

Trucost Sovereign Carbon Exposure

Methodology

S&P Global Sustainable1 – August 2024



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Terms and Definitions

Greenhouse gas (GHG): Greenhouse gases are those gaseous constituents of the atmosphere, both natural and anthropogenic, which absorb and emit radiation at specific wavelengths within the spectrum of thermal infrared radiation emitted by the Earth's surface, by the atmosphere itself, and by clouds. This property causes the greenhouse effect. Water vapor (H2O), carbon dioxide (CO2), nitrous oxide (N2O), methane (CH4), and ozone (O3) are the primary greenhouse gases in the Earth's atmosphere. Moreover, there are a number of entirely human-made greenhouse gases in the atmosphere, such as the halocarbons and other chlorine- and bromine containing substances, dealt with under the Montreal Protocol. Besides CO2, N2O, and CH4, the Kyoto Protocol deals with the greenhouse gases sulfur hexafluoride (SF6), hydrofluorocarbons (HFCs), and perfluorocarbons (PFCs).

Territorial GHG Emissions: GHG emissions produced from the economic activity within a country's borders. This can be further conceptualized as consisting of two components – emissions related to domestic consumption and emissions related to exports. Additionally, aggregate territorial emissions estimates can include or exclude an estimate of the emissions associated with land-use, land-use change and forestry ('LULUCF'), which will capture the equivalent emissions associated with gains or losses of natural and man-made GHG sinks.

Imported GHG Emissions: GHG emissions embedded in the goods and services consumed within a country's borders (either by industry as an intermediate product or in the form of 'final consumption') but produced abroad.

Exported GHG Emissions: emissions embedded in the production of goods or services within a country's borders but are consumed abroad.

Introduction and Context

The methodology presented in this document details the analytical approach underpinning the Trucost Sovereign Carbon Exposure dataset, which produces estimates for sovereign territorial GHG emissions broken out by sector along with estimates for imported and exported GHG emissions. This data in turn underpins the analysis of GHG impact of investments in sovereign bonds, which takes into account both territorial and imported emissions. Territorial emissions are made up of two components – domestic consumption related emissions and export related emissions for a country. As a country is not only responsible for the emissions that occur within its territories but also for the emissions linked with the products it imports from other countries, the model allows for evaluating both direct (Tier 1) and indirect (Tier N1) imported emissions. Sovereign emissions take into account that governments have far-reaching level of influence (regulatory control) and include emissions related to whole economy not just government operations.

Data Sources and Collection

This methodology uses publicly available socio-economic data sources (IMF, World Bank, etc.) and a combination of public and proprietary environmental data sources in conjunction with WIOD, a publicly available environmentally-extended multi-regional input-output model to estimate emissions embedded in trade. This model is calculated using territorial emissions numbers as publicly reported by two sources, the Postdam Institute for Climate Impact (PRIMAP) and Climate Watch, allowing end users to decide which emissions data source to utilize in their ultimate analysis.

¹Please see 'Monitoring and Review'



Database	Coverage	Data points	
World Input Output table Database	43 countries + Rest Of World		
(WIOD)	(ROW)	Input Output Table - Territorial + Imports	
PRIMAP	189 countries	GHG Territorial Emissions	
Climate Watch	186 countries	GHG Territorial Emissions (incl. LUCF)	
IMF	192 countries	GDP	
World Bank	190 countries	GDP, Economic Composition, Exports/Imports	
S&P Market Intelligence	192 Countries	GDP, Imports/Exports	
World Input Output table Database			
(WIOD)	61 sectors	Emission Factors	

Socioeconomic data, particularly the real/nominal GDP and total value of imports and exports for each country is primarily taken from S&P Market Intelligence, the World Bank or the IMF depending on which source has the most complete coverage for that country. Since the different sources may have a number of missing data points, for each of the key metrics, the data source with the fewest missing years of data for each country is chosen as the primary source. In cases where multiple sources have the same coverage for a particular country and metric, S&P Market Intelligence data is preferred over World Bank data which is preferred over IMF data. Any remaining missing years are estimated using a five-year average growth rate for that metric in that country. The available data from each source along with the ultimate data used in the GHG emissions modelling can be found in the Sovereign Socioeconomic reference table.

Additionally, figures for the relative value add for agriculture, industry (including manufacturing), manufacturing and service sectors across countries from the World Bank WDI dataset are used to disaggregate the emissions of countries in the WIOD input-Output Table 'Rest of World' category following the core geographical modelling. This data is cleaned and missing values estimated as follows. Since the WDI reported industry and manufacturing categories are not independent, missing industry or manufacturing numbers can be estimated in cases where the other value is present. Additionally, since the WDI estimates frequently do not go all the way up to the latest analysis year in the dataset, the most recently available numbers are used to proxy missing values (such as using the values for 2020 as estimates for the values in 2021 and 2022) on the assumption that the broad structure of a country's economy is not likely to shift enormously year on year. Next the manufacturing number is backed out of the total industry value, leaving values for manufacturing and all industry excluding manufacturing. Lastly, any remaining missing values are estimated so that the total fraction of value add accounted for across all four broad sectors sum up to 100% (so if a country is missing the service sector number, but has 80% of the economic activity accounted for in the other three sectors, the estimate for the remaining service sector number is likely around 20%).

Two main sources for the overall territorial GHG emissions in each country are used – PRIMAP and Climate Watch. Additionally, Climate Watch provides estimates for the total territorial emissions including LULUCF. Regardless of the source, any missing values for total territorial emissions up to the latest analysis year are estimated using each country's estimated GHG intensity of GDP. For each country, for each year with a total territorial GHG emissions number, the GHG intensity of GDP value is calculated for that country. This is then estimated for subsequent years using a compound annual growth rate. Total sovereign GHG emissions can then be modeled using this intensity and future values for the country's total GDP.

Methodology Overview

Country territorial GHG emissions by sector along with imported and exported emissions are estimated using underlying data from WIOD (World Input Output table Database) and publicly available country economic and overall emissions data. The WIOD tables contain detailed input/output information detailing the production and consumption linkages across the 61 covered sectors and 43 covered countries (plus a Rest of the World rollup for all other countries). With this information S&P Global Sustainable1 is able to estimate the volume of trade flows into and out of each sector and each country. From these estimates of economic activity, estimates of associated GHG emissions can then be derived.

First, calibrated emissions factors for each sector in each country are created, using the WIOD derived emissions factors and the actual total territorial emissions for each (sourced from PRIMAP or Climate Watch as detailed above. For a few countries present in the WIOD database but not in Climate Watch Dataset, an estimate is used based on PRIMAP data). A WIOD based estimate of total territorial emissions is calculated using the WIOD derived emissions factors along with the total sectoral production in each country. The sum of these modelled sector emissions data country level differs from reported territorial emissions, due to several factors, including the WIOD data source last being updated using 2014 data. By dividing reported territorial emissions with the sum of sector-wide modelled emission per country, it is then possible to obtain calibration factors to apply to the initial WIOD-derived emission factors in order to match real-word emissions. The result is a set of country and sector specific emission factors that can be directly applied to GDP value or any output for each economy. The territorial emissions of each sector in each country can then be estimated using these calibrated factors, and can be summed for each Country.

Subsequently, the WIOD input/output tables are used to estimate the size of trade flows to and from each sector in each country, using a Leontief inverse matrix, representing the complete set of interactions at all levels of the economy, accounting both direct (Tier 1) and indirect (Tier N²) trade flows. Imported and Exported GHG emissions are then estimated using these trade flows and the calibrated emissions factors calculated above. This allows for the creation of granular estimates of imported and exported emissions, based on the relative GHG intensity of each sector and each country. Imported emissions are also ultimately grouped in two ways. Primarily, imported emissions are grouped by the importing sector (e.g., "all emissions associated with the imports into Sector 1 in Country A, regardless of the country/sector of origin") and these are the figures that populate the final data table. To support the calculation of values for Scope 2 and 3, as recommended by the Partnership for Carbon Accounting Financials (PCAF), however, imports are also grouped by the sector of production (i.e., PCAF Scope 2 for sovereign emissions represents the emissions associated with the import of electricity, steam, heat and cooling, regardless of which sector within the importing country is utilizing the imported electricity).

Finally, emissions associated with the countries in the WIOD 'Rest of World' (ROW) category are disaggregated based on estimates of the relative size of the Agriculture, Manufacturing, Industrial and Service sectors in each country (obtained from World Bank Data). Starting with the estimates of total value add in each of these four broad sectors described above, an estimate for the total economic activity in each broad sector for each country is calculated with the total GDP of each country. A weighting is then generated for each country's share of the total ROW economic activity in each sector (e.g., if the total estimated agricultural GDP across all ROW countries was \$100 M, and Country A had an estimated agricultural GDP of \$1M, then it would be assumed that this represented around 1% of the total ROW agricultural activity and therefore represented 1% of the ROW exported Agricultural emissions). Each of the 56 producing sectors in the WIOD model is associated with one of the four broad sectors from the World Bank dataset and imported/exported emissions from those sectors are apportioned based on the that broad sector's weighting. For example, the three WIOD sectors 'Crop and animal production, hunting and related service activities', 'Forestry and logging', and 'Fishing and aquaculture' are associated with the broad Agricultural sector are weighted accordingly.

Imports associated with non-producing sectors (such as those associated with final consumption or capital formation) are apportioned based on the total imports of each country over the sum total imports across all ROW countries. (e.g., if a

² Please see 'Monitoring and Review'

country's total imports are \$10B and the sum total of imports across ROW countries is \$100B, then that country would be assumed to represent 10% of imports and therefore 10% of imported emissions).

Monitoring and Review

All new methodologies and any material changes to existing methodologies are reviewed and approved by an independent methodology governance committee.

The methodology that underpins the modeling of (Tier N) indirect emissions is currently under review and will not produce any results until the review concludes. Please refer to the <u>Release Notes</u> that support the latest release of this dataset for more information.

Assumptions and Limitations

There are some key assumptions for this methodology:

- 61 sectors (56 intermediate demand + 5 Final demand) used in WIOD tables for every economy represent the entire economy's trade flows adequately.
- Value Added from WIOD table is an adequate proxy for the structure of GDP for the corresponding country.
- Imported and exported GHG emissions for the ROW countries are disaggregated based on estimates of the relative size of only 4 sectors: the agricultural, manufacturing, industry and service sectors in those countries. This assumes that such sectors have similar levels of imported emissions and exported GHG intensity across countries.

As with any methodology, there are limitations surrounding the granularity and availability of key data inputs. In particular:

- The granularity of the WIOD input/output table data source, namely the number of countries and sectors covered, and to the level of detail covering the economic activities of the 'rest of world' countries. The core countries covered in detail by the WIOD input/output model represent around 75% of global emissions.
- The frequency of update of the WIOD input/output table. Large trade tables being difficult to assemble, are only infrequently updated. The WIOD database was last updated in 2016 with 2014 being the latest coverage year.
- The granularity of sectoral territorial, imported and exported emissions for countries in the ROW category is limited by the granularity of estimates of economy activity in each country. Currently, the estimates economic activity derived from the World Bank data are only for the four broad economic activities, Agriculture, Manufacturing, Industry and Services, and as such are less granular than the 56 productive sectors present in the WIOD model.

Maintenance/Updates

The Trucost Sovereign Carbon Exposure dataset is updated with new input data on an annual basis, with periodic methodological enhancements. S&P Global Sustainable1 periodically reviews the methodology as appropriate.

Significant Updates

This methodology was updated in June, 2024 to coincide with a major methodological enhancement. The following table describes the methodology enhancements implemented in the Q3 2024 Trucost Sovereign Carbon Exposure dataset release, the expected impact on the dataset, and the intended benefit of these enhancements for clients.

Enhancement Name	Enhancement Description	Client Benefit	Expected Impact on Dataset
Inclusion of the ClimateWatch Territorial Emissions dataset	ClimateWatch provides historical territorial GHG emissions data for 195 countries, including Land Use, Land- Use Change and Forestry (LULUCF) estimates, which were previously estimated by S1.	Additional data source, which includes estimates of LULUCF GHG emissions, previously missing from the original source (PIK)	A new alternative data source provides additional transparency and options to clients. New LULUCF data source will result in large changes in data for a number of countries, in particular for recent years.
Sunsetting of EORA Input- Output model	EORA was used in conjunction with WIOD to estimate countries emissions. Using more recent socio-economic data instead, EORA is replaced and the model relies solely on WIOD, simplifying the model used.	Model simplification allows easier interpretation/explanation of data. Use of current socio- economic data as proxies improves timeliness of estimates and reduces model divergences.	Trade-related data for most countries will likely change significantly.
New PCAF- related columns	Addition of new columns to provide Scope 2 and Scope 3 estimates in line with PCAF recommendations.	Better data interoperability with PCAF framework. Simplification of workflow.	New output columns providing additional information.
New Socio- Economic source: GIA to replace EIU	Switch of the Economist Intelligence Unit data to GIA (S&G MI official source)	Preserve consistency with other SPGI data and platform	Some countries socio-economic data will change, including for historical years.

References

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International Monetary Fund (IMF): World Economic Outlook Database (http://www.imf.org)

PRIMAP: The PRIMAP-hist national historical emissions time series (1850-2022) v2.5.1 developed by the Postdam Institute for Climate Impact Research.

Timmer, M. P., Dietzenbacher, E., Los, B., Stehrer, R. and de Vries, G. J. (2015),

"An Illustrated User Guide to the World Input–Output Database: the Case of Global Automotive Production", Review of International Economics., 23: 575–605

World Bank (WB): World Development Indicators (https://datacatalog.worldbank.org/)

World Input Output Databse (WIOD): World Input-Output Tables and underlying data, covering 43 countries, and a model for the rest of the world for the period 2000-2014. Data for 56 sectors are classified according to the International Standard Industrial Classification revision 4 (ISIC Rev. 4).

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