emissions from sovereign green bonds could better reflect their contribution to climate goals, as their use of proceeds is more targeted than general government spending. Addressing these areas would support a more holistic and accurate assessment of portfolio alignment with the Paris Agreement.

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Appendix – worked example of the methodology

Step	Description	Relevant data source	Illustrative numbers (as an example)	Results of the step
Project cumulative production-based emissions to 2050.	Sum each country's projected CO_2-eq emissions under current policies through 2050; extrapolate if needed.	Climate Action Tracker	USA projected emissions: 2026 = 5.7 $GtCO_2$, 2027 = 5.6 $GtCO_2$ … summed to 2050 = 115 $GtCO_2$ (cumulative)	USA → 115 GtC02 Japan → 22 GtC02 UK → 9.5 GtC02 CAD → 17.4 GtC02 AUS → 9.8 GtC02 NOK → 1.0 GtC02
Convert production to consumption emissions.	Add net imported CO_2 emissions to projected production totals to correct for outsourced emissions. Skip this step only if direct consumption data is available (rare)	Our World in Data	USA net imported emissions (cumulative) → 16 GtC02 USA consumption emissions → 115 + 16 = 131GtC02	USA → 131 GtC02 Japan → 26.5 GtC02 UK → 14.5 GtC02 CAD → 16.4 GtC02 AUS → 8.4 GtC02 NOK → 1.1 GtC02
Scale to global equivalent emissions	Divide a country's consumption emissions by its share of global population to estimate global emissions if everyone emitted like that country's average resident.	Worldometer (for population statistics)	USA percentage of global population → 4.24% Global equivalent emissions = 131/0.0424 = 3092 GtC02	USA → 3,092 GtC02 Japan → 1,648 GtC02 UK → 1,668 GtC02 CAD → 3,347 GtC02 AUS → 2,561 GtC02 NOK → 1,636 GtC02
Weight emissions by sovereign holdings in the portfolio.	Multiple the results calculated in step 3, by the percentage share of the sovereign in your investment portfolio.	Internal data on portfolio holdings	USA → 3,092 * 40% = 1,236 GtC02 Japan → 1,648 * 20% = 329 GtC02 UK → 1,668 * 10% = 167 GtC02 CAD → 3,347 * 10% = 335 GtC02 AUS → 2,561 *10% = 256 GtC02 NOK → 1,636 * 10% = 164 GtC02	1,236 + 329 + 167 + 335 + 256 + 164 = 2,489 GtC02
Adjust for emission leakage	Add cumulative emissions from aviation and shipping (to 2050) to account for unallocated emissions.	Climate Action Tracker	Shipping and aviation cumulative (2050 emission) → 50.6GtC02.	2,489 + 50.6 = 2,538 GtC02
Convert global emissions into temperature increase using TCRE.	Multiply total cumulative emissions by the TCRE (0.00045°C per $GtCO_2$) to estimate additional warming from emissions.	IPCC estimates	2,538 * 0.00045 = 1.14°C	1.14°C (ITR uplift)
Add to the current global temperature to derive the portfolios ITR.	Add the ITR uplift from step 6 to the 3-year average of recent median global temperatures above pre-industrial levels.	Berkely Earth (for recent temperatures)	2021 median → 1.20°C 2022 median → 1.25°C 2023 median → 1.54°C Baseline = (1.2 + 1.25 + 1.54)/3 = 1.27°C	1.27 + 1.14 = **2.4°C** (rounded to nearest 0.1°C)

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