Methodology

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FTSE Climate Risk Assessment Methodology

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Section 1

Introduction

1. Introduction

1.1 FTSE Climate Risk Assessment Methodology – Origination

The FTSE Climate Risk Assessment Methodology is based on its predecessor, the FTSE Climate Risk-Adjusted Methodology.[1] These enhanced methodology responds to increasing market maturity, customers' needs and World Bank and International Monetary Fund recommendations[2] and delivers a renewed and strengthened methodology.

1.2 FTSE Climate Risk Assessment Methodology - Introduction

The FTSE Climate Risk Assessment Methodology is a unique quantitative, relative, and systematic approach, based on 15 indicators for 50 countries, divided into three pillars of climate risk and preparedness assessment (*i.e.*, transition risk, physical risk and resilience).

For each indicator, LSEG Sovereign Sustainability calculates a score on a yearly basis, starting from 2001. Each of the 15 indicators is the outcome of numerous systematic statistical adjustments based on public, private and proprietary data.

All indicators are aggregated to obtain a pillar score, which is derived from advanced statistical techniques discussed hereafter.

[1] For more context and details on the origin of such a methodology, please refer to how_to_build_a_climate-adjusted_government_bond_index_final.pdf (ftserussell.com) and to Incorporating climate change into a government bond allocation (lseg.com).
[2] For more details on World Bank and International Monetary Fund recommendations, please refer to Demystifying Sovereign ESG and Sovereign Environmental, Social, and Governance (ESG) Investing: Chasing Elusive Sustainability (imf.org).

Section 2

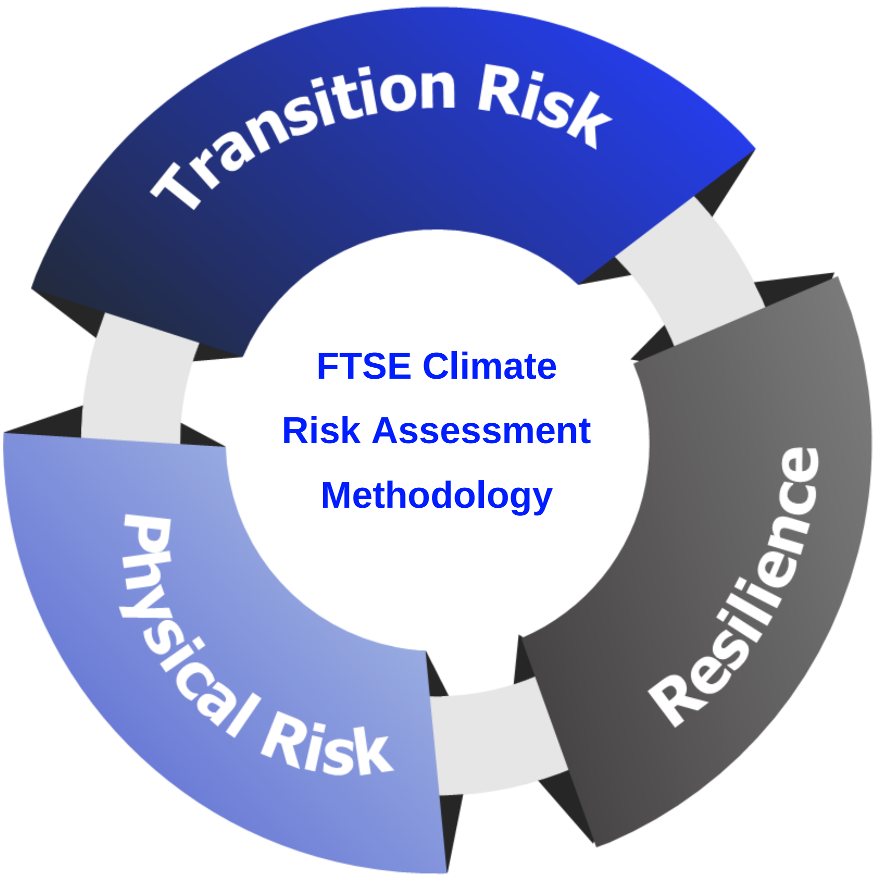
Scoring framework

2. Scoring framework

2.1 FTSE Climate Risk Assessment Methodology – Overall framework

The FTSE Climate Risk-Adjusted Enhanced Methodology assesses 15 indicators, or KPIs, from 2001 to the latest year available across three pillars for 50 countries.[3] Figure 1 provides a brief overview of the enhanced methodology.

Figure 1. FTSE Climate Risk Assessment Methodology in a nutshell



[3] The 50 assessed countries are: Argentina, Australia, Austria, Belgium, Brazil, Canada, Chile, China, Colombia, Croatia, Czech Republic, Denmark, Finland, France, Germany, Greece, Hong Kong, Hungary, India, Indonesia, Ireland, Israel, Italy, Japan, Malaysia, Mexico, Netherlands, New Zealand, Nigeria, Norway, Peru, Philippines, Poland, Portugal, Romania, Russia, Saudi Arabia, Singapore, South Africa, South Korea, Spain, Sri Lanka, Sweden, Switzerland, Taiwan, Thailand, Turkey, United Kingdom, United States and Vietnam.

The breakdown by pillar is as follows: (i) two KPIs for the Transition Risk pillar, (ii) two KPIs for the Physical Risk pillar, and (iii) 11 KPIs for the Resilience pillar (see Table 1 for more details on each indicator). The Resilience pillar is broken down into two sub-pillars, *i.e.*, the Domestic Resilience sub-pillar with seven indicators, and the Territorial & Ecosystems Resilience sub-pillar with four indicators. It is important to note that the Resilience pillar score is calculated as the arithmetic average of its two sub-pillar scores.

2.2 FTSE Climate Risk Assessment Methodology – Inputs

Country climate scores are derived from assessments across the three pillars mentioned above. Each pillar contains multiple underlying indicators, which are detailed in Figure 2. Both Transition Risk and Physical Risk pillars assessment extensively rely on the work carried out during the enhancement of our sovereign ESG risk assessment.[4]

Both Transition Risk and Physical Risk pillars consist of an exposure and vulnerability KPI to account for past and future conditions, respectively. While the exposure indicator measures countries' current degree of exposure, the vulnerability indicator uses climate models and government policies to forecast countries' capabilities in mitigating and adapting to climate change risks.

2.2.1 Transition Risk pillar

In the case of transition risks, consumption-based greenhouse gases (GHG) emissions (*i.e.*, territorial plus imported, minus exported emissions) represent the most fitting measure for sovereign footprint as outlined by the Partnership for Carbon Accounting Financials (PCAF).[5] The measure is normalized by gross domestic product (GDP) to calculate per capita emissions, helping to more accurately represent relative exposure to transition risks as it indicates whether countries are over-emitting or under-emitting GHG emissions relative to their level of development.

The forward-looking KPI is represented by the Climate Liabilities Assessment Integrated Methodology (CLAIM) Implied Temperature Rise metric.[6] This KPI assesses countries' implied global warming temperatures based on their national commitments to climate change mitigation, in line with their Nationally Determined Contributions (NDCs) submitted to the UNFCCC in the framework of the Paris Agreement. We use a temperature equation that reflects the scientific consensus on the relationship between GHG emissions and global temperature, which provides an output measured in degrees Celsius.

2.2.2 Physical Risk pillar

There are seven acute and chronic climate hazards that are considered when building physical risks scores: (i) heatwaves, (ii) droughts, (iii) water stress, (iv) intense precipitations, (v) riverine floods, (vi) coastal floods and (vii) average temperature.[7]

Such hazard scores are combined with broad sectoral vulnerability scores (Agriculture, Industry, and Services) to calculate one aggregated historical risk score and one aggregated forward-looking risk score for each country. Historical exposure will indicate countries' exposure to harmful climate conditions while forward-looking exposure will shed light on countries' vulnerability to strong changes in climate conditions. Forward-looking data is based on the IPCC SSP5-8.5 climate scenario, following a 'hope for the best, plan for the worst' type of approach.

2.2.3 Resilience pillar

Governments have an active role to play in adapting and mitigating climate risk. Their policies help determine the quality of governance, the degree of preparedness for climate risks, the resilience of infrastructure, economic productivity as well as the quality of human capital. These, in turn, can help determine whether a country is equipped to tackle climate change and attenuate its negative impacts.

However, in the absence of sufficient natural capital, the outcomes of these policies cannot materialise. *"Nature provides a vast range of services vital to humanity and our economies. They provide food and fresh*

[4] For more details, please refer to Rethinking the sovereign environmental score assessment | LSEG.
[5] For more details, please refer to The Global GHG Accounting and Reporting Standard for the Financial Industry (carbonaccountingfinancials.com).
[6] For more details on the CLAIM Implied Temperature Rise indicator, please refer to Evaluating national climate commitments using implied temperature rise | LSEG.
[7] The average temperature hazard can only be included in the forward-looking Physical Risk scores assessment. Please refer to footnote 4 for more details on methodologies.

water, protect us from disasters and disease and help sustain economic activity. Terrestrial and marine ecosystems, most importantly, regulate climate. They currently absorb roughly half of man-made carbon emissions[8].”

2.2.3.1 Domestic Resilience sub-pillar

The Domestic Resilience sub-pillar aims to assess a country’s preparedness to tackle the climate change through its institutions, its economy and its society.

On governance resilience, we refer to the World Bank’s World Governance Indicator database. The two selected indicators, Government Effectiveness and Voice and Accountability, represent the quality of policymaking, the liberty for society to participate in politics and the accountability to which governments hold all actors and policies. Together, these characteristics help signal governments’ capability and adaptability to address climate change.

On economic resilience, we focus on indicators that analyse social inequality, performance of human capital, and productivity.

The Sustainable GDP per capita indicator, developed by LSEG Sovereign Sustainability, is an ESG metric which compares relative to their GDP. Using a proprietary ESG assessment framework and over 190 indicators, countries with similar income levels will be compared with each other to determine the degree to which they overperform or underperform given the average expected performance for a given income level.[9]

Human Development Index is a measure developed by the United Nations Development Programme (UNDP) which emphasizes the importance of people and their capabilities to assess human development outcomes, providing an additional metric to economic growth. Using four indicators, it analyses three main dimensions: a long and healthy life, education and standard of living.

GINI Index, developed by the World bank, is a measure of income inequality. It observes the extent to which the distribution of income among individuals or households within an economy deviates from a perfectly equal distribution. A GINI index of 0 represents perfect equality while an index of 100 implies perfect inequality.

On business, we refer to two indicators developed by the World Bank: Ease of Doing Business[10] (EDB) and the Logistics Performance Index (LPI). These capture the ability for the business environment to cushion itself from climate change risks as well as to sustain and accept investment that would reduce vulnerability and improve adaptive capacity.

The EDB focuses on the quality of the regulatory environment to conduce starting or operating a local firm. This is determined by analysing the simplicity in starting a business, dealing with local permits, and accessing electricity and financing opportunities, amongst others. The overall score will range from 0 to 100, where higher scores imply better conditions.

The LPI helps identify challenges and opportunities countries may face in their performance on trade logistics. This includes factors such as the competence of logistics services, quality of trade and transport related infrastructure or the efficiency of the clearance process by the concerned agencies.

2.2.3.2 Territorial & Ecosystems Resilience sub-pillar

The Territorial & Ecosystems Resilience sub-pillar aims to assess the exposure and intrinsic vulnerability of a country through the preservation of its ecosystems and its natural carbon sinks.

On land cover, we use the forest cover (% of land area) indicator produced by the Food and Agriculture Organization (FAO) and the World Bank. Forest areas are not only critical to conserving biodiversity, but they can absorb carbon from the atmosphere, reduced temperatures, protect communities, and prevent natural disasters. Forest area is considered land under natural or planted stands of trees, whether

[8] United Nations, 2022. Biodiversity - our strongest natural defense against climate change.
[9] For example, if the access to electricity rate is 20% higher than it should be for its given income level, we estimate the Sustainable GDP associated with this indicator as 20% above what the reported GDP is. This is then done at the aggregate level for E, S and G separately, and finally at the ESG level in order to get a Sustainable GDP metric.
[10] The update of the Ease of Doing Business indicator has been paused (World Bank Group to Discontinue Doing Business Report) and will be replaced by the Business-Ready or B-Ready indicator (Business Ready (B-READY) (worldbank.org)). Therefore, the EDB indicator will be used until it is replaced by this new indicator by the end of 2024 at the earliest.

productive or not. It excludes trees in agricultural production systems (e.g., in fruit plantations and agroforestry systems) and trees in urban parks and gardens. For Taiwan and Hong Kong, we use the Global Forest Watch as an alternative source.

On ecosystem preservation, we use a total for three indicators.

On protected areas, the objective is to quantify the proportion of land area within a country that is designated as protected, or partially protected (hereafter areas referred as protected areas). Beyond the shares of protected areas, the index values can represent on one hand the size of biodiversity sensitive areas within a country, and as such its capacity to provide a certain level of ecosystem services. On another hand, it can also suggest a certain level of effort already undertaken by a country to protect its nature and the services it provides.

On ecosystem integrity, we make us of the Mean Species Abundance (MSA) indicator developed by GLOBIO (Conservation International), which measures biodiversity intactness. It calculates the abundance of individual species under influence of six human pressures (land use, road disturbance, fragmentation, hunting, atmospheric nitrogen deposition, and climate change), compared to their abundance in an undisturbed scenario (natural situation/reference). It ranges from 0 to 1, where 1 means that the species assemblage is fully intact, and 0 means that all original species are locally extinct. Local diversity is important for reliable provision of many ecological functions and services that help keep the earth system and, in turn, economies functioning[11].

On marine ecosystems, we use the Ocean Heath Index (OHI) provided by Conservation International. This indicator defines a healthy ocean as one that can sustainably deliver a range of benefits to people now and in the future. Ocean benefits delivered to humans are called goals[12] within the OHI framework and are widely recognized for supporting human well-being and sustainable ocean ecosystems. Goals are assigned a score of 100 if its benefits are maximized without compromising the ocean’s ability to deliver those benefits in the future, while lower scores imply that more benefits could be gained or that current methods are harming the delivery of future benefits. For the OHI, Austria, Czech Republic, Switzerland and Hungary are exempted because those countries are landlocked and have no maritime façade.

[11] De Palma, A., Hoskins, A., Gonzalez, R.E. et al. Annual changes in the Biodiversity Intactness Index in tropical and subtropical forest biomes, 2001–2012. Sci Rep 11, 20249 (2021). https://doi.org/10.1038/s41598-021-98811-1.

[12] There are 10 goals behind the OHI: (i) food provision, (ii) artisanal fishing opportunities, (iii) natural products, (iv) carbon storage, (v) costal protection, (vi) livelihoods and economies, (vii) tourism and recreation, (viii) sense of place, (ix) clean waters, and (x) biodiversity.

Table 1. FTSE Climate Risk Assessment Methodology – Pillars and Indicators

Climate Pillar	Indicator	Indicator description	Source(s)	Lag[13]	History[14]
Transition Risk	GDP-Adjusted Carbon Footprint	The deviation between consumed GHG emissions and the average emitting activity of countries with a similar level of income. Consumed GHG emissions are defined according to Partnership for Carbon Accounting Financials (PCAF)'s standards, which includes territorial, and imported emissions and excludes exported emissions.	LSEG	2-3 years	2000
	Implied Temperature Rise	Provides an approximation of the global warming level (in the year 2100) if the whole world had the same carbon budget overshoot than a specific country. This overshoot of a country is defined as the gap between its 1.5°C-consistent carbon budget and the carbon budget induced by its emission target (formalised in its Nationally Determined Contributions – NDC).	LSEG	1 year	2022
Physical Risk	Historical Physical Risk Score	For six climate hazards (heatwaves, droughts, water stress, intense precipitations, riverine floods, and coastal floods), we use raw climate data to calculate how its frequency and/or intensity impacts a country, depending on the repartition on its economic sectors. We use this to create a single, multi-hazard score that summarizes the country's overall absolute historical exposure to physical climate risk, using the average of the three highest hazard-specific scores for each country.	LSEG	1 year	2000
	2050 Delta Physical Risk Score	For seven climate hazards (heatwaves, droughts, water stress, intense precipitations, riverine floods, coastal floods and average temperature), we use raw climate data to calculate how its frequency and/or intensity will impact a country, depending on the repartition of its economic sectors. Forward-looking exposure is defined by the change in climate conditions, calculating the difference between future and past climate indicators (e.g., additional warm days). Forward-looking data is based on the IPCC SSP5-8.5 climate scenario. We use this to create a single, multi-hazard score that summarizes the country's overall relative change in physical climate risk by mid-century, using the average of the three highest hazard-specific scores for each country.	LSEG	1 year	2000
Resilience	Domestic Resilience	*Voice and accountability*: Voice and accountability captures perceptions of the extent to which a country's citizens are able to participate in selecting their government, as well as freedom of expression, freedom of association, and a free media.	World Bank WGI	1-2 years	2000
		Government effectiveness: Government effectiveness captures perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies.	World Bank WGI	1-2 years	2000
		Sustainable GDP per capita: Adjusted GDP per capita measure, that corrects countries' GDP per capita by comparing their ESG performance level to an expected one according to the level of development.	LSEG	1-2 years	2000
		Human Development Index: measures three key dimensions of human development: - A long and healthy life – life expectancy at birth;	World Bank WDI, UNDP	1-2 years	2000

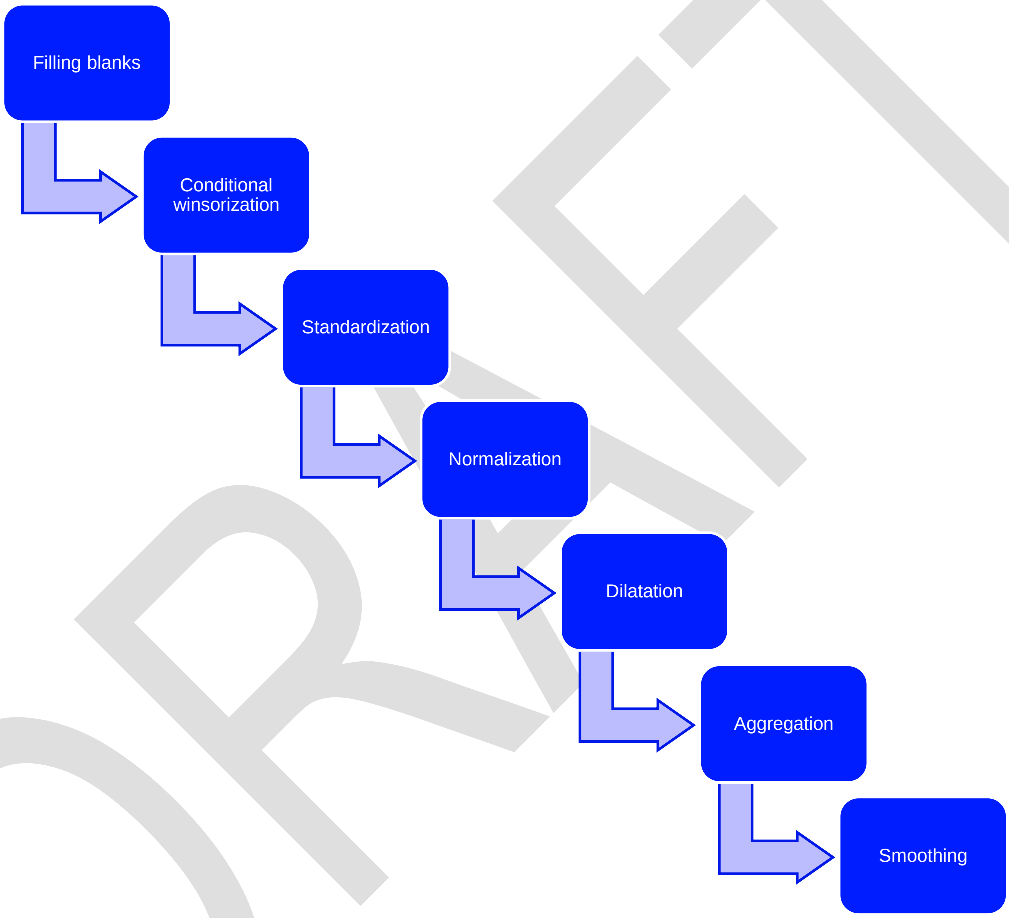
[13] Time period between indicator measurement and indicator publication.
[14] First available publication date for each indicator.

Climate Pillar	Indicator	Indicator description	Source(s)	Lag[13]	History[14]
		- Being knowledgeable – expected years of schooling and mean years of schooling; - Standard of living – Gross National Income (GNI) per capita.			
		GINI index: measures the extent to which the distribution of income among individuals or households within an economy deviates from a perfectly equal distribution.	World Bank WDI	0-5 years	2000
		Ease of doing business: measures the gap between an economy's performance and a measure of best practice across the entire sample of 41 indicators for 10 Doing Business topics.	World Bank Doing Business	0-1 year	2009
		Logistics performance index: reflects perceptions of a country's logistics based on efficiency of customs clearance process, quality of trade- and transport-related infrastructure, ease of arranging competitively priced shipments, quality of logistics services, ability to track and trace consignments, and frequency with which shipments reach the consignee within the scheduled time.	World Bank	0-1 year	2007
	Territorial & Ecosystems Resilience	*Forest cover:* proportion of the country covered by vegetation and evolution of this vegetation cover. Forests represent natural carbon storage areas as well as the ability to contribute to milder local temperatures.	World Bank, FAO, Global Forest Watch	2-3 years	2000
		Share of terrestrial protected areas: percentage of terrestrial protected areas of total territorial area. Terrestrial protected areas are totally or partially protected areas of at least 1,000 hectares that are designated by national authorities as scientific reserves with limited public access, national parks, natural monuments, nature reserves or wildlife sanctuaries, protected landscapes, and areas managed mainly for sustainable use.	AXA Climate	1 year	2023
		Ecosystems integrity: measured by the Mean Species Abundance (MSA) metric, an indicator of local biodiversity intactness. MSA ranges from 0 to 1, where 1 means that the species assemblage is fully intact, and 0 means that all original species are extirpated (locally extinct). This metric is a function of six human pressures: land use, road disturbance, fragmentation, hunting, atmospheric nitrogen deposition, and climate change.	GLOBIO	Not suitable	2000
		Ocean health index: The underlying philosophy behind the index is that a healthy ocean sustainably delivers a range of benefits to people now and in the future. The index accounts for 10 different goals. A goal is given a score of 100 if its benefits are maximized without compromising the ocean's ability to deliver those benefits in the future. Goal Scores are based on several components: current status, likely future status, trend, pressures, and resilience. A country's Index Score is the average of its goal scores. Goal scores are weighted equally in global assessments, but independent assessments could weight them differently depending on local conditions and values.	Conservation International	0-1year	2012

2.3 FTSE Climate Risk Assessment Methodology – Scoring framework

Raw data inputs for a total of 15 indicators, from year 2000 until today, are statistically transformed into scores. In this way, all 50 countries can be compared fairly. Indicator scores range between 0 and 1, where higher scores denote better resilience, less risk and in turn, better performance. Within each climate risk pillar and resilience sub-pillar, the underlying indicators are equally weighted to produce aggregated climate risk and resilience pillar scores (i.e., Transition Risk, Physical Risk, Resilience). This process is explained below and illustrated in Figure 2.

Figure 2. FTSE Climate Risk Assessment Methodology scoring framework



Source: LSEG Sovereign Sustainability.

2.3.1 Filling blanks

All indicators have different levels of coverage. For some indicators, data may be widely available across all 50 countries but not necessarily from a time perspective, *e.g.*, data available since 2012 only. In other cases, data may be available from year 2000 until today but not for all countries. To tackle the coverage gaps, for each country and each indicator, we carry out the following:

(i) When values are missing at the beginning of the time series, values are filled with the first available value. When values are missing at the end of the time series, values are filled with the last available value until the current year.

(ii) When some values are missing in the middle (encircled by available values) of the time series, we linearly interpolate the missing values using years.

(iii) When a whole time series is missing, we apply the following:

  i. Attribute the World Bank group average value: for every year and indicator, we calculate the average value by country income groups, according to the World Bank Income Group's country classification[15]. That is, for low income, lower-middle income, upper-middle income, and high income countries.

  ii. Use of proxy, where suitable: for instance, for the Ocean Health Index, no data is available for Hong Kong. In such cases, we use China as a proxy.

2.3.2 Conditional winsorization

To minimize the impact of sometimes erratic data points, all indicators are checked for outliers. An initial test is put in place to analyse the distribution and detect whether – for a given year and indicator – a country is found to have a data point above or below three standard deviations from the average. If this is the case, according to the country's position in the distribution, the country will be attributed the maximum value or the minimum value, respectively. If no country is detected as an outlier, then no winsorization will be done for the year and indicator. This rule is set to avoid the loss of valuable information.

2.3.3 Standardization

This is the first step towards the harmonisation of the data. For every indicator and year, country z-scores[16] are produced. This allows us to assess the relative risk linked to the initial data and corrects for data scaling.

2.3.4 Normalization

The z-scores are transformed into continuous scores on an interval, ranging from 0 to 1, in accordance with the cumulated distribution of a standard normal distribution (see Figure 3 for more details) – 0 representing the worst score, and 1 the best. Two different cases have to be taken into account:

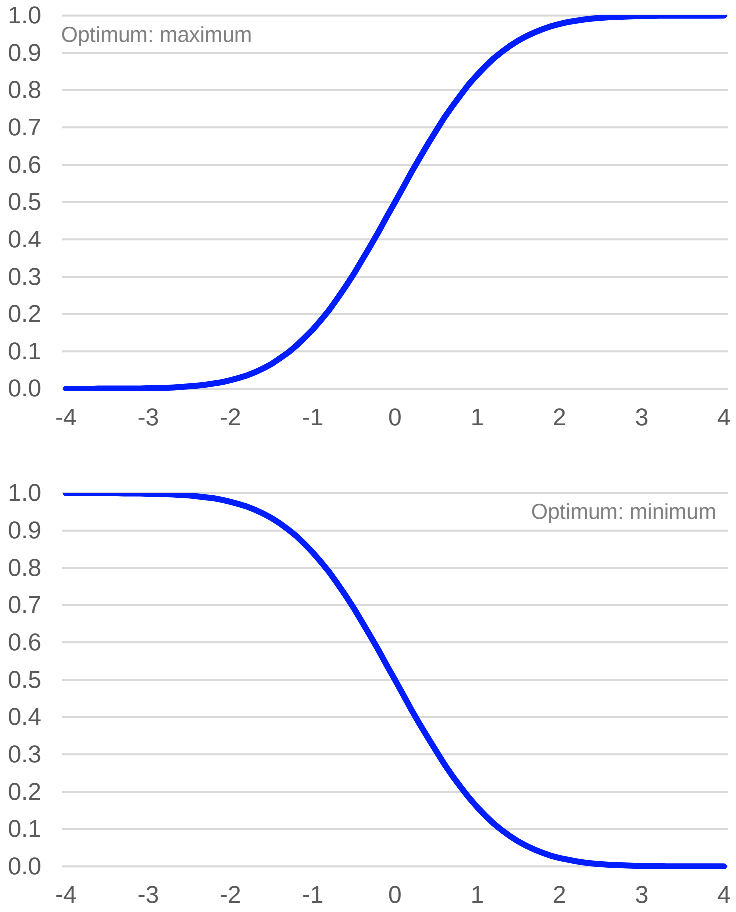
(i) When the optimum is a maximum, the higher the value, the higher the value of the corresponding z-score, and the higher the indicator. This is the case for most indicators.

(ii) When the optimum is a minimum, the lower the value, the lower the value of the corresponding z-score, and the higher the indicator. This is the case for the Implied Temperature Rise (ITR) indicator and the GINI index.

[15] For more details on the World Bank country and lending groups using the World Bank Atlas method, please see World Bank Country and Lending Groups – World Bank Data Help Desk.

[16] For a raw datum denoted $X_{i,t}$ with i the country and t the date, $z\text{-}score_{X_{i,t}} = \frac{X_{i,t}-\overline{X_t}}{\sigma_{X_t}}$ with $\overline{X_t} = n^{-1}\sum_{j=1}^{n} X_t$ and $\sigma_{X_t} = \sqrt{(n-1)^{-1}\sum_{j=1}^{n}\left(X_j - \overline{X_t}\right)^2}$.

Figure 3. Standard Normal Cumulative Distribution Function (x axis: z-scores; y axis: scores)



Source: LSEG Sovereign Sustainability.

2.3.5 Dilatation

To maximize the discriminating power between countries, a linear dilation is performed on all scores to ensure they range from 0 to 1[17] (included). This step allows us to finalize the transformation of raw data points into scores (i.e., indicators).

2.3.6 Aggregation

At every pillar level, an arithmetic mean will be calculated. For example, the Transition Risk pillar score will be the average of the indicators, ITR and GDP adjusted Carbon Footprint. This will only be done once, except for the Resilience pillar. Since the former is made up of the Domestic Resilience and Territorial & Ecosystems Resilience sub-pillars, an aggregation will occur at the sub-pillar level and then aggregated a second time at the pillar level.

It is key to note that for landlocked countries (i.e., Austria, Czech Republic, Hungary and Switzerland), there will be no Ocean Health Index data point. In these cases, the aggregation at the Territorial & Ecosystems Resilience sub-pillar level is done without taking this indicator into account.

[17] The linear dilation formula is the following: $\hat{X}_{t,i} = \frac{X_{t,i} - \min_X X_t}{\max_X X_t - \min_X X_t}$.

2.3.7 Smoothing

Following every aggregation, for a given pillar or sub-pillar and country, we will apply a smoothing function to every year. Using an exponential rule, we apply different weights to values in t, $t-1$ and $t-2$, with t being assigned the heavier weight and $t-2$ the lowest[18]. This method allows us to account for fluctuations over the last three years and to smooth potential one-off effects.

Finally, a final dilation will be carried out for each of the three pillar scores to effectively remain between 0 and 1.

[18] The weights for t, $t-1$ and $t-2$ are as follows: $\omega_t \approx 0.57$, $\omega_{t-1} \approx 0.29$ and $\omega_{t-2} \approx 0.14$.

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