Methodology document

Sustainable Sovereign Risk Monitor Methodology

July 2026

LSEG DATA & ANALYTICS

Contents

Model Change Log

Current Version	
Owner	SFI, Model Owner
Department	Sustainable Finance & Investment
Current Version	1.0
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Version Control Table:

Effective Date	Methodology Document Version Number	Model Version Number	Description of Key Changes from Previous Version
01/07/2026	1.0	1.1	First publication designed to support applicable regulatory disclosures.

Regulatory Information

For the purposes of Regulation (EU) 2024/3005 on the transparency and integrity of ESG rating activities, Refinitiv France SAS is the ESG Rating Provider responsible for the issuance of the relevant ESG ratings within the European Union.

This document describes the methodology used for the production of ESG ratings and related products distributed globally under the LSEG brand. References to LSEG products, methodologies, governance frameworks and related disclosures reflect the global operating framework supporting those products and services.

This methodology document forms part of the disclosure framework established to support compliance with the Regulation (EU) 2024/3005 and should be read together with the publicly available disclosure documents at: https://www.lseg.com/en/data-analytics/sustainable-finance/regulatory-disclosures.

The use of the LSEG brand in this document is for branding purposes only and does not affect, modify or supersede the identification of the ESG Rating Provider for the purposes of Regulation (EU) 2024/3005.

Executive Summary

LSEG D&A ESG scores measure an item's relative performance on fundamental ESG attributes, commitment, and effectiveness across ESG factors. The scores are derived using a proprietary, rule-based methodology applied to publicly available information from sources believed by the London Stock Exchange Group (LSEG) to be reliable; however, the accuracy and completeness of such information cannot be guaranteed. The scores are provided for informational purposes only and do not constitute investment advice or a recommendation. They should not be relied upon as the sole basis for any decision. LSEG makes no representations or warranties and accepts no liability for any loss or damage arising from the use of, or reliance on, the scores.

The Sustainable Sovereign Risk Methodology (2SRM) has been built on the Sovereign Risk Monitor (SRM) to respond to increasing market maturity, customer needs and the World Bank and International Monetary Fund recommendations.

2SRM is a quantitative, relative and systematic approach, based on 36 indicators for 151 countries, divided into three pillars of sustainable sovereign risk assessment. LSEG calculates a score on a quarterly basis for each indicator, starting from 1999 until the end of the latest quarter. Each of the 36 indicators is the outcome of numerous adjustments – mostly systematic – based on public, private and proprietary data.

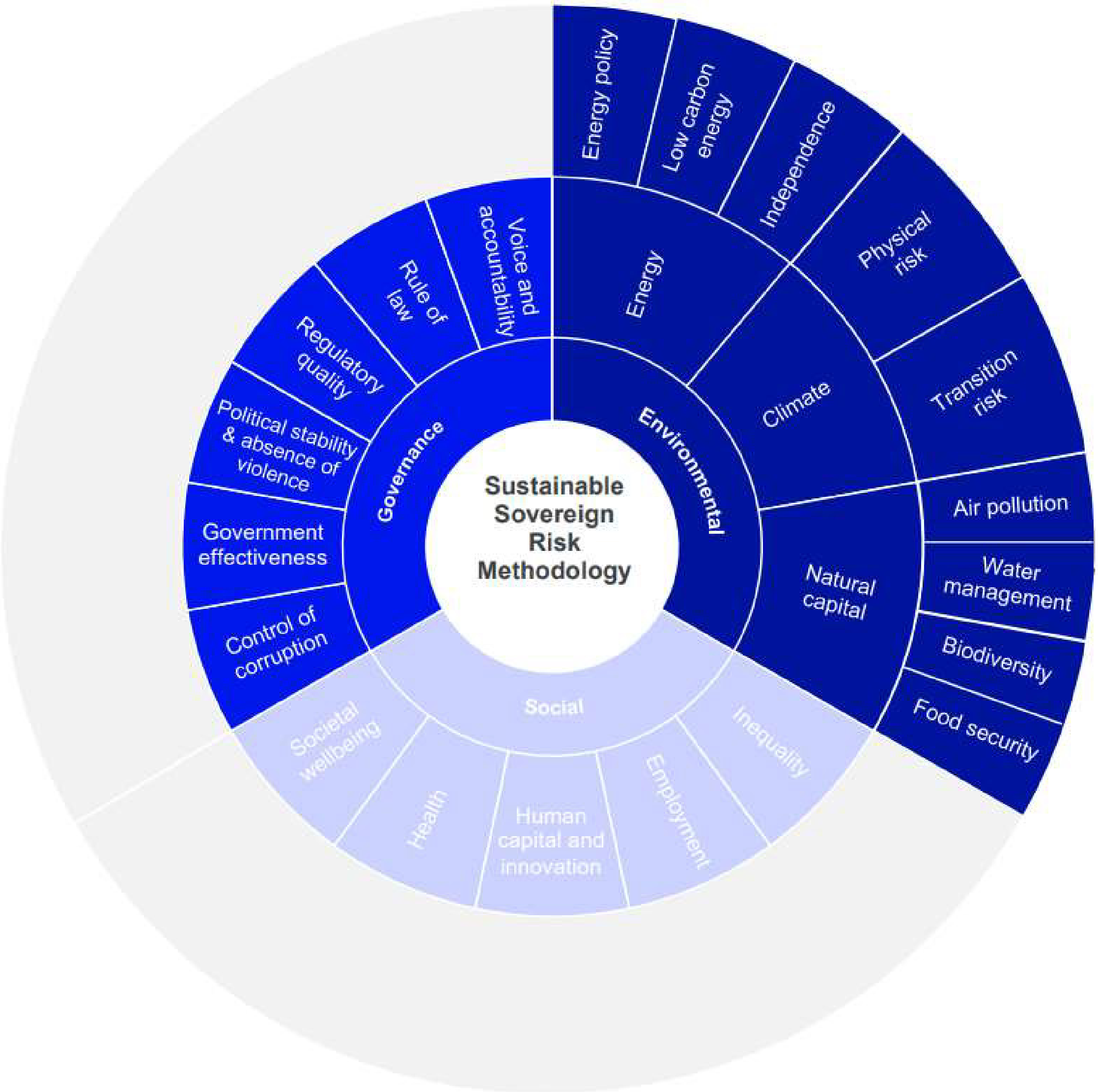
The 2SRM methodology incorporates elements of the double materiality principle by recognising both the financial implications of ESG factors on sovereign risk and the real-world environmental and social impacts associated with sovereign activities and policies. Financial materiality is addressed through the calibration of ESG indicators to sovereign credit risk. In parallel, the model incorporates elements of impact materiality through the inclusion of indicators that capture observable environmental outcomes. These include, among others, measures of greenhouse gas emissions and implied temperature rise (capturing contributions to global climate change) and biodiversity loss, water stress and air pollution (capturing pressures on natural capital and ecosystems). All indicators are combined at (i) a risk theme level and (ii) a pillar level to obtain an aggregated score, which is derived from advanced statistical and econometric techniques. Finally, the scores are aggregated from each pillar to obtain an aggregated ESG score, ranging from 0 to 100, where 0 means worst score and 100 means best score. 2SRM focuses on financially material ESG metrics. It is thus best adapted for use as an input and as a complement to traditional macroeconomic and financial analysis to quantify and better assess portfolio risk-return profiles.

2SRM relies on the quantitative assessment of Environmental (E), Social (S) and Governance (G) pillars which characterise sovereign creditworthiness.

Each pillar is structured around sub-pillars, which consist of several risk themes that include several indicators (see Figure 1). The Environmental Pillar, for example, is represented by three sub-pillars: Energy, Climate and Natural Capital.

The Energy sub-pillar is consequently made up of three risk themes: Energy Policy, Low-Carbon Energy and Energy Independence. The Energy Policy risk theme is composed of two indicators: Electricity Access and Energy Consumption. The quantity of indicators varies from one risk theme to another, but on average, they range between two and four.

Figure 1. The 2SRM Framework



Source: LSEG Sovereign Sustainability

Going beyond the Environmental, Social and Governance Risks, the 2SRM model addresses the income bias of high gross national income (GNI) countries.

The integration of ESG criteria in sovereign credit risk analysis results in the Ingrained Income Bias. High-income countries (i.e., AEs) tend to have higher ESG scores, whereas low- and middle-income countries (i.e., EMDEs) tend to have lower ESG scores. Social and Governance scores drive this bias due to the inherent correlation with economies' level of development, while Environmental scores are less correlated due to topic diversity and divergence in assessment frameworks. As 2SRM distinguishes between AEs and EMDEs, it allows the model to account for some of the income bias ex ante. However, to correct for the persisting income bias, LSEG Sovereign Sustainability uses an ex-post approach to generate separate income-adjusted E, S and G scores.

1. Methodology Overview

1.1 Computing raw data

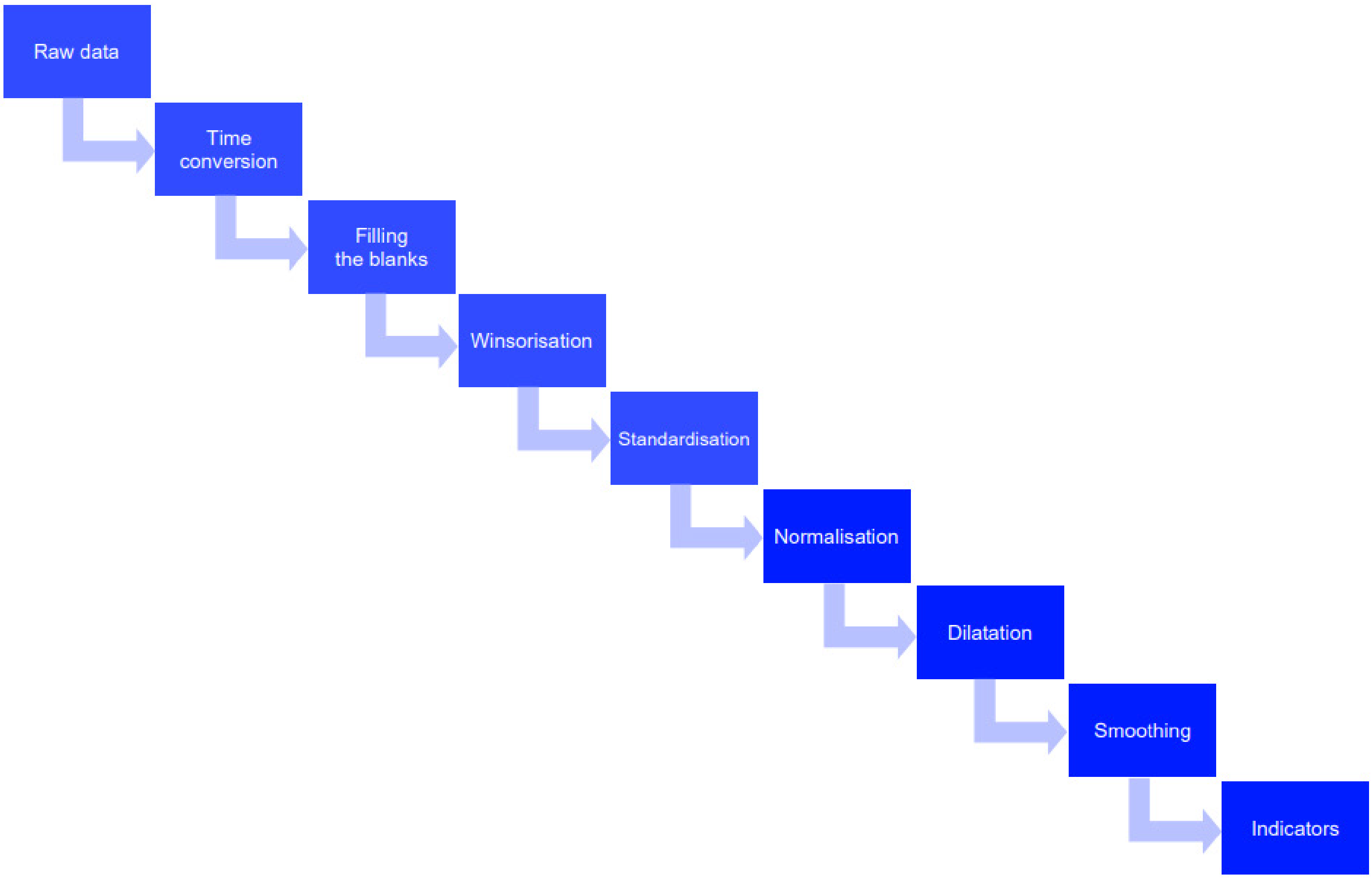
There are two indicators that serve as an input into this model that are computed before the next steps are performed:

1. Energy Consumption: it is computed as the percentage difference between an expected value and the actual energy consumption based on the GDP share of each type of economic activity (Agriculture, Industry and Services). The expected value is a linear estimation of the energy intensity of a certain country based on its GDP and the revenue generated by each type of economic activity mentioned above. 5
2. GHG to GDP Performance: it is computed as the percentage difference between an expected value and the actual GHG emitted. The expected value is a linear estimation of the quantity of GHG emitted in relationship to the country's GDP.

These two indicators are considered "raw" after the above computation happens as they are used in multiple Sovereign products.

1.2 From raw data to indicators

Figure 2. From raw data to indicators



Source: LSEG Sovereign Sustainability Solutions

Figure 2. illustrates the model technical pipeline that methodically converts raw, absolute measurements into robust, relative indicators suitable for comparison and decision-making: starting from raw data, values are first aligned through time conversion, ensuring observations are expressed on a consistent temporal basis before any analysis. Filling the blanks then restores missing absolute values to maintain continuity, while winsorisation tempers extreme observations so they do not dominate subsequent steps. With standardisation, the data is shifted from raw magnitudes to deviations relative to the income groups' distribution, and normalisation removes remaining scale effects by mapping values into a common range. Dilatation expands local patterns to emphasize relative relationships across time or entities, followed by smoothing, which suppresses short-term noise in favor of stable

trends. The process culminates in indicators, which no longer represent individual absolute measurements but instead condensed, relative signals that capture comparative performance, across both of the income groups.

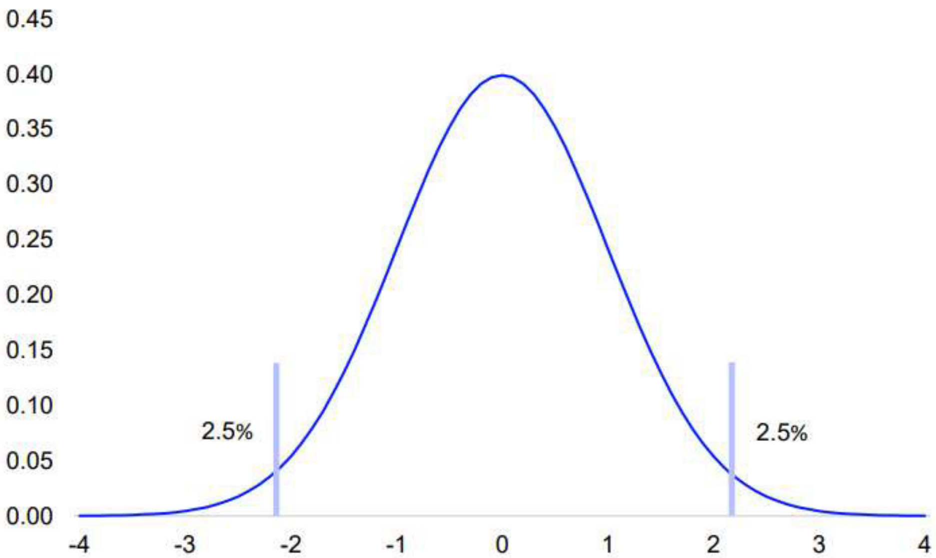
1.3 Time conversion

Raw datasets are received on an annual basis. As 2SRM provides scores on a quarterly basis, annual values will be attributed to the fourth quarter of a given year, which is followed by a linear interpolation between every current fourth quarter and the fourth quarter of the previous year. When the data gap is larger than the difference between two consecutive fourth quarters, the linear interpolation will only be performed for the first, second and third quarter of the given year and the fourth of the previous year. Remaining gaps will not be filled at this stage, except for the Implied Temperature Rise (ITR) indicator which will, be backward filled for the whole time series of every country as it is a forward-looking indicator which is not recorded historically.

1.4 Winsorisation

To minimise the impact of potential outliers, all indicators are corrected for extreme values that are higher than the 97.5th percentile or lower than the 2.5th percentile of the distribution (see Figure 3).

Figure 3. Standard distribution curve: Winsorisation process



Source: LSEG Sovereign Sustainability

1.5 Standardisation

Apart from the indicators noted below, indicators are transformed into z-scores for each country, by year and quarter using the following formula:

For a raw datum denoted $X_{t,i}$ with t the date and i the country, $z\text{-}score_{X_{t,i}} = \frac{(X_{t,i} - \bar{X}_t)}{\sigma_{X_t}}$ with $\bar{X}_t = n^{-1} \sum_{j=1}^{n} X_t$ and $\sigma_{X_t} = \sqrt{(n-1)^{-1} \sum_{j=1}^{n} (X_j - \bar{X}_t)^2}$

This allows to assess the relative risk linked to the initial data and corrects for data scaling. There are four indicators or families of indicators that are not winsorised and standardised – the World Governance Indicators produced by the World Bank, the Red List Index provided by the Sustainable Development Goals Database, the Physical Risk indicators and the Implied Temperature Rise indicator developed by LSEG Sovereign Sustainability – these indicators go through a standardisation process during production.

1.6 Normalisation

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 – where 0 represents the worst score and 1 the best score. Two different cases provide the framework for these additional adjustments: i. When the optimum is a maximum, the higher the value for the data, the higher the value of the corresponding z-score, and the higher the indicator (see Figure 4.1). ii. When the optimum is a minimum, the lower the value for the data, the lower the value of the corresponding z-score, and the higher the indicator (see Figure 4.2).

1.7 Dilatation

To maximise the discriminating power between sovereigns, a linear dilation is performed on all scores to ensure they range from 0 to 100 using the following formula:

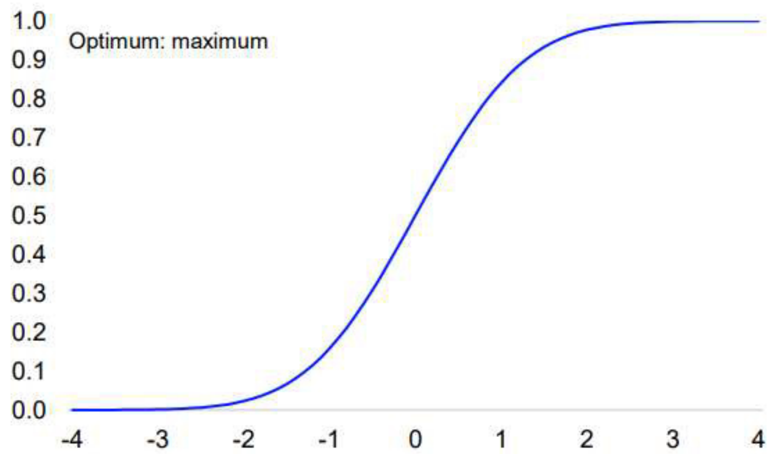
$$\hat{X_{t,i}} = \frac{X_{t,i} - \min_X X_t}{\max_X X_t - \min_X X_t}$$

This third phase allows to calculate scores (i.e., indicators).

1.8 Smoothing

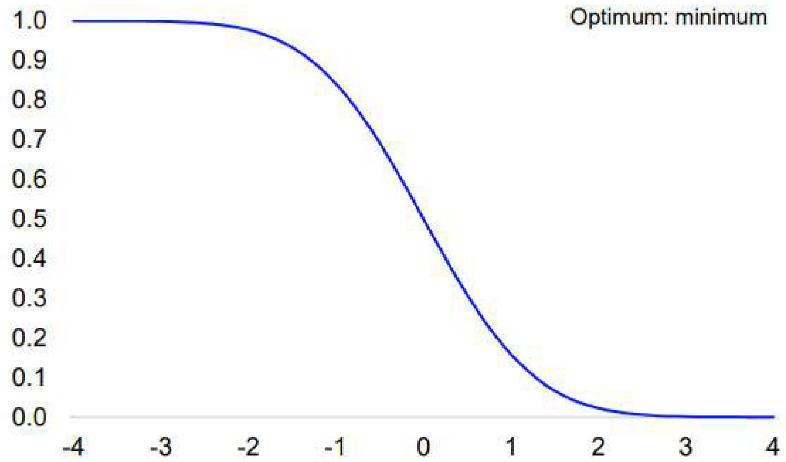
Finally, for every quarterly value for a given indicator and country, a smoothing process is applied. Following an exponential rule, different weights are applied to values in t, t-1, t-2 and t-3, with t being assigned the heavier weight and t-3 the lowest. This method accounts for fluctuations over the last four quarters and smoothing of potential one-off effects or erratic data.

Figure 4.1. Standard Normal Cumulative Distribution Function (x axis: z-scores; y axis: scores)



Source: LSEG Sovereign Sustainability

Figure 4.2. Standard Normal Cumulative Distribution Function (x axis: z-scores; y axis: scores)



Source: LSEG Sovereign Sustainability

1.9 Aggregation - From indicators to pillars

Figure 5 illustrates the systematic approach to assigning a score to a pillar based on its underlying indicators. The chart shows how the six indicators in the Governance pillar are aggregated to provide the Governance Pillar score, representing an approach that allows to derive a score in the form of a weighted average.

1.10 Accounting for the level of development

The relevance of each indicator in predicting the probability of default will depend on the level of economic development for every country. As a result, Advanced Economies (AEs), Emerging Markets and Developing Economies (EMDEs) are split, as defined by the International Monetary Fund's dynamic country classification,[11] to derive an indicator's weight for each group of countries. This means that indicators such as Poverty will be assigned a weight of 24.8% for AEs and 33.1% for EMDEs.

Figure 5. From indicators to pillars: example

	Control of Corruption	Government Effectiveness	Regulatory Quality	Rule of Law	Political Stability & Absence of Violence	Voice & Accountability
Advanced Economies	18.8%	18.6%	20.2%	19.4%	11.9%	11.1%
Emerging Markets & Developing Economies	15.5%	18.3%	18.1%	16.7%	12.1%	19.2%

Source: LSEG Sovereign Sustainability

1.11 Calibration process

The weights of each indicator for each pillar, i.e., intra-pillar weights, are calibrated using the econometric modelling framework called Partial Least Squares (PLS), with an added Variable Importance in Projection (VIP) score (see Appendix 1 for further details).

This type of econometric modelling aims to be more robust than a simple linear model of the Ordinary Least Squares (OLS) type.[2] The OLS econometric modelling does not consider the potential issues linked to collinearity between each indicator. Indeed, it is obvious that some indicators are strongly correlated with others, e.g., a country's general government overall balance is de facto strongly correlated with the general government primary balance of this same country. Therefore, the coefficients estimated through OLS are biased.

The PLS econometric model with an added VIP score allows consideration of potential issues linked to collinearity between each indicator and ranking of the information value contained in each indicator within a pillar to estimate an aggregated measure of sovereign risk. The aggregated sovereign risk measure is the endogenous variable. It is calculated as the average of the non-linear numerical adjustment of the empirical default probabilities derived from the financial credit ratings of the three main credit rating agencies (Standard & Poor's, Moody's Investors Service and Fitch Ratings, as publicly disclosed on their websites).

This aggregate measure of sovereign risk is therefore considered to calibrate the intra- and inter-pillar weights of 2SRM. Once the coefficients for each indicator within each pillar are estimated, the scores are normalised under a significance constraint: to not underestimate too much the weight of some indicators in the modelling, a minimum value is assigned ($Minimum\ Weight$ = 1/2N with N the number of indicators constituting the pillar) below which no weight can be. If some indicators are assigned that minimum weight, all the other weights are once again normalised to obtain weightings set the sum of which is 100% for each pillar.

The results derived from this advanced econometric framework are calibrated on a data sample from Q4 1999 to Q4 2020.

The calibration period runs from Q4 1999 to Q4 2020. The choice of this period was motivated by data availability constraints and the date at which we carried out this calibration. Regarding the former, to ensure the outputs are based on a large enough sample, we focused on a sample that was sufficiently complete across geography and in frequency. Regarding the latter, the calibration was carried out in 2022 meaning that the data was relatively incomplete between 2020 and 2022. However, it is key to note that the results of the first calibration process, which was first carried out in 2016 using the same methodology, resulted in almost identical outputs.

1.12 Exceptions

The weights of some indicators cannot be exclusively decided using an econometric framework, but rather through the support of multidisciplinary research. This is especially the case for Physical Risk, Transition Risk, Air Pollution, Water Stress, Biodiversity and Food Security indicators. Even if such indicators do not show a direct theoretical link to sovereign credit risk, they quantify the degree of exposure and vulnerability of countries' populations, infrastructure and ecosystems to environmental degradation, which can help predict the severity of economic impact in the short, medium and long term. In such cases, and within the scope of this model, the indicators have been attributed equal weights to represent their equal importance, irrespective of countries' level of economic development.

1.13 From pillars to an aggregated ESG risk score

The E, S and G pillars are equally weighted to provide the ESG risk score. This is to mitigate the risk that empirical econometric analysis tends to reduce the importance of the Environmental pillar. Environmental indicators are a priority for some investors and are increasingly relevant for sovereign risk in areas of the world more exposed to physical and/or transition risks due to climate change. Moreover, overall resource depletion ought to be accounted for as a set of weak signals, which are precursors for potential second-round effects in geopolitical and economic terms.

1.14 Validation of final scores

In addition to the input validation process, we carry out a validation process of the outputs of the 2SRM model. This helps us ensure that the scores reflect the reality presented by the data points and that these are free of methodological or human error. The process is done by comparing the latest time series (e.g., Q2 2024) from the newly produced outputs of the current quarter update with the latest time series produced by the outputs of previous quarter update (i.e. Q1 2024). Countries are flagged when their E, S and G pillar scores experience changes above 3 points or below -3 points. For those countries, we will identify which indicator is leading the shift. Flagged changes in the E, S and G pillars are usually due to absolute changes of at least 8 points at the indicator level. Once the indicator is identified, we will compare the current quarter and previous quarter raw data. In most cases, changes are caused by updates or revisions of the raw data, carried out by the data provider. Otherwise, distributional changes can also influence final scores. All discrepancies and their justification are written up in quarterly reports for documentation and reference purposes.

1.15 Income-adjusted methodology

LSEG Sovereign Sustainability uses a simple econometric framework to construct income-adjusted sovereign ESG scores. To neutralise the information related to income bias from 2SRM's E, S and G scores, a univariate pooled ordinary least square (POLS) regression for 149 economies is used, on a quarterly basis, between Q4 1999 and Q4 2020.

Empirical linkages between GNI per capita and ESG scores

The Environmental, Social and Governance scores from 2SRM are regressed on the explanatory variable that is the natural logarithm of the gross national income (GNI) per capita (at purchasing power parity in constant USD) for each economy and quarter.

Table 1. POLS coefficients for E, S and G pillars

	Environmental	Social	Governance
α	38.33*** (5.94)	-69.67*** (6.30)	-100.45*** (9.81)
β	1.90*** (0.69)	12.71*** (0.70)	16.12*** (1.11)
# Observations	12495	12495	12495
R-squared	0.06	0.67	0.56

Source: LSEG Sovereign Sustainability

Notes: The table presents the coefficient of the POLS $Eit = \alpha E + \beta E * LN(GNI\ per\ capitait) + eit$ for Environmental Risk pillar, $Sit = \alpha S + \beta S * LN(GNI\ per\ capitait) + sit$ for Social Risk pillar and $Git = \alpha G + \beta G * LN(GNI\ per\ capitait) + git$ for Governance Risk pillar. Standard errors are in parentheses. *, ** and *** denote statistical significance at the 10%, 5% and 1% level of confidence, respectively.

1.16 Beyond GNI per capita

The residuals from these three regressions are then retrieved (which represent the share of the initial E, S, and G scores that is not explained by the income level) to calculate the income-adjusted sovereign E, S and G scores. To do these calculations, these residuals are transformed into z-scores for each score and economy on a quarterly basis. Then, the z-scores are transformed into continuous scores based on an interval, ranging from 0 to 100, in accordance with the cumulative distribution function of a standard normal distribution – where 0 represents the worst score and 100 the best score. Finally, the E, S, and G scores are aggregated to calculate overall income-adjusted sovereign ESG scores.

1.17 Limitations, assumptions and mitigation steps

The methodology is subject to several data and modelling limitations that are actively mitigated through systematic controls embedded in the production process. Source coverage varies across indicators and time (particularly pre-2000 and for EMDEs), which may affect comparability; this is mitigated through structured imputation rules, income-group benchmarking and continuous data validation. Missing observations are filled using forward/backward filling, linear interpolation or income-group averages, with smoothing applied to reduce artefacts from imputation. Econometric steps (e.g., PLS weighting and smoothing techniques such as exponential filters) rely on statistical assumptions regarding linearity, stability and noise reduction, which may not fully capture structural breaks; these risks are mitigated by regular recalibration, validation against sovereign risk proxies and expert review. Income-group segmentation (AEs vs EMDEs) improves comparability but may introduce boundary effects or mask within-group heterogeneity; this is addressed through income-adjusted scores and periodic reassessment of grouping. Outliers and abrupt changes are controlled through winsorisation and quarterly monitoring thresholds, with flagged deviations investigated and documented through formal governance processes.

Table 2.1. Summary of limitations and applied mitigation approaches

Limitation	Potential impact	Mitigation
Uneven source coverage (country/time)	Reduced comparability across countries and history	Multi-source integration, quarterly updates, validation checks, minimum coverage thresholds
Imputation of missing data	Signal distortion, especially for sparse series	Hierarchical filling rules (interpolation, carry-forward/backward, income-group averages) + smoothing
PLS / smoothing assumptions (e.g., LOESS-like effects)	Model may not capture non-linearities or regime shifts	Regular recalibration, benchmarking to sovereign risk proxies, expert review
Income-group segmentation	Boundary and heterogeneity effects	Dual approach: segmented calibration + ex-post income adjustment
Outliers and extreme values	Disproportionate influence on scores	Winsorisation (2.5%–97.5%) and distribution-based normalisation
Data and model drift over time	Unnoticed structural changes in inputs or outputs	Quarterly monitoring, threshold-based flagging, SME review and documented overrides

Source: LSEG Sovereign Sustainable Solutions

Table 2.2. Summary of shortcomings and applied mitigation approaches

Shortcoming	Description	Mitigation

Data gaps and availability constraints	Incomplete coverage across countries, indicators or time periods	Transparent coverage rules, use of proxies and income-group averages, disclosure of gaps
Imputation reliance	Filling methods may smooth or bias true dynamics	Use of simple, transparent rules (interpolation/carry-forward) combined with smoothing and validation checks
Calibration period limitations	Model calibrated on Q4 1999–Q4 2020 may not fully reflect recent structural shifts	Periodic recalibration, stability testing, and comparison with updated datasets
PLS / VIP assumptions	Dependence on linear relationships and component extraction; VIP thresholds may retain weaker predictors	Use of PLS to address multicollinearity, minimum weight constraints, robustness checks and expert oversight
Equal-weight exceptions	Some indicators (e.g. environmental risks) use equal weights outside econometric output	Supported by multidisciplinary research, documented rationale and periodic review
Income-adjustment assumptions	Income bias correction via regression may not fully isolate structural differences	Use of both segmented modelling (AEs vs EMDEs) and residual-based income adjustment, with ongoing validation

Source: LSEG Sovereign Sustainable Solutions

2. Data Collection Process[1]

The 2SRM ingests data from several sources. These include proprietary data and public data. Both sets of data are handled by a data manager, who specialises in receiving, validating and storing all raw data. The data manager keeps a schedule of when all raw inputs are updated and when they should be validated. In this way, it is assured that each update of 2SRM has the latest available data and covers any major changes that happened between refreshes without any subjective intervention.
The 2SRM inputs are gathered every January, April, July and October for the model's quarterly updates, therefore the ESG score is considered valid for a quarter, between refreshes. When datasets are updated, the manager goes through a validation process. They verify that all previously available data points are available or not, as for some countries or time periods, some data points are lost or added. This also includes the verification of null values.
Along with this, the manager will verify how values have evolved. Using quantitative rules, maximum thresholds for change will be calculated for each indicator type and these will be used to accept or reject new values.
When a value is not accepted, be it because its change goes beyond the maximum threshold or because the evolution seems erroneous, the value will be flagged, and the subject-matter-experts (SMEs) will be made aware to review the data point. In these cases, the raw data values may be either overruled, whereby the new value will be replaced by its previous one, or it may be accepted, and the new value will be integrated in the database.
All changes to raw data points are very carefully analysed and documented by both the manager and the SMEs, keeping in mind the impact these may have on final scores and its users. These processes also apply to LSEG's proprietary data, where the inputs and outputs of intermediary models are validated equally. The final check, before being ingested by the 2SRM model, includes a verification that all the necessary data for the 151 countries, years (since 1999) and 36 total indicators concerned is available.

2.1 Filling the blanks

All indicators have different levels of coverage. For some indicators, data may be widely available across all countries for which a country score is produced, but not necessarily over the entire data set since 1999. In instances where an indicator is unavailable, the following approach is followed:

i. If an indicator value is missing at the beginning of the time series, the value is populated with the first available value. When values are missing at the end of the time series, values are populated with the last available value.
ii. If an indicator value is missing at some point in time during the history of the time series (encircled by available values), a linear interpolation is used to derive the missing values.

If an indicator is missing for the entire time series for a given country, the income group average values will be attributed: for each year and KPI, the average value by country income groups, according to the IMF Income Group's country classification, is calculated. The Income Groups are defined as: Advanced Economies and Emerging Economies. If a change of income group occurs, the average of this new income group is taken from the year of the change of group.

2.2 Indicators used

ENVIRONMENTAL RISK

Sub-pillar: Energy Risk

Theme: Energy Policy

Indicator: *Electricity Access*
Definition:
The electricity access measures the percentage of population with largely uninterrupted access to decentralised or grid power. Electricity access gives a strong indication of a country's energy poverty status and the degree of constraint exerted by energy, as a production factor, on the whole economic system, and as such is a governmental priority. Electricity access data are collected from international sources, industry and national surveys.
Source: World Bank - Public

Indicator: *Energy Consumption*
Definition:
The energy consumption measures the degree of energy over- or under- consumption against a standard determined by the country's level of income based on an extensive geographical coverage of about 200 countries. It captures various drivers, from structural (climate conditions, population density, population concentration), to cyclical (economic cycles) and to technological

[1] No AI was used in the data collection or rating process and the rating methodology is not based on scientific evidence

(energy and overall efficiencies). The standard level is econometrically estimated, based on the whole sample of countries over the period starting from 2000. Each country is then attributed a ranking depending on its performance relative to the GDP per capita level.
Source: LSEG - Internal

Theme: Low Carbon Energy

Indicator: *Brown Proxy*
Definition:
The brown proxy indicator measures the percentage of fossil fuels in primary energy consumption. These include oil, gas, and coal.
Source: LSEG - Internal

Indicator: *Green Proxy*
Definition:
The green proxy indicator measures the percentage of low-carbon energy sources used in primary energy consumption. These include hydropower, wind, solar, geothermal, tidal, and nuclear energy.
Source: LSEG - Internal

Theme: Energy Independence

Indicator: *Total Energy Independence*
Definition:
The energy independence indicator is calculated using primary energy consumption and production metrics. This indicator provides a more global view of the resources directly available to a country's energy system.
Source: LSEG - Internal

Sub-pillar: Climate Risk

Theme: Physical Risk

Indicator: *Historical Physical Risk*
Definition:
Six climate hazards are considered in the building of physical risks scores: heatwaves, droughts, water stress, intense precipitations, riverine floods, and coastal floods. For each hazard, raw climate data is used to calculate specific indicators that will describe a hazard's frequency and/or intensity. Past exposures are computed from the absolute values of climate indicators (e.g., the frequency of warm days). Then, given that the potential impact on a given sector of the economy depends on this sector's vulnerability to the hazard, the hazard scores are combined with the sectoral vulnerability scores. Following so, the sectoral risk scores are linked to the sectoral Gross Domestic Product (GDP) breakdown, using a weighted average to obtain each hazard's risk scores for each country. Finally, a single, multi-hazard score is created that summarises the overall physical climate risk level of the country. This synthetic score is calculated from the average of the three highest hazard specific scores for each country.
Source: LSEG - Internal

Indicator: *2050 Physical Risk*
Definition:
Seven climate hazards are considered in the building of physical risks scores: heatwaves, droughts, water stress, intense precipitations, riverine floods, coastal floods and increase in average temperature. For each hazard, raw climate data is used to calculate specific indicators that will describe a hazard's frequency and/or intensity. 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, following a 'hope for the best, plan for the worst' type of approach. Then, given that the potential impact on a given sector of the economy depends on this sector's vulnerability to the hazard, the hazard scores are combined with the sectoral vulnerability scores. Following so, the sectoral risk scores are linked to the sectoral Gross Domestic Product (GDP) breakdown, using a weighted average to obtain each hazard's risk scores for each country. Finally, a single, multi-hazard score is created that summarises the overall physical climate risk level of the country. This synthetic score is calculated from the average of the three highest hazard-specific scores for each country.
Source: LSEG - Internal

Theme: Transition Risk

Indicator: *GHG to GDP Performance*
Definition:
This indicator measures the deviation of consumed GHG emissions from the standard defined by the country's level of income. Consumed GHG emissions includes territorial and imported emissions but excludes exported emissions. This indicator captures key drivers: (i) Structural (climate conditions, population density, population concentration, GDP structure); (ii) Cyclical (economic cycles); (iii) Energy (energy balance structure, energy domestic prices); (iv) Technological (energy and overall efficiency). The

standard level is econometrically estimated, based on a sub-sample of 130 countries over the period starting from 2000. Each country is then attributed a ranking depending on its relative performance.
Source: LSEG - Internal

Indicator: *NDC Implied Temperature Rise (ITR)*
Definition:
The Implied temperature Rise (ITR) is an indicator providing an approximation of the global warming level (in 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). The country for whom the 'NDC-based' projected emissions are below its 1.5°C-carbon budget is called 'undershoot', whereas it is called an 'overshoot' if its projected emissions are above its Paris-aligned carbon budget. To define the countries' carbon budget consistent with a 1.5°C objective (or 2°C), LSEG D&A developed the CLAIM methodology. It relies on a statistical approach that remains as neutral as possible, because the way to share the global carbon budget is a politically sensitive issue. CLAIM takes into account a lot of parameters that can be considered to reflect the climate profile of a country relatively to the other countries in this sharing perspective, such as the GDP, the energy intensity of the GDP, the carbon intensity of the energy mix, the past emissions, etc.
Source: LSEG - Internal

Sub-pillar: Natural Capital Risk

Theme: Air Pollution

Indicator: *Air Pollution*
Definition:
Population-weighted exposure to ambient PM2.5 pollution is defined as the average level of exposure of a nation's population to concentrations of suspended particles measuring less than 2.5 microns in aerodynamic diameter, which are capable of penetrating deep into the respiratory tract and causing severe health damage. Exposure is calculated by weighting mean annual concentrations of PM2.5 by population in both urban and rural areas.
Source: World Bank - Public

Theme: Water Management

Indicator: *Water Stress*
Definition:
The level of water stress indicator measures freshwater withdrawal as a proportion of available freshwater resources. It calculates the ratio between total freshwater withdrawn by all major sectors and total renewable freshwater resources, after taking into account environmental water requirements. Main sectors, as defined by ISIC standards, include agriculture; forestry and fishing; manufacturing; electricity industry; and services. This indicator is also known as water withdrawal intensity.
Source: World Bank - Public

Theme: Biodiversity

Indicator: *Red List Index*
Definition:
The Red List Index, used to track the Sustainable Development Goal of Life on Land (Goal 15), measures the change in aggregate extinction risk across groups of species. It is based on genuine changes in the number of species in each category of extinction risk on The IUCN Red List of Threatened Species (IUCN 2015). It is expressed as changes in an index ranging from 0 to 1. Governments use the index to track their progress towards targets for reducing biodiversity loss.
Source: UN SDG Database - Public

Theme: Food Security

Indicator: *Prevalence of Undernourishment*
Definition:
The prevalence of undernourishment is the percentage of the population whose habitual food consumption is insufficient to provide the dietary energy levels that are required to maintain a normal active and healthy life. This indicator serves as a proxy for the prevalence of moderate or severe food insecurity in the World Bank's population indicator (PFI) as its geographical and historical coverage is limited.
Source: World Bank - Public

SOCIAL RISK

Sub-pillar/Theme: Human Capital and Innovation

Indicator: *R&D Expenditures*
Definition:
Expenditures for research and development are current and capital expenditures (both public and private) on creative work undertaken systematically to increase knowledge, culture, and society improvement, and the use of knowledge for new applications. R&D covers basic research, applied research, and experimental development. It is expressed as a share of GDP.
Source: World Bank - Public

Indicator: *High-Tech Exports*
Definition:
High-technology exports are products with high R&D intensity, such as in aerospace, computers, pharmaceuticals, scientific instruments, and electrical machinery. Expressed as share of manufactured exports.
Source: World Bank - Public

Indicator: *Education Expenditures*
Definition:
General government expenditures on education (current, capital, and transfers) are expressed as a percentage of GDP. It includes expenditures funded by transfers from international sources to government. General government refers to local, regional, and central governments.
Source: World Bank - Public

Sub-pillar/Theme: Health

Indicator: *Health Expenditures*
Definition:
Total health expenditure is the sum of public and private health expenditure. It covers the provision of health services (preventive and curative), family planning activities, nutrition activities, and emergency aid designated for health but does not include provision of water and sanitation.
Source: World Bank - Public

Indicator: *Hospital Beds*
Definition:
Hospital beds include in-patient beds available in public, private, general, and specialised hospitals and rehabilitation centres. In most cases beds for both acute and chronic care are included.
Source: World Bank - Public

Indicator: *Physicians*
Definition:
Physicians include generalist and specialist medical practitioners. It is expressed per 1,000 people.
Source: World Bank - Public

Indicator: *Life Expectancy*
Definition:
Life expectancy at birth indicates the number of years a newborn infant would live if prevailing patterns of mortality at the time of its birth were to stay the same throughout its life.
Source: World Bank - Public

Sub-pillar/Theme: Societal Wellbeing

Indicator: *Female Labour Participation Rate*
Definition:
The female to male labour force participation rate (from national sources) is a good proxy of the place of women in the society. Labour force participation rate is the proportion of the population aged 15 and older that is economically active: all people who supply labour to produce goods and services during a specified period.
Source: World Bank - Public

Indicator: *Internet Access*
Definition:
Internet users are individuals who have used the Internet (from any location) in the last 12 months. Internet can be used via a computer, mobile phone, personal digital assistant, games machine, digital TV etc. It is expressed per 1,000 people.
Source: World Bank - Public

Indicator: *Urbanisation Rate*
Definition:

Urban population refers to people living in urban areas as defined by national statistical offices. The data are collected and smoothed by the United Nations Population Division.
Source: World Bank - Public

Sub-pillar/Theme: Inequality

Indicator: *GINI Index*
Definition:
Gini index measures the extent to which the distribution of income (or, in some cases, consumption expenditure) among individuals or households within an economy deviates from a perfectly equal distribution. A Lorenz curve plots the cumulative percentages of total income received against the cumulative number of recipients, starting with the poorest individual or household. The Gini index measures the area between the Lorenz curve and a hypothetical line of absolute equality, expressed as a percentage of the maximum area under the line. Thus, a Gini index of 0 represents perfect equality, while an index of 100 implies perfect inequality.
Source: World Bank - Public

Indicator: *Income Distortion Index*
Definition:
The income distortion index corresponds to the share of income held by the top 10% richest households in a country.
Source: World Bank - Public

Indicator: *Social Contributions*
Definition:
Social contributions include social security contributions by employees, employers, and self-employed individuals. They also include actual or imputed contributions to social insurance schemes operated by governments. It is expressed as a share of government revenue.
Source: World Bank - Public

Indicator: *Poverty Rate*
Definition:
Poverty headcount ratio at USD 1.90 a day is the percentage of the population living on less than USD 1.90 a day at 2011 international prices.
Source: World Bank - Public

Sub-pillar/Theme: Employment

Indicator: *Labour Participation Rate*
Definition:
The labour force participation rate is the proportion of the population ages 15 and older that is economically active: all people who supply labour for the production of goods and services during a specified period.
Source: World Bank - Public

Indicator: *Unemployment Rate*
Definition:
The unemployment rate is calculated as the number of persons who are unemployed during the reference period given as a percent of the total number of employed and unemployed persons (i.e., the labour force) in the same reference period.
Source: World Bank - Public

Indicator: *Youth Unemployment Rate*
Definition:
The youth unemployment rate refers to the share of the labour force ages between 15 and 24 without work but available for and seeking employment.
Source: World Bank - Public

GOVERNANCE RISK

Indicator: *Control of Corruption*
Definition:
Control of corruption captures the extent to which public power is not exercised for private gain, including both petty and grand forms of corruption, as well as avoiding the "capture" of the state by elites and vested interests. The more corruption there is in the country, the weaker the indicator.
Source: World Bank (WGI) - Public

Indicator: *Government Effectiveness*
Definition:
Government effectiveness captures 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.
Source: World Bank (WGI) - Public

Indicator: *Political Stability & Absence of Violence*
Definition:
Political stability & absence of violence captures the likelihood that the government will be destabilised or overthrown by unconstitutional or violent means. The more the political power is unstable and the more violence there is in the country, the weaker the indicator.
Source: World Bank (WGI) - Public

Indicator: *Regulatory Quality*
Definition:
Regulatory quality captures the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development and limit negative externalities from commerce.
Source: World Bank (WGI) - Public

Indicator: *Rule of Law*
Definition:
Rule of law captures the extent to which agents have confidence in and abide by the rules of society, and in particular the ability to enforce property rights, the quality of the police and the courts, as well as the level of crime and violence **Source:** World Bank (WGI) - Public

Indicator: *Voice & Accountability*
Definition:
Voice & accountability captures 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.
Source: World Bank (WGI) - Public

Access to non-public data is performed in two ways, depending on the provider. Where supported, we access the data directly through the provider's platform using authorized login credentials supplied for this purpose and managed in accordance with our security controls. Alternatively, when direct access is not available or when automation is required, we retrieve the data via the provider's API, using a Python-based script to authenticate, request, and process the data securely and in line with the provider's technical and usage requirements.

The data sources are not mapped against sustainability statements under CSRD or from information disclosed under SFDR, or EU Taxonomy.

For the input data checks, some comparisons are done between:

- the previous update and the new one;
- the new update and reference tables (which contains metadata details).

The process is recorded in a csv log file. These checks are standardised to be applied to all the sources used to populate the database.

1. Metadata checks:
   a) Comparisons between countries from the golden data (i.e., data already stored and used for different products) newly imported and the country reference table → check if all countries codes are on the reference table and if codes are the same. A pop-up appears during the ingestion process with the discrepancies:
      i. we can choose to continue the process without updating the reference table (if discrepancies concern regions for example);
      ii. we can update the reference table before further ingestion (add missed countries for example).
   b) Comparisons between indicators metadata details:
      i. check if a golden data is missed;
      ii. check if unit of indicators newly imported is the same as the one described in metadata table.

2. Comparison between data points for the 2 latest updates:
   a) check if data imported contain data for all the countries previously imported or if some countries are missed or added;
   b) check if both new and old value are null;
   c) list all data points which match with abs(new value/old value-1) > 0.3;
      i. for indicators with percentage unit, only those with abs(old_val -new_val)>5
      ii. for indicators with constant prices and deflator, calculate the ratio of value_n -1/value n for each year and check if this ratio is constant.
   d) list all data points which the new value is null and the old value not;
   e) list all data points which the old value is null and the new value not;

f) list all data points for which the new value < average-3*std deviation; 18
g) list all data points for which the new value > average+3*std deviation;
h) list indicators with unique value in time series;
i) list indicators for which the unit have changed between the previous and the new update;
j) list indicators for which unit is null and value not;
k) list indicators missed or added between the 2 updates;
l) list of data overruled on the previous update, the value overruled and the new value.

Once all these checks files are validated, data are recorded in the final table which contains all data points (raw data and computed data).

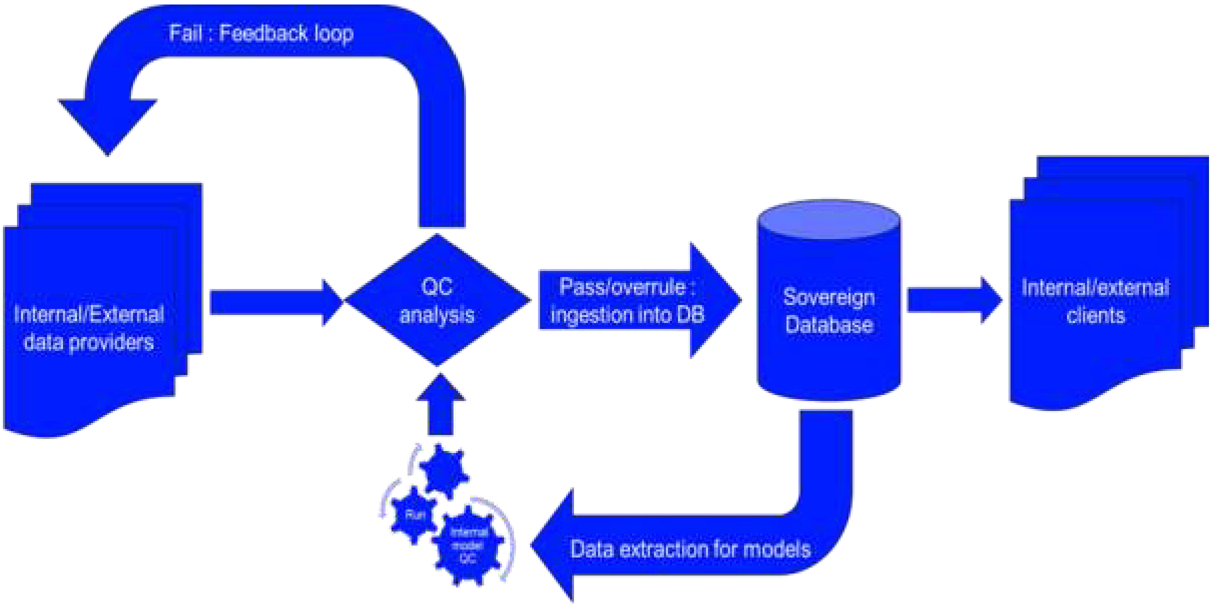
2.3 Model Coverage

Countries were chosen based on data availability and based on our index-building clients feedback and asks at the time of the development.

3. Model Management

3.1 Model Input/Output Validation

Figure 6. Data validation flow



Source: LSEG Sovereign Sustainability.

Notes: In figure 6, “Run” refers to the regular updating of methodologies.

Data validation is a process that encompasses all activities aimed at identifying, processing, and, if necessary, correcting data entering the Sustainable Finance (SFI) information systems. The importance of this process lies in the fact that the data is later used by internal or external clients. This process is centralized upstream of the Sovereign Database (DB), which is the master database for sovereign SFI data and it is performed after each model run (quarterly). It consists of three parts:

1. Metadata checks:

a) Comparisons between countries from the newly imported “golden” data (i.e., data already stored and used for different products) and the country reference table. First check revises if all countries codes are in the reference table and if codes are identical.
After checks, discrepancies can:
   i. Either be ignored if it does not impact downstream flow

ii. Or lead to an update in the reference table before further ingestion (add missed countries, for example). 19

b) Comparisons between indicators metadata details:
   i. Check if a golden data point is missing;
   ii. Check if the unit of a newly imported indicator is the same as the one described in metadata table.

2. Model specific checks:
   i. Flag indicators that have a change of ±10 points and caused a pillar score change of ±2 points run versus run and create narrative using the input raw data for both non-adjusted and Income Adjusted scores
   ii. Flag indicators that have a change of ±10 points and caused a pillar score change of ±2 points year-on-year for the last 5 years and create narrative using the input raw data for both non-adjusted and Income Adjusted scores

3. Comparison between data points from the 2 latest updates allows the flagging of suspicious datapoints:
   i. check if the imported dataset contains data for all the countries previously imported or if some countries are missing or have been added;
   ii. check if both new and old values are null;
   iii. list all data points which match with abs(new value/old value-1) > 0.3;
   - for indicators with a percentage unit, only those with abs(old_val -new_val)>5 are flagged
   - for indicators with constant prices and a deflator, calculate the ratio of value_n-1/value n for each year and check if this ratio is constant.
   iv. list all data points where the new value is missing but not in the previous instance;
   v. list all data points where the old value is missing and not the new value;
   vi. list all data points where the new value < average-3*std deviation;
   vii. list all data points where the new value > average+3*std deviation;
   viii. list indicators with unique value in time series;
   ix. list indicators where the unit have changed between the previous delivery and the new update;
   x. list indicators where unit is missing but not the value;
   xi. list missing or added indicators between the 2 updates;
   xii. list of overruled data on the previous update, the value overruled and the new value.

Once all these checks files are validated, data are recorded in the final table which contains all data points (raw data and computed data). Where a data point fails one or more of the validation checks described above and no supporting evidence can be obtained from publicly available sources, the overrule procedure is applied. If no decision is made, questions are raised back to the provider for further investigation and justification.

An overrule is applied only in exceptional circumstances where a data point is identified as erroneous and its inclusion would result in an unjustified increase or decrease in a country's score. Following validation of the issue, the affected variable is replaced with the value reported in the most recent data refresh where the variable was considered reliable. Where no reliable historical value is available, the variable is assigned a null value. This process is intended solely to mitigate the impact of confirmed data errors on the scoring results and to ensure the consistency, comparability, and robustness of the methodology pending correction of the underlying data issue.

3.2 Data Limitations

All indicators have different levels of coverage. For some indicators, data may be widely available across all countries for which a country score is produced, but not necessarily over the entire data set since 1999. In instances where an indicator is unavailable, the following approach is followed:

- If an indicator value is missing at the beginning of the time series, the value is populated with the first available value. When values are missing at the end of the time series, values are populated with the last available value.
- If an indicator value is missing at some point in time during the history of the time series (encircled by available values), a linear interpolation is used to derive the missing values.
- If an indicator is missing for the entire time series for a given country, the IMF group average value will be attributed: for each year and KPI, the average value by country income groups, according to the IMF Income Group’s country classification, is calculated. IMF Income Groups are defined as: Advanced Economies and Emerging Economies. If a change of income group occurs, the average of this new income group is taken from the year of the change of group.

The impact of new values that are backwards filled is further mitigated by the Smoothing step presented above; by reducing the impact they have on the final calculation of the indicator.

The impact of a KPI’s data series missing for a certain country is that it may not accurately represent the reality for that rated entity due to the fact that average value would be used as a replacement for that KPI for the specific income group. By using the average, the distribution and the relative scoring are not affected by a large amount, because the rated entity would be placed in the centre of the distribution.

Appendix 1: Partial Least Squares (PLS) regression and Variable Importance in Projection (VIP) score

The Sovereign Risk Monitor aims to produce a comprehensive and relevant assessment of sovereign risk. To design such a framework, a statistical and econometric methodology capable of analysing multiple indicators and extracting valuable sovereign risk-related information has been developed. Sovereign risk is often influenced by numerous indicators, covering topics as wide-ranging and as different as economic performance, public finances, social features, etc. but also exposure to climate change or the quality of governance. Some indicators that make up these topics are uncorrelated, while others show a strong correlation. Therefore, extracting precise and specific sovereign risk-related information cannot be undertaken by using simple regression techniques as the results would be biased. To circumvent this issue, specific regression techniques are used to estimate the weight of each indicator in predicting an aggregated sovereign risk measure. The following model is used:

$$Y = \alpha + \sum_{j=1}^{N} \beta j X j + \varepsilon$$

where:

- Y is the aggregated sovereign risk measure with $Y = (Y1, \ldots, Yn)_t$, t the number of quarters and n the number of countries;
- For $j = 1, \ldots, J$, Xj is the j-th explicative indicator X matrix and J the number of indicators;
- βj is the j-th coefficient. As already stated, it cannot be estimated by a simple Ordinary Least Squares regression as this estimator would be biased.

These indicators can present strong correlations (e.g., between Social Risk and Governance Risk indicators), hence, to consider this specificity of the selected data, Partial Least Squares (PLS) regressions are used. That econometric framework, developed by Wold19 in the 1960s, enables the construction of predictive models in the presence of many correlated independent variables. It finds orthogonal components – thus eliminating the multicollinearity issue – of the X matrix that explain as much as possible the covariance between X and Y. Then, this breakdown of X is used in the regression to predict Y. 20 More precisely, the PLS regressions follow several steps: i. The PLS regressions produce a matrix W such as $T = XW$, where T is the factor score matrix and W is estimated such as to minimise collinearity and maximise the covariance between the explanatory and endogenous variables; ii. estimate the matrix Q so that $Y = TQ + E$; iii. estimate the matrix P so that $X = TP + E'$; iv. compute $\beta = WQ$. To estimate the T matrix, the standard algorithm for computing PLS components is used, i.e., Nonlinear Iterative Partial Least Squares (NIPALS) algorithm. It uses all the matrices defined above to estimate W and then compute T. The aim is not to predict directly Y but rather to find the optimal weights of each indicator in SRM. So, the β coefficient is not used directly in the regressions. Instead, the Variable Importance in Projection (VIP) score is used. It represents the summary of the importance of each indicator in finding the components of the X matrix21 during the first step of the PLS regressions. Formally, it is the weighted sum of squares of the PLS weights (the W matrix), which considers the explained variance of each dimension. It is used to select relevant predictors according to their value. In the academic literature, the VIP score is statistically significant if it based above a given threshold ranging from 0.8 to 1.22 However, in order not to exclude too many indicators, the VIP scores are used directly to calculate the weights. This approach remains relevant because VIP scores higher than 0.8 account for more than 80% of SRM indicators. The last 20% are rarely below 0.5.