

CONTRIBUTORS

**Gautier Desme**

Research Manager  
Financial Institutions  
Trucost, part of S&P Global  
[gautier.desme@spglobal.com](mailto:gautier.desme@spglobal.com)

**Lauren Smart**

Managing Director, Global Head of  
Financial Institutions Business  
Trucost, part of S&P Global  
[lauren.smart@spglobal.com](mailto:lauren.smart@spglobal.com)

# Accounting for Carbon: Sovereign Bonds

## INTRODUCTION

In 2015, the Paris Agreement was signed, committing 195 signatory nation-states to limiting greenhouse gas (GHG) emissions to well below 2 degrees Celsius above pre-industrial levels.<sup>1</sup> This recognized the clear role of governments around the globe in curtailing potentially catastrophic levels of global warming, which could have widespread and systemic impacts on the global economy, capital markets, and the quality of human life. Sovereign bonds, the issuance of debt by a country to finance its activities, is one of the largest asset classes in the world, with over USD 20 trillion of central government debt securities outstanding in 2016<sup>2</sup> and general government debt exceeding USD 62 trillion in 2016.<sup>3</sup> As such, it is a key mode of financing for governments, is one of the largest asset allocations by pension funds, and should be a focus of examination for climate risk analysis.

Portfolio carbon footprinting as a tool to support climate reporting and risk assessment has grown in popularity over recent years, so much so that it has become incorporated into best practice reporting guidelines for investors. These include those outlined by the Financial Stability Board's Task Force on Climate-related Financial Disclosures (TCFD), which is backed by the central banks of the G20 countries and is legislated as part of France's Article 173 regulation. While it is now becoming common practice for asset owners and managers to report the footprint of their listed equity holdings and corporate fixed income portfolios, sovereign bonds have remained largely unexamined from a carbon risk and reporting perspective due to lack of appropriate metrics and actionable insight. However, climate change affects all asset classes, so investors would need to measure, understand, and manage the climate change risks embedded in their sovereign bond portfolios as well.

In this paper, Trucost outlines a number of approaches to sovereign bond evaluation and the metrics available. Scope and breadth of emissions are key considerations, as is the denominator chosen to normalize emissions to

<sup>1</sup> <https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement>

<sup>2</sup> Bank for International Settlements Debt Securities Statistics, <https://stats.bis.org/statx/toc/SEC.html>.

<sup>3</sup> World Economic Outlook Database April 2018 - International Monetary Fund, <https://www.imf.org/external/pubs/ft/weo/2018/01/weodata/index.aspx>.

facilitate comparison between entities of different size. The most appropriate metric may differ depending on the question(s) that investors intend to answer.

## WHAT ARE SOVEREIGN BOND CARBON EMISSIONS?

Sovereign bonds are financial instruments that provide capital to national governments, which makes the emissions associated with them the primary focus of a sovereign bond carbon footprint analysis. Opinions vary, however, on the appropriate scope at which to consider a country's GHG emissions based on carbon accounting protocols, different notions of "responsibility," and how to compare carbon efficiency between governments. Key questions to consider include the following.

Sovereign bonds are financial instruments that provide capital to national governments, which makes the emissions associated with them the primary focus of a sovereign bond carbon footprint analysis.

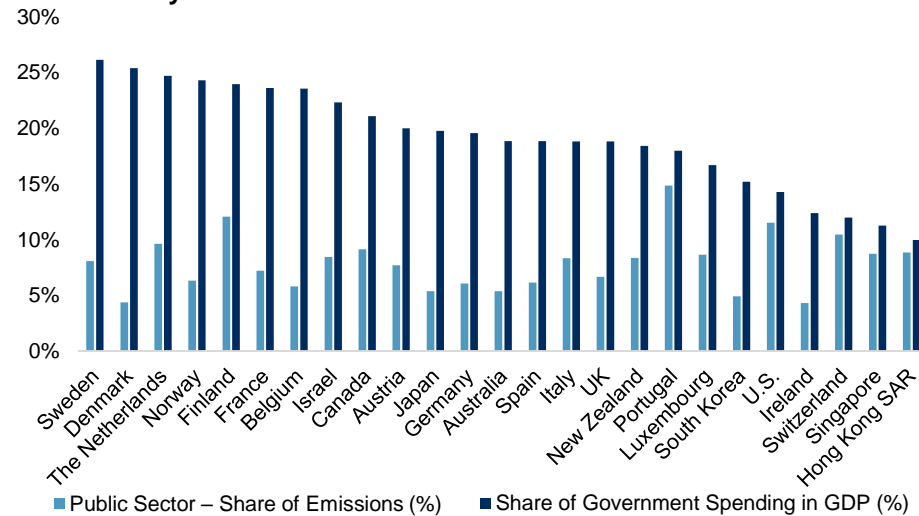
- Should the allocated emissions be limited to just the public sector or the country as a whole, which would include the private sector and households? More philosophically, can these aspects of the economy be separated or not?
- Should we consider emissions created domestically but then exported (e.g., the mining of coal for export and processing overseas), or those created internationally but imported and consumed domestically (e.g., the processing involved on creating our smart phones, which are then imported)?
- How should we normalize emissions to make comparisons of economies of different sizes and assess emission intensity and efficiency? How do we compare economies of different wealth and population size? Which is more important for an assessment of carbon efficiency for a given purpose?
- Which is more important: the emissions created per capita of the population (carbon efficiency of the people) per USD 1 million of economic output (carbon efficiency of the domestic economy) or per USD 1 million of government debt (carbon efficiency of the debt financing)?

## GOVERNMENT AS AN "ECONOMIC AGENT"

Within the narrowest definition, the government is seen as separate from the private sector and households, and its emissions are simply those generated by the public sector. Under this approach, the emissions of a national government would principally result from its consumption of goods and services for provision of public services and defense. For example, it would include emissions from energy used in public buildings (scopes 1 and 2) and embodied in the goods and services of the supply chain (scope 3 upstream). This is much like any other economic agent, such as corporations.

This approach is recommended by some reporting frameworks, for example, the Dutch Platform for Carbon Accounting Financials.<sup>4</sup> It has the benefit of limiting double counting and is consistent with the notions of scopes as defined by the Greenhouse Gas Protocol. However, this approach is open to criticism for underestimating government emissions and downplaying their responsibilities. Under a broader assessment of sovereign emissions, the potentially significant role of the government in influencing private markets and individuals via regulation and taxation is considered. This takes into account how governments can use policy tools as demand and supply drivers, influencing production and consumption patterns of the public, private, and household aspects of the economy. It is also worth considering that public services and defense are not financed only by debt issuance, but also by taxes and customs, and there is no observable relationship between the carbon emissions of the public sector and levels of public spending as a percent of gross domestic product (GDP) (see Exhibit 1).

**Exhibit 1: Government Spending (% of GDP) and Share of Emissions Generated by the Public Sector**



The Dutch Platform for Carbon Accounting Financials has the benefit of limiting double counting and is consistent with the notions of scopes as defined by the Greenhouse Gas Protocol.

Source: Trucost, IMF, World Bank, WIOD, EORA, PRIMAP, S&P Dow Jones Indices LLC. Data as of December 2016. Chart is provided for illustrative purposes. Countries included make up the S&P Global Developed Sovereign Bond Index.

### GOVERNMENT AS A “REGULATOR”

An alternative approach is to quantify a country’s emissions more broadly by considering all emissions generated within its territorial boundary. In this case, the entire economy becomes the unit of analysis, with its own emissions making up its direct emissions, and indirect emissions would include those of its imports from other nations. This is consistent with the scope of a government’s regulatory oversight and impact, which is not limited to the central government and public services activities.

<sup>4</sup> The Platform Carbon Accounting Financials, “Paving the way towards a harmonised Carbon Accounting Approach for the Financial Sector,” <http://carbonaccountingfinancials.com/>.

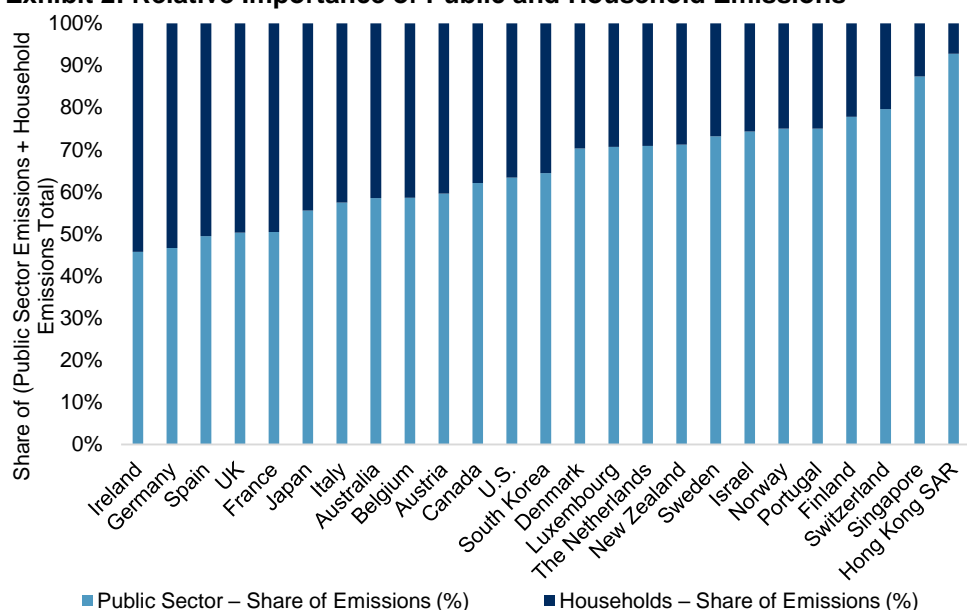
There are many examples where a government has been able to exercise control and influence over emissions both within and outside its own territorial boundaries. Carbon taxes on producers of emissions or on imported goods are obvious examples, as are subsidies for carbon efficiency or renewable energy investment. More subtle cases are also evident, such as the implementation of Article 173 in France, which may indirectly lead to changes in the financing and cost of capital of high-emitting business activities.

### TO DOUBLE COUNT OR NOT

The main downside of the “government as regulator” approach is double counting. Accounting for the economy’s entire emissions leads to double counting of those emissions generated by private sector companies, since these are also attributed to investments in other asset classes. However, this perspective acknowledges the broader impact of a government on the private sector and households when investing in a sovereign bond. Private households’ emissions are, at least partly, under the responsibility of governments, especially those that provide significant welfare services, which are financed through taxes and debt. Indeed, household emissions represent part of a government’s scope 3 emissions. Exhibit 2 illustrates this point by representing the relative share of public and household emissions for the [S&P Global Developed Sovereign Bond Index](#). With scope 3 emissions becoming a growing concern for investors, double counting may be necessary to understand the full breadth of emissions created by sovereign financing.

With scope 3 emissions becoming a growing concern for investors, double counting may be necessary to understand the full breadth of emissions created by sovereign financing.

**Exhibit 2: Relative Importance of Public and Household Emissions**



Source: Trucost, IMF, World Bank, WIOD, EORA, PRIMAP, S&P Dow Jones Indices LLC. Data as of December 2016. Chart is provided for illustrative purposes. Countries included make up the S&P Global Developed Sovereign Bond Index.

Moreover, while double counting might be an issue when assessing what institution is responsible for emissions, there may be cases that would need to consider double (or triple) counting when taking a risk-oriented view, as financial risks can also double up. For example, if a pension fund owns a bond from an Australian coal mining company while also holding Australian sovereign bonds, then this investor may bear carbon risk on both positions. Risk is also magnified in a company's or economy's supply chain, which would also call for double counting.

## HOW SHOULD SOVEREIGN CARBON EMISSIONS BE ACCOUNTED FOR?

### Production-Based Accounting

Governments generally report their GHG emissions in accordance with international standards set out for National Greenhouse Gas Inventories by the Intergovernmental Panel on Climate Change (IPCC). This means their carbon estimates and reporting are based on a territorial approach and measure emissions on a "production" basis. This accounts for all the point source emissions generated (or sequestered) within their borders, regardless of the destination of the goods or services; so a country could, essentially, export its emissions by creating products with significant embedded carbon that need to be processed in a different country. In technical terms, this amounts to the sum of domestic consumption emissions (domestic emissions) and emissions embedded in goods and services that are exported (exported emissions).

While this choice is understandable from a practical point of view, it introduces or encourages "carbon leakage." According to the IPCC, carbon leakage is defined as "the increase in CO<sub>2</sub> emissions outside the countries taking domestic mitigation action divided by the reduction in the emissions of these countries." In layman's terms, it describes the transfer of emissions from high-emitting industries from highly regulated countries (e.g., members of the Organisation for Economic Co-operation and Development [OECD] since the 1990s) to countries with less stringent regulation—or no rules at all (e.g., developing and emerging economies, especially Brazil, Russia, India, China, and South Africa [BRICS] since the 1990s). This approach can be criticized for failing to address the demand side of the emissions problem.

### Consumption-Based Accounting

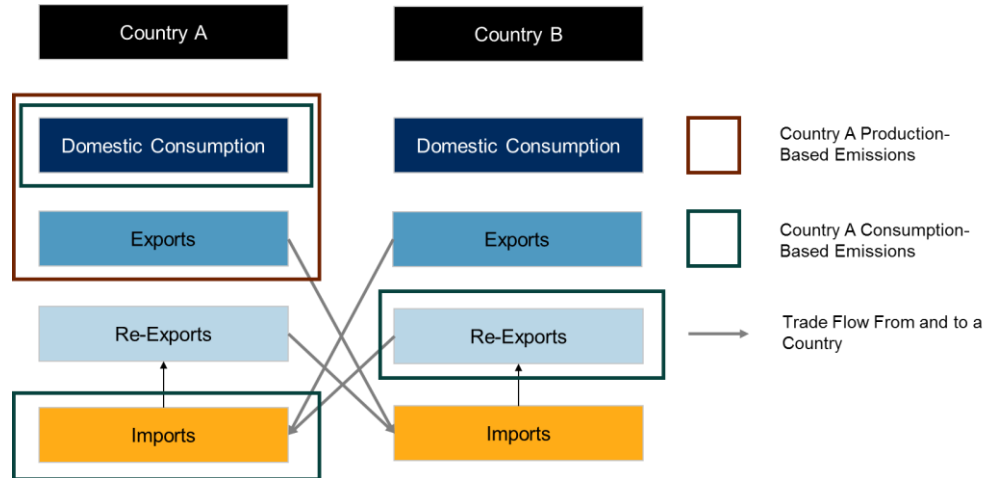
In order to mitigate this bias, consideration should be given to the emissions embedded in the goods and services traded by countries—their imports and exports. This approach is called "consumption-based" accounting. Mathematically, this amounts to summing emissions embedded in domestic consumption and emissions embedded in imported goods and services (imported emissions). This will negatively bias net

Carbon leakage refers to the transfer of emissions from high-emitting industries from highly regulated countries to countries with less stringent regulation—or no rules at all.

importers of carbon emissions embedded in goods and services, which are typically developed economies with higher GDPs.

Exhibit 3 represents the flow of emissions between two theoretical economies. Note, “re-exports” is a term used to describe goods imported, processed, then re-exported.

**Exhibit 3: Emissions Flow Between Theoretical Economies**



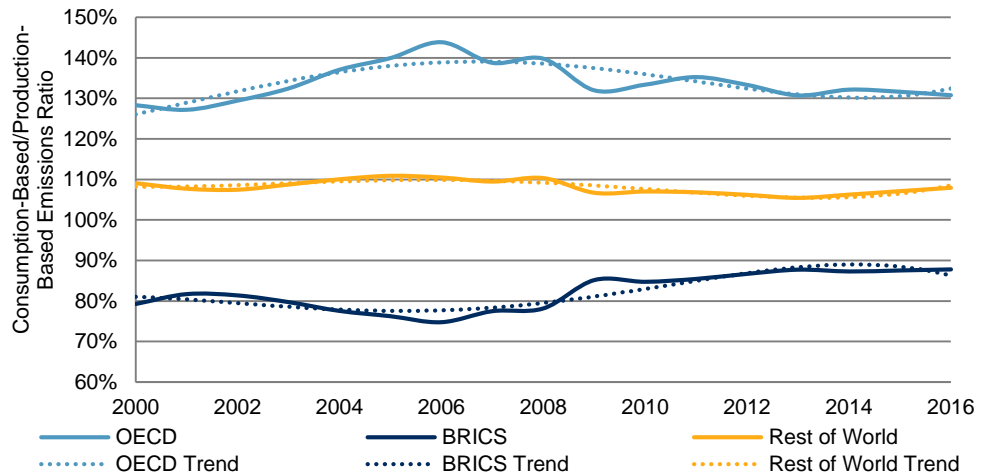
Source: Trucost. Chart is provided for illustrative purposes.

Accounting for the carbon balance of trade is important in determining a country's carbon exposure, risk, and responsibilities.

**The Third Way**

Exhibit 4 illustrates the relationship between countries that are net consumers (or importers) of GHGs and countries that are net producers (or exporters) of these emissions. It is notable that the net consumers are typically developed economies, which are also those that typically “outsource” most production emissions to emerging economies. This is a key reason why accounting for the carbon balance of trade is important in determining a country's carbon exposure, risk, and responsibilities.

**Exhibit 4: Real Emissions Trading on a Global Scale – Consumers Versus Producers**



Source: Trucost, IMF, World Bank, WIOD, EORA, PRIMAP. Data as of May 2018. Chart is provided for illustrative purposes.

Production-based and consumption-based accounting both have a common characteristic: they avoid double counting by attributing emissions to a single entity. In other words, the sum of all consumption-based emissions is equal to the sum of all territorial emissions. However, there is a third way that allows for eliminating bias at the expense of avoiding double counting: attributing to a country all emissions upon which it has direct or indirect control, namely summing all domestic, exported, and imported emissions.

Which one to choose will depend on the question that investors would like to answer. Exhibit 5 breaks down the three options.

**Exhibit 5: Three Options for Accounting Emissions**

ASPECT	PRODUCTION-BASED ACCOUNTING	CONSUMPTION-BASED ACCOUNTING	THIRD WAY: TERRITORIAL EMISSIONS + IMPORTED EMISSIONS
<b>Scope</b>	Emissions generated by an economy within its national territory	Emissions associated with the consumption of a country's population or final demand	Emissions associated with any aspect of an economy's activity, i.e., the intensiveness of an economy
<b>Calculation</b>	Territorial emissions = Domestic emissions + Exported emissions	Domestic emissions + Imported emissions	Domestic emissions + Exported emissions + Imported emissions
<b>Bias</b>	Toward exporters or GHG producers	Toward importers or GHG consumers	No bias
<b>Complexity</b>	Low	High	High
<b>Pros</b>	Consistent with international standards; reflects the carbon-intensity of an economy's output	Reflects demand-based emissions, wherever the emission is produced	Reflects the carbon dependency of an economy, whether it is demand-driven (domestic or imported) or offer-driven (exported); equivalent of accounting for direct + first-tier indirect emissions already a standard in the corporate world
<b>Cons</b>	Unable to address carbon leakage; may be seen as socially unfair, as it puts the responsibility on emerging economies (versus developed economies)	Does not capture the carbon intensity of an economy's output; political acceptability; difficult or complex mitigation effectiveness	Introduces double counting

Source: Trucost. Table is provided for illustrative purposes.

## WHAT DENOMINATOR?

Once the scope of emissions accounting has been defined, the next question is what denominator to use. This enables us to compare countries with economies of different size by normalizing a country's emissions into an intensity figure. Again, the choice depends on the question and produces different insights and actions for investors and policy makers. Key questions to consider include the following.

- Am I interested in the carbon emissions generated per USD 1 million dollars of government debt?

Once the scope of emissions accounting has been defined, the next question is what denominator to use.

- Am I interested in the carbon emissions per USD 1 million dollars of economic output or value added?
- If the country's economy grows, will emissions grow at a lesser rate? Can I use this to compare countries of different size and indebtedness?
- Am I interested in the carbon emissions generated per person in the country, i.e., how much carbon each person uses?
- As the population grows, will emissions grow at a lesser rate, and how does this compare with "peer" countries? Why?
- Am I interested in the changing energy mix of a country and its transition from "brown" to "green"?

## GDP

A production-based approach to quantifying a country's carbon emissions focuses on an economy's output, as produced within its borders. Normalizing production-based emissions by GDP—the monetary value of goods and services produced within a country—is therefore a logical normalizing factor to express the carbon intensity of an economy, as it mirrors the scope of the emissions calculation. Comparing countries over time runs the risk of fluctuating exchange rate influence, but consistently using the U.S. dollar as the reference currency in a base year should help reduce the impact of currency rate swings and inflation in ongoing analysis.

A production-based approach to quantifying a country's carbon emissions focuses on an economy's output, as produced within its borders.

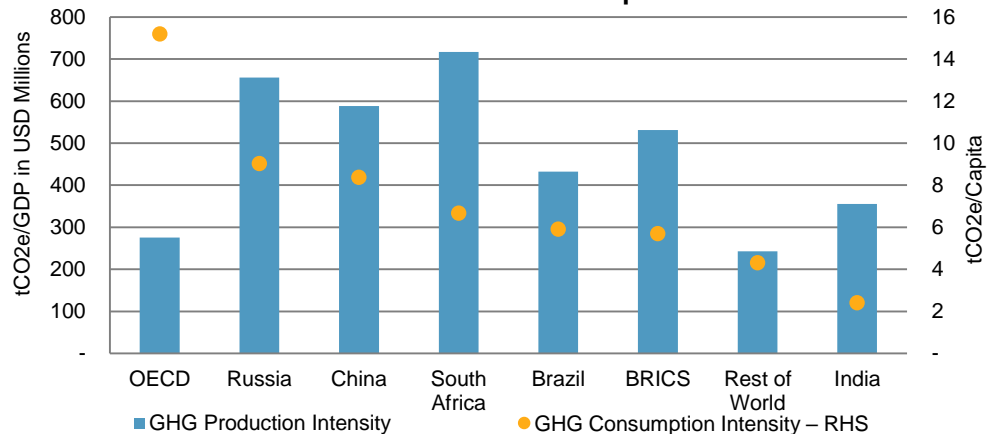
## Per Capita

A consumption-based approach to calculating carbon emissions has an inherent dependency on individual consumption patterns of people in the economy, thus a per capita approach might provide a more appropriate denominator.

The approaches will yield different results, albeit both compelling. As presented in Exhibit 6, OECD countries' GDP-based intensities are among the lowest in the world, while their per capita emissions are the highest. The opposite is true for most BRICS countries, especially India. This is an illustration of carbon leakage, essentially the exportation of a country's carbon emissions often from developed to emerging economies, which is not well addressed by GDP-based metrics. Note also that GDP is a price-dependent indicator, and the same goods and services may command lower prices in developing or emerging economies, leading to artificially high carbon intensities, which may divert capital should a GDP-based intensity be used exclusively to manage a sovereign bond portfolio.



**Exhibit 6: Production Intensities Versus Consumption Intensities**



Source: Trucost, IMF, World Bank, WIOD, EORA, PRIMAP. Data as of May 2018. Note: Constant USD is used with a base year of 2010. Chart is provided for illustrative purposes.

**Per USD 1 Million of Debt**

An additional denominator that may be of interest to investors focused on the public sector’s emissions is normalizing by the amount of central or general government debt. This tells you the carbon emissions per USD 1 million of debt, but results are heavily skewed by the different debt levels of countries, which may disguise more environmentally relevant production and consumption emission patterns.

Investors who wish to evaluate their portfolio exposure to carbon-intensive countries need to choose a way to allocate the relative importance, or contribution, of each holding to the portfolio.

**APPORTIONING, PORTFOLIO AGGREGATION, AND THE DEBT BIAS**

Investors who wish to evaluate their portfolio exposure to carbon-intensive countries need to choose a way to allocate the relative importance, or contribution, of each holding to the portfolio. One approach is to use an intensity metric (GDP-based for instance) and weigh each issuer’s intensity by the weight in the portfolio in order to aggregate these at the portfolio level. The metric obtained is the weighted average carbon intensity of the portfolio, which estimates how carbon efficient or intensive the issuers are, on average.

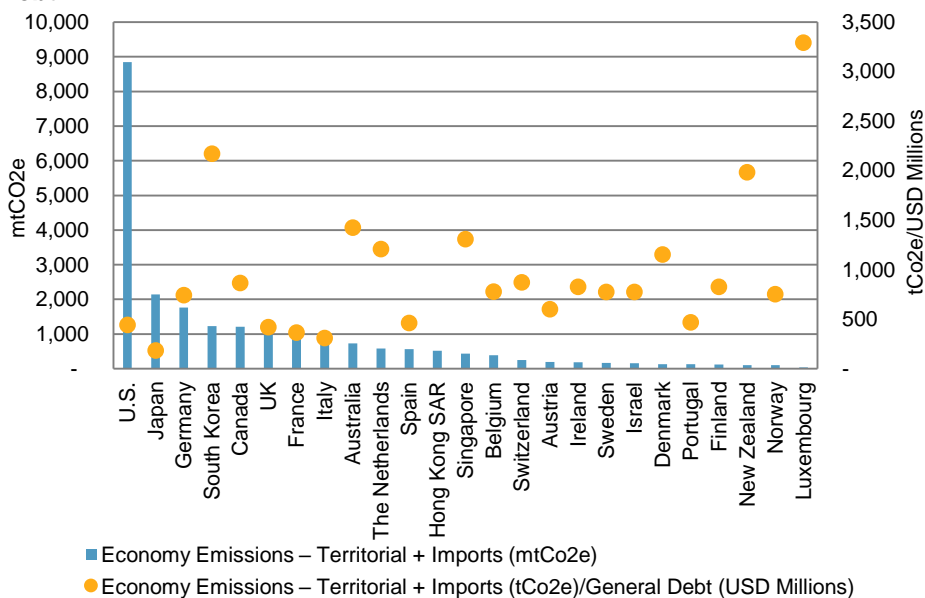
Investors who wish to estimate their portfolio footprint according to the ownership (or responsibility) approach will need to calculate the portion of a country’s (or government’s) emissions that is financed by the bonds the investor holds. This is known as apportioning. For equity and corporate fixed income securities, apportioning is done using the market capitalization or enterprise value of a company as the denominator to calculate an apportionment factor. This approach proves challenging in the sovereign realm, as a government’s equity is rarely valued and the concept of enterprise value is not directly applicable. The closest proxy available is the general gross debt of a government, which is a figure readily available and updated in a timely manner that allows for the calculation of two “ownership”-driven metrics:

- Carbon footprint per unit of GDP (output method); and
- Carbon footprint per unit of investment (assets under management [AUM] method).<sup>5</sup>

The output and AUM methods provided comparable results; however, the weighted average carbon intensity of the index was much lower

While apportioning may seem appealing because it enables us to estimate an absolute amount of emissions attributable to an investment, results obtained using this method can be significantly distorted due to the amount of debt issued by a country. In other words, investors will find themselves “responsible” for a significant portion of a country’s emissions if the amount of debt outstanding is low, or a small portion if the country is highly indebted, yet there is no immediate link between an economy’s emissions and the amount of its government debt (see Exhibit 7).

**Exhibit 7: No Link Between an Economy’s Emissions and Its Government Debt**



Source: Trucost, IMF, World Bank, WIOD, EORA, PRIMAP. Data as of May 2018. Chart is provided for illustrative purposes.

We illustrated this debt bias by calculating the carbon footprint and carbon intensity of a USD 1 million investment in the [S&P Global Developed Sovereign Bond Index](#) using all three metrics, as of Dec 31, 2016 (see Exhibit 8). The output and AUM methods provided comparable results (1,091 tCO2e/USD million GDP and 1,734 tCO2e/USD million AUM, respectively); however, the weighted average carbon intensity of the index was much lower (497 tCO2e/USD million GDP). While Hong Kong only represented 0.05% of the index, it contributed to 52% and 75% of the index negative carbon performance according to the apportioned output and AUM methods, respectively. This is due to the low level of government debt (0.01% of the GDP), which artificially inflates the contribution of the issuer. By contrast, Singapore displayed a comparable carbon intensity per unit of

<sup>5</sup> Please refer to the appendix for more details on the computation steps.

GDP and similar GDP figures (321 USD billion for Hong Kong versus 310 USD billion for Singapore), and despite making up a higher proportion of the index (0.29%), it barely contributed to the carbon footprint of the portfolio. This is because the large amount of debt (106.8% of GDP) dilutes the bond investment. The weighted average carbon intensity was not affected by such bias, and Hong Kong and Singapore contributed little to the portfolio intensity compared with countries like Japan and the U.S., which each make up about 30% of the index.

**Exhibit 8: Carbon Footprint Contribution of Selected Constituents of the S&P Global Developed Sovereign Bond Index**

COUNTRY	GROSS DEBT (% GDP)	WEIGHT IN INDEX (%)	CARBON INTENSITY (tCO <sub>2</sub> e/USD MILLIONS GDP)	APPORTIONED EMISSIONS (tCO <sub>2</sub> e)	FOOTPRINT RELATIVE CONTRIBUTION		
					OUTPUT METHOD (%)	AUM METHOD (%)	WEIGHTED AVERAGE INTENSITY METHOD (%)
Hong Kong	0.1	0.05	1,702	1,110	-52	-75	0
Japan	235.6	30.14	456	45	5	39	4
Singapore	106.8	0.29	1,475	3	0	0	-1
U.S.	107.2	28.94	501	104	10	31	0
					<b>1,091</b>	<b>1,734</b>	<b>497</b>
<b>Index Footprint</b>					tCO <sub>2</sub> e/ USD Millions GDP	tCO <sub>2</sub> e/ USD Millions AUM	tCO <sub>2</sub> e/USD Millions GDP

Source: Trucost, IMF, World Bank, WIOD, EORA, PRIMAP, S&P Dow Jones Indices LLC. Data as of December 2016. Table is provided for illustrative purposes.

Carbon exposure and intensity metrics, if used in the correct way, provide useful indicators of risk and progress, provided territorial emissions are adjusted for international trade in order to account for the total carbon dependency of an economy, either through its imports or its exports.

## CONCLUSION

Carbon footprinting is a first step in the assessment of a sovereign bond portfolio's exposure to carbon-intensive economies, but it is important in identifying potentially material issues across a portfolio. While an "ownership" approach will address the amount of emissions that an investor is responsible for per unit of economic output, investment, or even per capita, an "exposure" approach using an intensity metric seems to provide more insights on the risk embedded in the portfolio, and it is less prone to bias introduced by the level of indebtedness of a country.

It is recognized that the current measures proposed are imperfect and not fully aligned with creditworthiness or probability of default. However, it is important that our quest for progress is not paralyzed by the quest for perfection. Carbon exposure and intensity metrics, if used in the correct way, provide useful indicators of risk and progress, provided territorial emissions are adjusted for international trade in order to account for the total carbon dependency of an economy, either through its imports or its exports.

Only once the current contribution of a country to the global balance of emissions is understood can progress toward decarbonization be assessed and the winners and losers of a low-carbon transition be identified.

## APPENDIX: PORTFOLIO AGGREGATION

The analysis of a sovereign bond portfolio requires the aggregation of each bond's emission impacts to the portfolio level. Sovereign bond investments can be mapped to Trucost's sovereign GHG data set using mappings of bond international securities identification numbers to country ISO codes or names. There are several common ways to calculate the carbon footprint of an investment portfolio, with each providing a different set of insights.

- **Portfolio Emissions “Ownership”:** These approaches calculate the specific portion of sovereign emissions a holding is responsible for (“apportioned emissions”) and can use a variety of denominators in deriving portfolio carbon intensity metrics.
- **Portfolio Emissions “Exposure”:** These approaches assess the portfolio's relative exposure to specific investments by investment weight (% of total value invested). The portfolio's overall footprint will be determined by the individual bond intensities.

All of the following carbon footprint approaches use GDP as their denominator in intensity metrics, though intensities can be denominated by GDP, population, or another parameter.

### APPORTIONING TO PORTFOLIO BONDS

Once mapped, the level of financing of a country's government can be calculated using the value invested in each bond and knowledge of each country's gross general debt. In principle, this is equivalent to calculating the level of equity ownership of a corporation for listed equity investments (holdings value/market capitalization), or the level of financial debt of a corporation for corporate bond investments (holdings value/enterprise value). Once this ratio is calculated, it can be multiplied by a country's emissions to derive the emissions apportioned to an investment in a specific bond.

#### Equation 1: Apportioned Sovereign Emissions

$$\frac{\text{Sovereign Bond Investment (USD)}}{\text{Gross General Debt (USD)}} * \text{Country Emissions (tCO}_2\text{e)}$$

This calculation feeds into two sovereign bond carbon footprint methodologies (economic output and AUM) adopted by Trucost.

### I) ECONOMIC OUTPUT METHOD

This sovereign bond carbon footprint metric describes the relationship between the average amount of GHG emissions (tCO<sub>2</sub>e) generated per USD 1 million of national economic output (GDP) generated. A lower level of emissions relative to the benchmark represents a lower dependency on production and consumption of carbon-intensive goods and services on average.

This metric is calculated by dividing the sum of all portfolio-apportioned emissions by the sum of all portfolio-apportioned GDP.

**Equation 2.1: Output Carbon Footprint**

$$\frac{tCO_2e'}{GDP'} = \frac{\sum_i^n tCO_2e'_{i,c}}{\sum_i^n GDP'_{i,c}}$$

Where:

$tCO_2e'$  = Total portfolio-apportioned territorial emissions (tCO<sub>2</sub>e).

$GDP'$  = Total portfolio-apportioned GDP (USD millions).

$tCO_2e'_i$  = Apportioned territorial emissions of sovereign bond 'i' mapped to country 'c'.

$GDP'_{i,c}$  = Apportioned real GDP of sovereign bond 'i' mapped to country 'c'.

**Equation 2.2: Output Carbon Footprint – Portfolio Apportionment**

$$\frac{\sum_i^n tCO_2e'_{i,c}}{\sum_i^n GDP'_{i,c}} = \frac{\sum_i^n \frac{\text{Sovereign Bond Investment (USD)}_{i,c}}{\text{Gross General Debt (USD)}_c} * \text{Country Emissions (tCO}_2\text{e)}_c}{\sum_i^n \frac{\text{Sovereign Bond Investment (USD)}_{i,c}}{\text{Gross General Debt (USD)}_c} * \text{Real GDP (USD mn)}_c}$$

Where:

**Sovereign Bond Investment (USD)<sub>i</sub>** = The value invested in sovereign bond 'i' in USD that is mapped to country 'c'.

**Gross General Debt (USD)<sub>c</sub>** = The value of gross general debt of country 'c' in USD.

**Country Emissions (tCO<sub>2</sub>e)<sub>c</sub>** = The sovereign GHG emissions (tCO<sub>2</sub>e) of country 'c'.

**Real GDP (USD mn)<sub>c</sub>** = The real GDP of country 'c' in USD millions.

**n** = The number of sovereign bonds in the portfolio.

**II) AUM METHOD**

This sovereign bond carbon footprint metric describes the relationship between the average amount of GHG emissions (tCO<sub>2</sub>e) generated per USD 1 million of investments made in the portfolio. A lower level of emissions relative to the benchmark represents a lower GHG impact per unit of investment on average.

This metric is calculated by dividing the sum of all portfolio-apportioned emissions and the USD millions invested.

**Equation 3: AUM Carbon Footprint**

$$\frac{tCO_2e'}{Inv (USD mn)} = \frac{\sum_i^n tCO_2e'_i}{\sum_i^n Inv (USD mn)_i}$$

Where:

$tCO_2e'$  = Total portfolio-apportioned territorial emissions (tCO<sub>2</sub>e).

$Inv (USD mn)'$  = The total value invested in the sovereign bond portfolio in USD millions.

$tCO_2e'_i$  = Apportioned territorial emissions of sovereign bond 'i' mapped to country 'c'.

$Inv (USD mn)_i$  = The value invested in sovereign bond 'i' in USD millions.

**n** = The number of sovereign bonds in the portfolio.

## PORTFOLIO EXPOSURE CARBON FOOTPRINTS

A third carbon footprint metric Trucost uses to analyze sovereign bond portfolios is the weighted average carbon intensity metric, which describes a portfolio's average exposure to the carbon intensities of different bond investments.

### III) WEIGHTED AVERAGE CARBON INTENSITY METHOD

This sovereign bond carbon footprint metric describes the portfolio's exposure to specific countries' carbon intensities on a portfolio weight (%) basis. Portfolio weight is determined by value invested, so the portfolio's overall carbon intensity (carbon footprint) will be determined by individual country-level carbon intensities, depending on how much is invested in each country's bonds.

This metric calculates the weighted average of each bond's portfolio weight and the territorial carbon intensity of the bond's mapped country.

#### Equation 4: AUM Carbon Footprint

$$\sum_i^n W_i * \left( \frac{\text{Country Emissions (tCO}_2\text{e)}_c}{\text{GDP (USD mn)}_c} \right)$$

Where:

**W<sub>i</sub>** = The value of holding portfolio weight (%) of sovereign bond 'i'.

**Country Emissions (tCO<sub>2</sub>e)<sub>c</sub>** = The sovereign GHG emissions (tCO<sub>2</sub>e) of country 'c'.

**GDP (USD mn)<sub>c</sub>** = The real GDP of country 'c' in USD millions.

**n** = The number of sovereign bonds in the portfolio.

## About Trucost

Trucost is part of S&P Global. A leader in carbon and environmental data and risk analysis, Trucost assesses risks relating to climate change, natural resource constraints, and broader environmental, social, and governance factors. Companies and financial institutions use Trucost intelligence to understand their ESG exposure to these factors, inform resilience and identify transformative solutions for a more sustainable global economy. S&P Global's commitment to environmental analysis and product innovation allows us to deliver essential ESG investment-related information to the global marketplace. For more information, visit [www.trucost.com](http://www.trucost.com).

## About S&P Global

S&P Global (NYSE: SPGI) is a leading provider of transparent and independent ratings, benchmarks, analytics and data to the capital and commodity markets worldwide. For more information, visit [www.spglobal.com](http://www.spglobal.com).

## CONTACT US

### The Americas

+1 800 402 8774  
[Trucostnorthamerica@spglobal.com](mailto:Trucostnorthamerica@spglobal.com)

### Europe, Middle East & Africa

+44 (0) 20 7160 9800  
[Trucostinfo@spglobal.com](mailto:Trucostinfo@spglobal.com)  
[TrucostEMEA@spglobal.com](mailto:TrucostEMEA@spglobal.com)

### Asia-Pacific

+65 6597 6158  
[Trucostasiapacific@spglobal.com](mailto:Trucostasiapacific@spglobal.com)

### Disclaimer

Copyright © 2019 S&P Trucost Limited ("Trucost"), an affiliate of S&P Market Intelligence. All rights reserved. Trucost and EBoard are trademarks of Trucost. Redistribution or reproduction in whole or in part is prohibited without written permission. This document does not constitute an offer of services in jurisdictions where Trucost and its affiliates do not have the necessary licenses. All information provided by Trucost is impersonal and not tailored to the needs of any person, entity or group of persons.

This document does not constitute an offer of services in jurisdictions where Trucost and its affiliates do not have the necessary licenses. Trucost is not an investment advisor, and Trucost makes no representation regarding the advisability of investing in any investment fund or other investment vehicle. A decision to invest in any investment fund or other investment vehicle should not be made in reliance on any of the statements set forth in this document. Prospective investors are advised to make an investment in any fund or other vehicle only after carefully considering the risks associated with investing in such funds, as detailed in an offering memorandum or similar document that is prepared by or on behalf of the issuer of the investment fund or other investment product or vehicle.

The materials have been prepared solely for informational purposes only based upon information generally available to the public from sources believed to be reliable. No content contained in these materials (including credit-related analyses and data, research, valuation, models, software or other application or output therefrom) or any part thereof ("Content") may be modified, reverse-engineered, reproduced or distributed in any form or by any means, or stored in a database or retrieval system, without the prior written permission of Trucost. The Content shall not be used for any unlawful or unauthorized purposes. Trucost and its third-party data providers and licensors (collectively "Trucost Parties") do not guarantee the accuracy, completeness, timeliness or availability of the Content. Trucost Parties are not responsible for any errors or omissions, regardless of the cause, for the results obtained from the use of the Content. THE CONTENT IS PROVIDED ON AN "AS IS" BASIS. TRUCOST PARTIES DISCLAIM ANY AND ALL EXPRESS OR IMPLIED WARRANTIES, INCLUDING, BUT NOT LIMITED TO, ANY WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OR USE, FREEDOM FROM BUGS, SOFTWARE ERRORS OR DEFECTS, THAT THE CONTENT'S FUNCTIONING WILL BE UNINTERRUPTED OR THAT THE CONTENT WILL OPERATE WITH ANY SOFTWARE OR HARDWARE CONFIGURATION. In no event shall Trucost Parties be liable to any party for any direct, indirect, incidental, exemplary, compensatory, punitive, special or consequential damages, costs, expenses, legal fees, or losses (including, without limitation, lost income or lost profits and opportunity costs) in connection with any use of the Content even if advised of the possibility of such damages.

The Content does not constitute or form part of any offer, invitation to sell, offer to subscribe for or to purchase any shares or other securities and must not be relied upon in connection with any contract relating to any such matter. 'Trucost' is the trading name of S&P Trucost Limited a limited company registered in England company number 3929223 whose registered office is at 20 Canada Square, London E14 5HL, UK.