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CO_2 EMISSIONS EMBODIED IN INTERNATIONAL TRADE AND DOMESTIC FINAL DEMAND, USING THE OECD ICIO 2018

METHODOLOGY AND RESULTS

Norihiko YAMANO and Joaquim J. M. GUILHOTO

Abstract

Earlier OECD studies on carbon footprint analyses taking into account for global production networks have contributed to increase awareness of divergences in territorial or production-based and consumption-based carbon emissions. The differences in these measures are essential for formulating responses to international climate change negotiations. This paper provides the latest estimates of carbon emissions embodied in final demand and international gross trade of selected 65 economies for the period between 2005 and 2015 with a revised methodology of territorial and economic output-based emissions. Using the OECD Inter-Country Input-Output (ICIO) tables, 2018 edition, and the IEA CO_2 emissions from fuel combustion data, 2018 edition, new estimates of emissions embodied in final demand and in international trade were generated using a more refined methodology than previous versions. Namely, following extensions are included: 1) explicit distinctions between territorial, economic output, final demand-based emissions as well as emissions embodied in gross imports and exports, 2) estimates by major fuel combustion sources, 3) fuel purchases by non-resident industries (road transportation; international aviation and marine bunkers) and household (motor vehicles fuels consumption abroad).

The overall results show, from 2005 to 2015, a decrease in total emissions from production and consumption for the OECD countries, despite that they still have a high intensity of emissions per-capita and are net importers of emissions. On the other hand, for the developing nations, in the same period, they show an increase in their total emissions from production and consumption, being net-exporters of emissions and presenting a continuous growth in their intensity of emissions; however, these countries still have a low per-capita emission, when compared to the more developed nations. Looking at the international trade, the fragmentation of production can be associated to a better use of resources, but also to the outsourcing of emissions.

Keywords: Inter-Country Input-Output; Consumption-based accounting, CO_2 emissions, International trade

JEL Code: F18, F64, Q56, R15, C67

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Executive Summary

Earlier OECD studies on carbon footprint analyses taking into account for global production networks have contributed to increase awareness of divergences in territorial or production-based and consumption-based carbon emissions. The differences in these measures are essential for formulating responses to international climate change negotiations. This paper provides the latest estimates of carbon emissions embodied in final demand and international gross trade of selected 65 economies for the period between 2005 and 2015 with a revised methodology of territorial and economic output-based emissions. Using the OECD Inter-Country Input-Output (ICIO) tables, 2018 edition, and the IEA CO_2 emissions from fuel combustion data, 2018 edition, new estimates of emissions embodied in final demand and in international trade were generated using a more refined methodology than previous versions. Namely, following extensions are included: 1) explicit distinctions between territorial, economic output, final demand-based emissions as well as emissions embodied in gross imports and exports, 2) estimates by major fuel combustion sources, 3) fuel purchases by non-resident industries (road transportation; international aviation and marine bunkers) and household (motor vehicles fuels consumption abroad).

From the analysis of the results it's possible to have a clear view of the role played by the international trade in the allocation of emissions to consumer and producing countries. Through these indicators, e.g., it is possible to observe if the countries are reducing, or not, they emissions in the production and consumption process, and the degree to which they maybe outsourcing the production made by their most pollutant industries to countries more lenient with emissions. In such a way, this outsourcing of emissions maybe possible due to the need of the developing economies to speed-up their development and improve the poor conditions of their population.

Overall the world CO_2 emissions from fuel combustions has increased by 19.2% between 2005 and 2015 (from 27.07 Gigatonnes (Gt) to 32.28 Gt), i.e., a yearly growth rate of 1.78% against a world population increase of 12.85%, i.e., a yearly growth rate of 1.22% in the same period. As a result, in this time lag the yearly world average per capita emission has increased from 4.13 tonnes of CO_2 to 4.37 tonnes of CO_2, an increase of 5.65%, mainly due to the emissions and consumption increase in the developing countries.

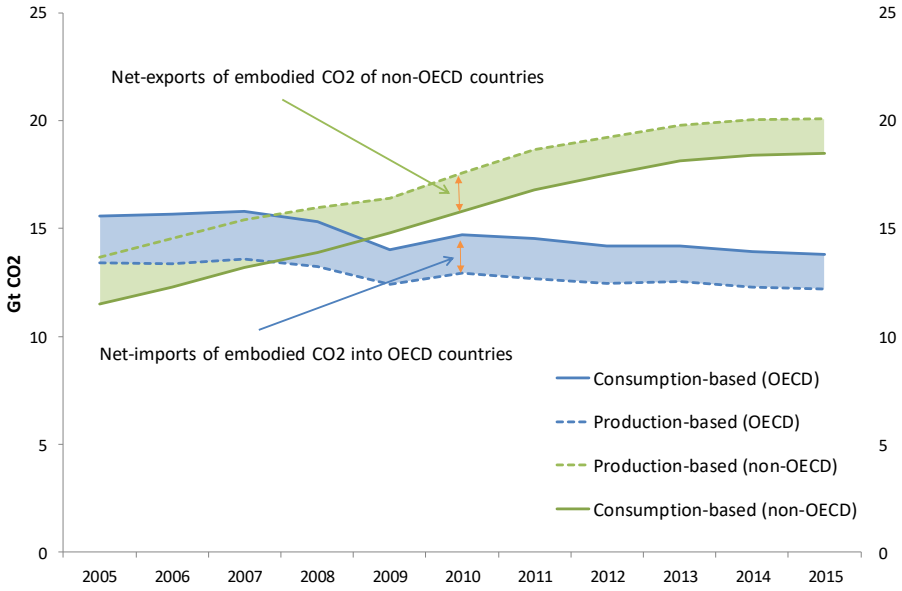
Of the CO2 emitted in 2015, 8.8 Gt of CO_2, representing 27.2% of the world CO_2 emissions from fuel combustion in 2015, is linked with international trade. The main industries aggregates responsible for around 2/3 of the CO2 emissions embodied in exports in 2015 being: a) mining and extraction of energy producing products, D05T06, 6.1%; b) textiles, wearing apparel, leather and related products, D13T15, 3.7%; c) chemicals and non-metallic mineral products, D19T23, 18.2%; d) basic metals and fabricated metal products, D24T25, 16.1%; e) computers, electronic and electrical equipment, D26T27, 11.6%; f) machinery and equipment, D28, 5.6%; and g) motor vehicles, trailers and semi-trailers, D29, 4.4%. Its stand out the fact that China usually appears as the main exporter of emissions and the USA as the main importer. However, the set of main exporter or importers, ant how the trade of emissions is concentrated will depend on the kind of good traded and the human, natural and technological resources available in the countries.

By blocks of counties, the overall results for the OECD countries show, from 2005 to 2015, a decrease in the total production-based emission from 13.42 Gt to 12.20 Gt, consumption based emission from 15.56 Gt to 13.78 Gt, consumption based per-capita emissions from 13.0 tonnes of CO_2 to 10.8 tonnes of CO_2, and net imports of CO_2 emissions from 2.1 to 1.6 Gigatonnes (Gt). Despite this welcomed performance, the consumption per-capita emissions of the OECD countries are around 2.5 times greater than the average world per-capita emission and 3.6 times greater than the non-OECD countries.

By its turn, the non-OECD countries show an increase in all of the above indicators, with production emissions increasing from 13.65 Gt to 20.07 Gt, consumption emissions from 11.51 Gt to 18.50 Gt, and per-capita consumption based emissions increasing from 2.2 tonnes CO_2 to 3.0 tonnes CO_2. These increases are in great part linked with the need of these countries to sustain their own development and to improve the quality of life of their population, but also that these countries are important net suppliers of CO_2 emissions to attend the consumption needs of more of developed nations, as showed above. The non-OECD countries per-capita emissions, of 3.0 tonnes of CO_2 in 2015, is still low when compared to the OECD countries.

As developed nations are emitting less and finding their way in being less intense in emissions, they still have a high intensity of emissions and there is the need to accelerate the process of decarbonisation of these economies. However, the big challenge still to be faced by the nations is how to improve the quality of life in the developing countries, and reduce their income disparities and emissions at the same time. The development and diffusion of new technologies for sure plays an important role in this process, however, a most crucial element is the political determination of the nations and as Nordhaus (2015) pointed out, when he introduces the notion of "Climate Clubs", is to find a way to effectively engage all of them in the decarbonisation process of the world.

Figure. CO_2 emissions from fuel combustion (OECD and non-OECD countries)



Source: OECD's Carbon dioxide (CO_2) emissions embodied in international trade (TECO2) database (http://oe.cd/io-co2), 2019.

1. Introduction

Earlier studies on consumption-based emissions based on inter-country input-output tables (OECD, 2013; Wiebe and Yamano, 2016; Owen et al., 2014; Moran & Wood, 2014) indicate that the deviations between territorial emission accounting greenhouse gas (GHG) and emissions embodied in final demand have been widening in many studies. Reliable emissions information for different types of emissions are increasingly referred by environment economics and climate change policy discussions (Wiedman, 2009).

Numerous literature on measuring GHGs from "consumption-based accounting" approaches have been recently published for different geographical coverages (Lenzen, 2016; Weber et al., 2019; Duarte et al., 2018; Wieland et al., 2018; Arto et al., 2014; Wilting, 2012) . However, the definitions of terms on production-based and consumption-based emissions could be slightly different for each studies[1]. In this paper, we explicitly clarify the types of emissions into three allocation methods (Barrett, *et al*., 2013):

1. Territorial-based emission accounting (e.g. UNFCCC_GHG; IEA_CO2)
    - Fuel purchased and combusted in domestic territory. Fuels combusted by non-residents' motor vehicles are included here. In general, the international bunker fuels are separately estimated from domestic navigation and aviation emissions.
    - The industry dimension is defined by fuel users in domestic territory
2. Production-based emission accounting (e.g. SEEA-AEA; OECD)
    - Production-based emissions in OECD study is differentiated from territorial emissions by the allocation of fuels combusted for owned or leased motor vehicles of non-residents' households and land transportation industries and purchases on international bunker fuels by foreign aviation and marine operators to the country of residence. In principle, this type of emissions are following the definition of National Accounting Matrices including Environmental Accounts (NAMEA) or System of Environmental-Economic Accounting (SEEA) framework.
    - The industry dimension is defined by fuel users by economic resident industries and households
3. Final demand-based emission accounting (demand-based emissions, hereafter)
    - The GHGs emitted at all production stages are captured in emissions embodied in final demand.
    - The type of household consumption and capital formation expenditures defines the product dimension and emissions sources industry by origin countries can be identified.

There are a variety of different GHG gas databases ranging from aggregated emissions for all countries in the world and high level of detail for individual countries. Table 1.1

[1] Links to data and definitions presented in this section are available in the *Data Links* section of this paper.

summarises the existing international databases on greenhouse gas (GHG) emissions based on the submissions from their members countries with customised questionnaires.

Table 1.1. International databases on greenhouse gas emissions and energy demand

Institution	Database	Target Economies	T/P
FAO	FAOSTAT Emissions database	Over 270, countries and aggregate regions	T
IEA	World Energy Balances	Over 170, countries and aggregate regions	T
IEA	CO_2 emissions from Fuel Combustion	Over 180, countries and aggregate regions	T
Eurostat / OECD	Air Emissions Account (SEEA)	EU28 and other annex I countries	P
UNFCCC	Greenhouse Gas Inventory Data	All members Detailed (Annex I)	T

Note: See UNFCCC (https://unfccc.int/process/transparency-and-reporting/greenhouse-gas-data/greenhouse-gas-data-external-sources) for an overview of availability. T: territorial-based, P: production (economic resident)-based.

Among the new features presented in this study, we highlight the following ones:

- Filling the gaps of the IEA CO_2 database for all countries to complete the coverage of CO_2 emissions from fuel combustions
- Complete allocation of CO_2 emissions from fuel combustion by non-resident households and industries. In earlier studies, the emissions from international bunkers were not distributed across operating transportation services providers due to the lack of industry details.
- CO_2 intensity for each bilateral trade borders. The database now enable to compare the emissions embodied in each bilateral trade pairs by specific product.

The structure of the remainder of this paper is as follows. Section 2 presents the methodological approach taken to calculate the 2019 release of CO_2 emissions embodied in international trade and final demand (OECD's TECO2 database, available in http://oe.cd/io-co2). The third section describes the detailed estimation procedure to allocate emissions to the countries and the industries in OECD's ICIO. Section 4 presents and discuss the main results, while the last section presents the summary and the final comments.

2. Methodology

The methodology used to estimate the origins of CO_2 emissions embodied in international trade and final demand (TECO2) resembles the methodology used to calculate the trade in value added (TiVA) and the trade in employment (TIM) embodied in international trade and final demand – the basis for many TiVA indicators (http://oe.cd/tiva). Emissions embodied in gross trade and final demand are calculated by similar equations using the vectors of production-based emissions and the output multipliers from the Inter-Country Input-Output (ICIO) tables (See Table 2.1 for basic equations). However, the indicators need to be selected to avoid the double counting issues of emissions embodied in intermediate trade flows e.g. exported intermediate products could be used in domestic production processes. The differences between the demand-based and gross trade flows-based emissions are summarised using the three production stages (emission sector, intermediate and final producers) in a conceptual diagram of Figure 2-1.

2.1. Final demand-based emissions

Using the ICIO components (Table 2.1) and emissions variables (Table 2.2), the emissions embodied in final demand of each country are estimated.

Output multiplier matrix (**B** in Table 2.1) of the ICIO system derives the domestic and foreign output of all upper stages by a unit final expenditure. The output vector generated in source country of all countries by final expenditure of country *s* is written as

$$X^{rs} = \mathrm{B}\, Y^{s} \qquad (1)$$

where $\boldsymbol{X^{rs}}$ is the output of country *r* generated by final demand of country *s*.

The emissions embodied in the final demand of a country is, then, estimated by multiplying the emissions factor vector, output multiplier (Leontief inverse from ICIO system) and final demand vector of a target country. The relationship of territorial-base, production-based and demand-based emissions of country *s* are respectively written as:

- Territorial-based emissions: Industry (TI^s) and households (TH^s).
- Production-based emissions (industry):

$$P^s = TI^s + \sum_s DI^{rs} - \sum_r DI^{rs} \qquad \mathbf{(2)}$$

- Emissions factor vector:

$$EF^s = (TI^s + \sum_s DI^{rs} - \sum_r DI^{rs})/X^s \qquad \mathbf{(3)}$$

- Resident-based fuel combustion emissions at households:

$$HC^s = TH^s + \sum_s DH^{rs} - \sum_r DH^{rs} \qquad \mathbf{(4)}$$

- Emissions embodied in unit production (emissions multiplier):

$$\mathrm{eB} = \mathrm{diag}\,(\mathrm{EF})\,\mathrm{B} \qquad \mathbf{(5)}$$

- Production-based emissions:

$$C^{s\cdot} = EF^s * X^s + HC^s \qquad \mathbf{(6)}$$

Table 2.1. Basic equations for OECD's ICIO

Matrix	Size of the matrix	Description
X	$(N*K)\times 1$	**Gross output**, where x_i^r is the gross output from industry *i* in country *r*
Z	$(N*K)\times(N*K)$	**Intermediate consumption**, where z_{ij}^{rs} is the flow of goods from producing industry *i* in country *r to the purchasing industry j* in country *s*
A	$(N*K)\times(N*K)$	**Input coefficients**, calculated as $a_{ij}^{rs} = z_{ij}^{rs}/x_j^s$
B	$(N*K)\times(N*K)$	***Leontief inverse***, $\mathbf{B} = (\mathbf{I}-\mathbf{A})^{-1}$, where the element b_{ij}^{rs} shows the direct and indirect requirements of inputs from industry *i* in country *r for the production of one unity of output to the final demand by industry j* in country *s*
Y	$(N*K)\times N$	**Final demand,** where the element $\boldsymbol{y_i^{rs}}$ shows the final demand of country *s* for goods and services produced by industry *i* in country *r*
TRD	$(N*K)\times N$	**Trade** matrices by exporting industry/country and importing country. The element $\boldsymbol{trd_i^{rs}}$ shows exports of products from industry *i* of country *r* to country *s* (imports of products from industry *I* of country *r* by country *s*).

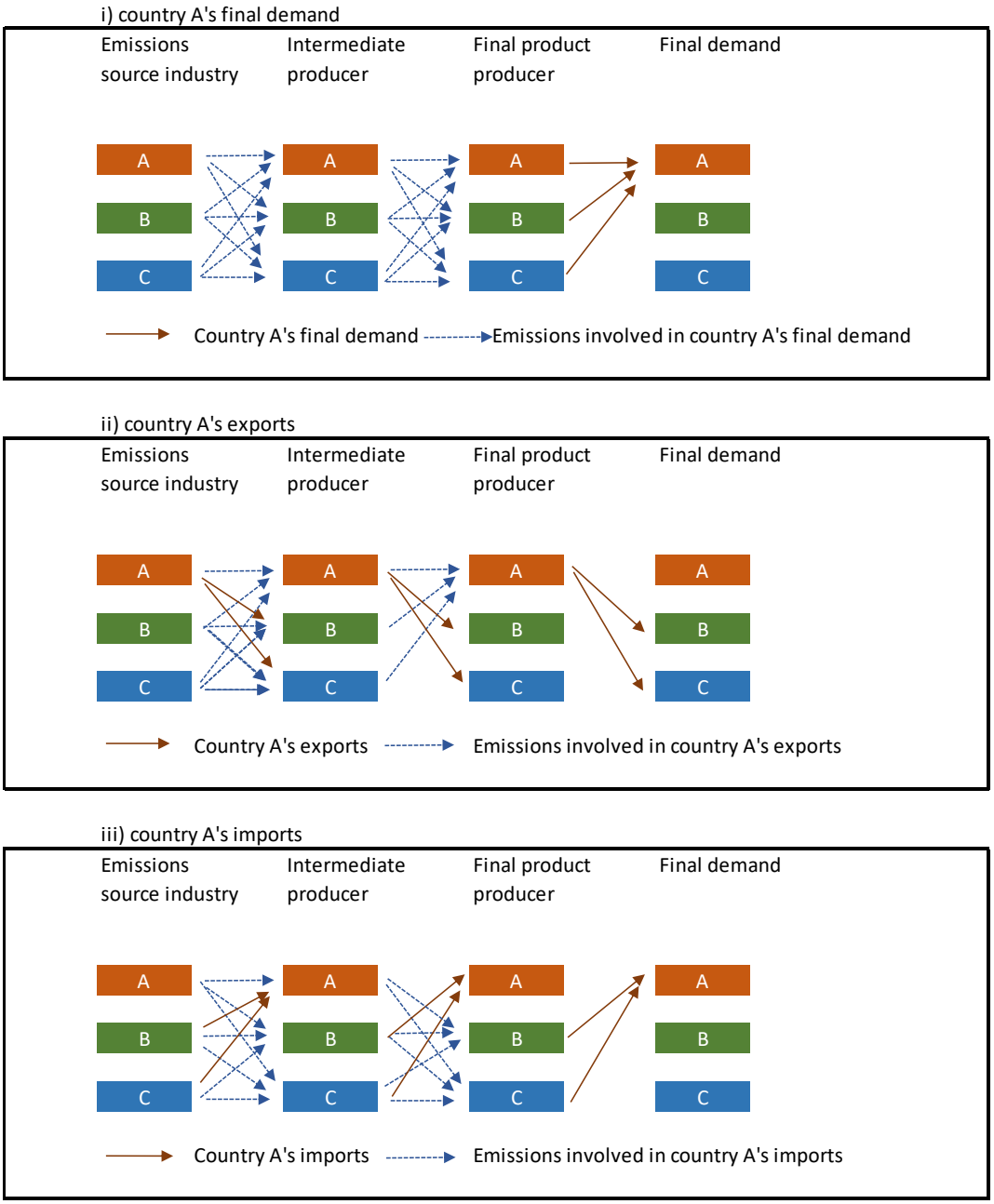
Note: N is number country and K is number of industry.

Table 2.2. CO_2 Emissions from fuel combustion

TI and TH	$1\times N$	Territorial-based emissions where ti_i^r and th_i^r are the emissions calculated from the fuel purchases by industry *i* in country *r* by domestic and foreign industries and households respectively
DI	$(N*K)\times N$	Emissions allocated to fuel purchases by non-resident industries
DH	$(N*K)\times N$	Emissions allocated to fuel purchases by non-resident households
CFI	$1\times(N*K)$	Fuel combustion by resident industries
EF	$1\times(N*K)$	Emissions factor (emissions to output ratio), where $ef_i^r = cfi_i^r/x_i^r$ is the coefficient of CO_2 emissions from industry i's intermediate fuel consumption (cfi_i^r) to output (x_i^r) ratio in country *r*
CFH	$1\times(N*K)$	Fuel combustion by resident households, where the element CFH_i^s shows emissions of fuel *i* consumption by household of country *s*

Note: *N* is number country and *K* is number of industry.

Figure 2-1. Emissions embodied in trade and final demand



- Demand-based emissions:

$$C^{\cdot s} = \text{eB } Y^{\cdot s} + HC^{s} \qquad \textbf{(7a)}$$

Both, the estimation procedures of production-based emissions vectors ($\widehat{\text{EF}}^{r}$ and HC^{r}) are described in next section. Demand-based emissions can be estimated using expanded matrix format for the efficient calculation as follows

$$\begin{bmatrix} \mathbf{cc}^{11} & \mathbf{cc}^{12} & \dots & \mathbf{cc}^{1N} \\ \mathbf{cc}^{21} & \mathbf{cc}^{22} & \dots & \mathbf{cc}^{2N} \\ \vdots & \vdots & \ddots & \vdots \\ \mathbf{cc}^{N1} & \mathbf{cc}^{N2} & \dots & \mathbf{cc}^{NN} \end{bmatrix} = \begin{bmatrix} \widehat{\mathbf{EF}}^{1} & \mathbf{0} & \dots & \mathbf{0} \\ \mathbf{0} & \widehat{\mathbf{EF}}^{2} & \dots & \mathbf{0} \\ \vdots & \vdots & \ddots & \vdots \\ \mathbf{0} & \mathbf{0} & \dots & \widehat{\mathbf{EF}}^{N} \end{bmatrix} \mathbf{B} \begin{bmatrix} \mathbf{y}^{11} & \mathbf{y}^{12} & \dots & \mathbf{y}^{1N} \\ \mathbf{y}^{21} & \mathbf{y}^{22} & \dots & \mathbf{y}^{2N} \\ \vdots & \vdots & \ddots & \vdots \\ \mathbf{y}^{N1} & \mathbf{y}^{N2} & \dots & \mathbf{y}^{NN} \end{bmatrix} + \begin{bmatrix} \widehat{\boldsymbol{HC}}^{1} & \mathbf{0} & \dots & \mathbf{0} \\ \mathbf{0} & \widehat{\boldsymbol{HC}}^{2} & \dots & \mathbf{0} \\ \vdots & \vdots & \ddots & \vdots \\ \mathbf{0} & \mathbf{0} & \dots & \widehat{\boldsymbol{HC}}^{N} \end{bmatrix}$$

(7b)

CO_2 emissions, cc_i^{rs}, associated with country *s'*s final demand emitted by industry *i* in country *r*, are calculated by multiplying the intensities of the production-based emissions (diagonalised vector **EF** of size NK, where *N* is the number of countries and *K* the number of industries) with the global Leontief inverse (**I-A**)$^{-1}$ (of size $NK \times NK$) and global final demand matrix (**Y** of size $NK \times N$) from the OECD ICIO.

Vectors $\mathbf{cc}^{rs}$ represent the emissions produced in country *r* by industry associated with final demand of country *s*, while $\widehat{\mathbf{EF}}^{r}$ is a diagonalised vector of industry-specific emission intensities for country *r* i.e. fuel combusted in each industry in country *r*, $\mathbf{A}^{rs}$ is the coefficient matrix of country *r*'s intermediate inputs into country *s*'s production and $\mathbf{y}^{rs}$ the demand of country *s* for final goods and services produced by country *r*, by industry. $\boldsymbol{HC}$ denotes direct emissions by final demand e.g. combustions of fuels for motor vehicles by households and natural gas for residential use.

Demand-based emissions of country *s* are then calculated as the column sum of column *s* in matrix **CC** plus direct emissions from final demand HC^{s}. Similarly, production-based emission can be calculated as row sums of matrix **CC** (of size $NK \times N$) plus direct emissions from final demand HC^{s}. In this case, as $\mathbf{cc}^{rs}$, are vectors where the number of rows equal to the number of industries, we get production-based emissions by country and industry.

These calculations give the possibility of creating four-dimensional indicators relating emissions source industry and production of exports or final demand for each target year. The dimensions are

- Emitting country,
- Emitting industry,
- Final demand country and
- Final demand industry.

Thus, the world total emissions of demand-based and production-based emissions become equal.

$$\sum_r \sum_s \mathbf{cc}^{rs} + HC = \sum_r \mathbf{EF}^{r} X^{r} + \text{HC} \qquad \textbf{(8)}$$

Where X^{r} is output of country *r*.

The production-based and final demand-based emissions are basis of the indicators presented in the OECD green growth indicators (OECD, 2011; OECD, 2014; OECD,

2017). Carbon productivity indicators are defined from production-based and demand-based perspectives:

- *CO_2 productivity (production-based)* calculated as real GDP generated per unit of CO_2 emitted (USD/kg).
- *CO_2 productivity (demand-based)* calculated as real GDP generated per unit of CO_2 emitted from final demand (USD/kg).

2.2. Calculating emissions embodied in trade

Using the same emissions multiplier matrix of previous section, emissions embodied in the exports (imports) are estimated for trade flow as

$$C = \text{diag(EF) B } T \qquad \textbf{(9)}$$

where C is vector of emissions source industry by country, EF is emissions factor vector, B is global Leontief inverse and T is a matrix of trade flows with element of bilateral trade flows. The example for the emissions embodied in exports of product 2 from country 1 to the rest of the world is written as

$$\begin{bmatrix} c_1^1 \\ c_1^2 \\ \vdots \\ c_K^N \end{bmatrix} = \widehat{\mathbf{EF}}\,\mathbf{B} \begin{bmatrix} 0 & 0 & \dots & 0 \\ 0 & t_2^{12} & \dots & t_2^{1,N} \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \dots & 0 \end{bmatrix} \text{u} \qquad \textbf{(10)}$$

where c_i^r is the emissions from industry *i* in country *r*, **EF** is global emissions factor vector, **B** is the global Leontief inverse (*NK* X *NK*), *N* is number country and *K* is number of industry, trade product *p* from country *r* to country *s* (import by *s*) is $t_p^{r,s}$ and u is an aggregation vector (row sum) with elements of 1 (*NK* x 1).

Then, the emissions embodied in imports of product K for country 2 is described as

$$\begin{bmatrix} c_1^1 \\ c_1^2 \\ \vdots \\ c_K^N \end{bmatrix} = \widehat{\mathbf{EF}}\,\mathbf{B} \begin{bmatrix} 0 & 0 & \dots & 0 \\ 0 & t_K^{12} & \dots & 0 \\ \vdots & \vdots & \vdots & \vdots \\ 0 & t_K^{22} & \vdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & t_K^{N2} & \dots & 0 \end{bmatrix} \text{u} \qquad \textbf{(11)}$$

where c_i^r is the vector of source CO_2 emissions by industry *i* in country *r* embodied in imported product K by country 2.

Using the same emissions factor and global Leontief structures, the emissions embodied in a specific country pair's gross trade flow can be estimated. The example of the emissions involved in the backward production stages of country 1's exports of product *K* to country 2 is

$$\begin{bmatrix} c_1^1 \\ c_1^2 \\ \vdots \\ c_K^N \end{bmatrix} = \widehat{\mathbf{EF}}\,\mathbf{B} \begin{bmatrix} 0 \\ t_K^{12} \\ \vdots \\ 0 \\ \vdots \\ 0 \end{bmatrix} \qquad \textbf{(12)}$$

where c_i^r is the vector of source CO_2 emissions by industry *i* in country *r* embodied in imported product K by country 2 from country 1.

3. Estimation of CO2 emissions factor

The estimation the 2019 edition of OECD CO_2 emissions embodied in international trade and final demand using the methodology presented above needs the estimation of the emissions factors at the country and industry level. The subsections below present the methodology developed to obtain these factors, by combining the detailed information on country and industry output from OECD ICIO[2] with the IEA-CO_2 emissions from fuel combustions[3] databases.

3.1. Territorial-based emissions

Following the earlier versions of OECD demand-based emissions databases, the emissions from IEA CO_2 emissions from fuel combustions database (IEA-CO2) remains as the main data source for territorial-based emissions. The detailed emissions by fuel product and by flow (fuel combusting sectors) for over 140 individual countries and for the world as a whole are annually reported.

In the latest edition of IEA-CO_2 (IEA, 2018) there are: a) 46 unique fuel products, marked with asterisk in Table 3.1; b) 34 unique flows (combustion sectors), marked with asterisk in Table 3.2; and c) 138 individual economies that matches the target countries in the enlarged OECD ICIO database[4]. To avoid the rounding errors and unreported detailed information, as first step, the original IEA dataset is rescaled to the world total and national total emissions. The rescaling procedure takes following two steps:

- World total emissions

$$CF_R^* = CF_W - \sum_c CF_c \qquad \textbf{(13)}$$

- Country total emissions by fuel product and by flow

$$CF_{c,p,f}^* = CF_c^* \frac{CF_{c,p,f}}{\sum_p \sum_f CF_{c,p,f}} \qquad \textbf{(14)}$$

where CF_c is CO_2 emissions from fuel combustion for country c's total emissions, CF_W is world total emissions, CF_R is rest of the world emissions (rest of 137 countries) and $CF_{c,p,f}$ is country c's emissions for fuel product p and flow f. * indicates rescaled result.

[2] The latest published OECD ICIO system considers: a) 65 economies and 17 regions (Annex A); and b) 36 industries and 19 industry aggregates (Annex B).

[3] IEA CO2 Emissions from Fuel Combustion (2018 edition), https://www.iea.org//statistics/

[4] The construction of the OECD's ICIO considers in its estimation 197 countries, 75 commodities and 75 industries.

Table 3.1. Fuel products in IEA CO2 from fuel combustion database

PRODUCTS		
Rank	Code	Name
1	TOTAL	CO2 Fuel Combustion
1.1	COAL	Coal
1.1.1	HARDCOAL *	Hard coal (if no detail)
1.1.2	BROWN *	Brown coal (if no detail)
1.1.3	ANTCOAL *	Anthracite
1.1.4	COKCOAL *	Coking coal
1.1.5	BITCOAL *	Other bituminous coal
1.1.6	SUBCOAL *	Sub-bituminous coal
1.1.7	LIGNITE *	Lignite
1.1.8	PATFUEL *	Patent fuel
1.1.9	OVENCOKE *	Coke oven coke
1.1.10	GASCOKE *	Gas coke
1.1.11	COALTAR *	Coal tar
1.1.12	BKB *	BKB
1.1.13	GASWKSGS *	Gas works gas
1.1.14	COKEOVGS *	Coke oven gas
1.1.15	BLFURGS *	Blast furnace gas
1.1.16	OTHKERO *	Other recovered gases
1.2	PEAT_T	Peat Total
1.2.1	PEAT *	Peat
1.2.2	PEATPROD *	Peat products
1.3	OILSHALE *	Oil shale
1.4	OIL	Oil
1.4.1	CRNGFEED *	Crude/NGL/feedstocks (if no detail)
1.4.2	CRUDEOIL *	Crude oil
1.4.3	NGL *	Natural gas liquids
1.4.4	REFFEEDS *	Refinery feedstocks
1.4.5	ADDITIVE *	Additives/blending components
1.4.6	ORIMUL *	Orimulsion
1.4.7	NONCRUDE *	Other hydrocarbons
1.4.8	REFINGAS *	Refinery gas
1.4.9	ETHANE *	Ethane
1.4.10	LPG *	Liquefied petroleum gases (LPG)
1.4.11	NONBIOGASO *	Motor gasoline excl. bio
1.4.12	AVGAS *	Aviation gasoline
1.4.13	JETGAS *	Gasoline type jet fuel
1.4.14	NONBIOJETK *	Kerosene type jet fuel excl. bio
1.4.15	OGASES *	Other kerosene
1.4.16	NONBIODIES *	Gas/diesel oil excl. bio
1.4.17	RESFUEL *	Fuel oil
1.4.18	NAPHTHA *	Naphtha
1.4.19	WHITESP *	White spirit & SBP
1.4.20	LUBRIC *	Lubricants
1.4.21	BITUMEN *	Bitumen
1.4.22	PARWAX *	Paraffin waxes
1.4.23	PETCOKE *	Petroleum coke
1.4.24	ONONSPEC *	Non-specified oil products
1.5	NATGAS *	Natural gas
1.6	OTHER	Other
1.6.1	INDWASTE *	Industrial waste
1.6.2	MUNWASTEN *	Municipal waste (non-renew)

*Note: * refers to unique fuel products*
Source: IEA (2018)

3.2. Economic output (production)-based emissions

This section explains how to estimate, for each country *r* and year *t*, a vector of CO_2 emissions per unit of industry output and an emission factor $EF^{tr}[i]$ for each industry *i*. Out of total 34 flows in the IEA-CO2 database, 11 flows have "one-to-many" relationship with the ICIO industry list (Table 3.2)[5]. These aggregate flows should be allocated to corresponding sectors to estimate the complete emissions factor. The rest of the flows in IEA-CO2 database is fully compatible with specific individual industry in OECD system.

3.2.1. Autoproducer of electricity and other energy industries

The difference between main Activity and autoproducer of electricity and other energy sources is defined as:[6] "Main Activity supply undertakings generate electricity and/or heat for sale to third parties, as their primary activity whereas autoproducer undertakings generate electricity and/or heat, wholly or partly for their own use as an activity which supports their primary activity."

The main industries who use the energy input to generate electricity and heat are commodity type manufacturing industries.[7] There four aggregate flows in IEA-CO2: Autoproducer electricity plants, autoproducer CHP plants, autoproducer heat plants, and Other energy industry own use. The largest auto producer industries are steel producers from coal related gases (coking coal, other bitumen coal and blast furnace gas). Coal fuel products of these autoproducers are allocated to steel industry (ISIC4-241) and other type of fuel combustion by these autoproducers are allocated to based on the fuel combustion by other material manufacturing industries.

3.2.2. Road Transportation

The emissions for road transportation in IEA-CO2 includes the emissions from fuel combustion from all industries and household in one flow. It is required to separate this number to fuel combusting industries and households for the economic output-based emissions calculation.

The consumption patterns of gasoline and diesel fuels by industries and households are available from the detailed input-output tables for few countries (Australia, Brazil, Canada, Japan and Korea). The emissions from road transportation activities are allocated by the sales shares of gasoline and diesel fuel to resident industries and households for these countries.

For the rest of the countries those do not provide sufficient details of fuel products transactions, the share of gasoline and diesel (light oil) to total petroleum products share for each industry are applied (Table 3.3).

$$ER^{s} = CFR\frac{Z(D19,s)xREFroad\_D19(s)}{\sum_{s}\left(Z(D19,s)xREFroad\_D19(s)\right)}$$

where *CFR* is the reported emissions from fuel combustion for road transportation,

[5] This estimation considers the OECD's ICIO system with 75 commodities and 75 industries.

[6] https://www.iea.org/statistics/resources/questionnaires/faq/#three

[7] The Federation of Electric Power Companies of Japan, Electricity Statistics Information, http://www5.fepc.or.jp/tok-bin-eng/kensaku.cgi

Z(D19,i) is petroleum consumption by industry and household *s* from balanced use table of the 2018 OECD ICIO system, REFroad_D19(s) is the road transportation fuel to total petroleum input by sector *s* from reference countries.

Table 3.2. Concordance between CO_2 flows (IEA) and OECD ICIO industry classification

FLOWS			Industries
Rank	Code	Name	
1	CO2FCOMB	CO2 Fuel Combustion	
1.1	ELECHEAT	Electricity and heat production	
1.1.1	MAINPROD	Main activity electricity and heat production	
1.1.1.1	MAINELEC *	Main activity electricity plants	D35
1.1.1.2	MAINCHP *	Main activity CHP plants	D35
1.1.1.3	MAINHEAT *	Main activity heat plants	D35
1.1.1.4	EPOWERPLT *	Own use in electricity, CHP and heat plants	D35
1.1.2	AUTOPROD	Unallocated autoproducers	
1.1.2.1	AUTOELEC *	Autoproducer electricity plants	Fuel
1.1.2.2	AUTOCHP *	Autoproducer CHP plants	Fuel
1.1.2.3	AUTOHEAT *	Autoproducer heat plants	Fuel
1.2	OTHEN *	Other energy industry own use	Fuel
1.3	TFC	Total final consumption	
1.3.1	TOTIND	Manufacturing industries and construction	
1.3.1.1	IRONSTL *	Iron and steel	D241_2431
1.3.1.2	CHEMICAL *	Chemical and petrochemical	D20T21
1.3.1.3	NONFERR *	Non-ferrous metals	D242_2432
1.3.1.4	NONMET *	Non-metallic minerals	D23
1.3.1.5	TRANSEQ *	Transport equipment	D29T30
1.3.1.6	MACHINE *	Machinery	D25T28
1.3.1.7	MINING *	Mining and quarrying	D07TD09
1.3.1.8	FOODPRO *	Food and tobacco	D10TD12
1.3.1.9	PAPERPRO *	Paper, pulp and printing	D17T18
1.3.1.10	WOODPRO *	Wood and wood products	D16
1.3.1.11	CONSTRUC *	Construction	D41T43
1.3.1.12	TEXTILES *	Textile and leather	D13T15
1.3.1.13	INONSPEC *	Non-specified industry	D22,D31T32
1.3.2	TOTTRANS	Transport	
1.3.2.1	ROAD *	Road	All industries + Households
1.3.2.2	DOMESAIR *	Domestic aviation	D51
1.3.2.3	RAIL *	Rail	D49
1.3.2.4	PIPELINE *	Pipeline transport	D49
1.3.2.5	DOMESNAV *	Domestic navigation	D50
1.3.2.6	TRNONSPE *	Non-specified transport	Fuel
1.3.2.7	AVBUNK *	Memo: International aviation bunkers	Estimated
1.3.2.8	MARBUNK *	Memo: International marine bunkers	Estimated
1.3.3	TOTOTHER	Other	
1.3.3.1	RESIDENT *	Residential	Households
1.3.3.2	COMMPUB *	Commercial and public services	D33,D36T39,D45T47,D52TD96
1.3.3.3	AGRICULT *	Agriculture/forestry	D01T02
1.3.3.4	FISHING *	Fishing	D03
1.3.3.5	ONONSPEC *	Non-specified other	D33,D36T39,D45T47,D52TD96

*Note: * refers to unique flows*
Source: IEA (2018)

Table 3.3. Examples of detailed level input-output table for fuel combustion by industries and household

A: Japan 2014 (trillion JPY)					
	Agriculture (D01)	Land transport (D49)	Public administration (D84)	Household consumption	Total intermediate and household use
Gasoline	61	28	36	4,976	7,489
Diesel/light oils	111	1,273	18	311	4,202
Other petroleum products	80	990	28	1,644	12,809
Total use of petroleum products	252	2,291	82	6,932	24,500
Road transport fuel / total petroleum use by industry	68%	57%	65%	76%	48%
Road emissions users	1%	11%	0%	45%	100%

B: Canada 2013 (million CAD)					
	Agriculture (D01)	Land transport (D49)	Public administration (D84)	Household consumption	Total intermediate and household use
Gasoline	1,225	499	1,257	42,791	111,935
Diesel/light oils	1,595	12,259	1,115	892	33,768
Other petroleum products	207	270	841	3,939	50,375
Total use of petroleum products	3,027	13,029	3,213	47,621	196,079
Road transport fuel / total petroleum use by industry	93%	98%	74%	92%	74%
Road emissions users	2%	9%	2%	30%	100%

Source: METI Extended I-O table for Japan, and StatCan Use table for Canada

Converting the territorial emissions to resident production-based emissions are adjusted by the direct purchases abroad and direct purchases by non-resident expenditures of gasoline and diesel in balance of payment travel, national accounts household consumption expenditures and detailed input-output / supply use tables.

If the detailed fuel purchase information by non-residents are not available, the underlying balanced data for direct purchases of OECD ICIO system is used to allocate the non-residents expenditures.

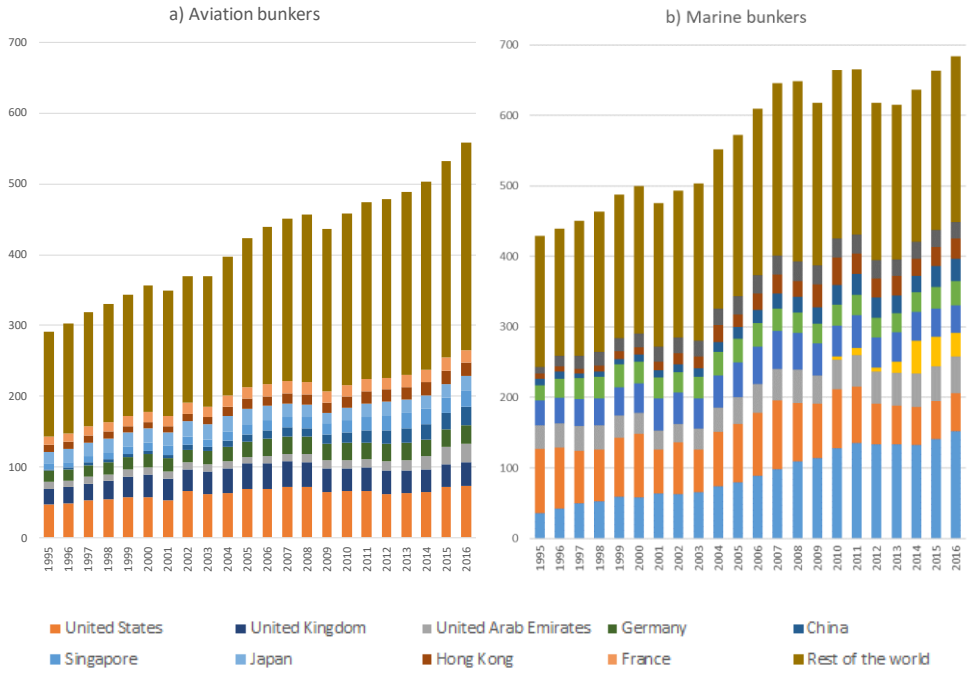
3.2.3. Emissions from fuel used for international transportation

The IPCC guideline (2006) suggests that emissions from international bunkers are separately measured from the rest of fuels used for domestic aviation and navigation activities. The IEA CO_2 emissions database separately reports the international aviation and marine bunker emissions in each reporting country. This territorial-based emissions need to be converted to fuel combustion countries and industries i.e. production-based emissions by available data sources under assumption.

The sales of marine bunker fuels are much concentrated in few countries compared to international aviation bunkers (Figure 3-1). In 2015, the territorial emissions from top 5 countries (Singapore, United States, United Arab Emirates, Russia, Netherland) account for half of global emissions of marine bunkers while the share of top 5 countries (United States, United Kingdom, United Arab Emirates, Germany, China) of global aviation bunkers is only 33%. Both marine and aviation bunker emissions are steadily growing since

the mid-1990 but the aviation bunkers are relatively less volatile. In general, the household final consumption expenditure of air transportation to the total supply of air transportation activity are relatively high for air transportation than water transportation in use tables at purchasers' prices.

Figure 3-1. Emissions from international bunkers (million tonnes)



Source: IEA (2018) CO2 emissions from fuel combustion.

Aviation bunkers

In principle, fuels loaded at origin airports are largely consumed by each trip. The international aviation bunker emissions are allocated to domestic and foreign operators by combining a) airline nationality, b) airport locations and scheduled route traffic. Note that the international aviation emissions are all allocated to air transport activities (ISIC Rev 51). List of privatized and low-cost-carriers airlines are summarized from ICAO Data[8] and the nationality of the operating airline is adjusted from headquarter-based list to establishment activity-based list that matches better for National Accounts and use table framework. The operating bases of most international flights are usually registered either in origin airport or destination airport. Some low-cost-carrier airlines e.g. Ryanair may have larger output in foreign airport bases than the output from headquarter-locating domestic airports. The flight route information is extracted from Openflight database (http://openflights.org).

[8] https://www.icao.int/sustainability/Documents/LCC-List.pdf

https://www.icao.int/sustainability/SiteAssets/Pages/Eap_ER_Databases/FINAL_Airlines%20Privatization.pdf

Global total emissions from international aviation emissions is defined by sum of emissions from all flights of all operating countries is defined as

$$E_p^{ab} = \sum_p \sum_a \sum_b E_p^{ab} \quad \textbf{(15)}$$

where E_p^{ab} is the emissions came from flights from countries *a* to *b* operated by country *p*. Thus, the territorial-based emissions of country *a* and the production-based emissions of country *p* are respectively calculated as

$$TE_a = \sum_p \sum_b E_p^{ab} \quad \textbf{(16)}$$

and

$$PE_p = \sum_a \sum_b E_p^{ab} \quad \textbf{(17)}$$

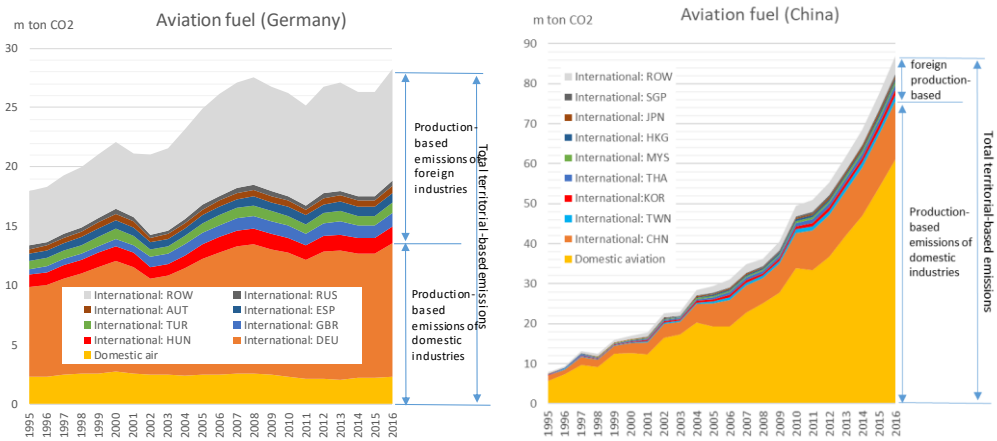
where TE_a is total territorial-based international aviation bunker emissions of country *a* and PE_p is total production-based emissions of country p.

Since territorial-based international aviation bunker emissions are only reported in the IEA emissions database, the element of emission is calculated using accumulated number of flights for each country pairs as

$$E_p^{ab} = TE_a \frac{F_p^{ab}}{\sum_b \sum_p F_p^{ab}}$$

where F_c^{od} is the number of flights routes between country *o* and country *d* operated by country *c*'s air transport industry. It is also assumed the equal number of flights are operated for the same airport pairs (i.e. $F_c^{od} = F_c^{do}$).[9]

Figure 3-2. Territorial-based and production-based emissions of aviation fuel



Source: Authors' calculation based on IEA (2018) CO_2 emissions from fuel combustion.

[9] Further data collection and harmonization for

Marine bunkers

Unlike the aviation bunker emissions, the fuels purchased (loaded) in ports are not fully consumed in each transport node between origin and destination ports. The international cargo transportation companies (e.g. Maersk's Global Voyage Center) chose optimized options of fuel purchases and usages by adjusting the locations of bunker fuel refill ports, vessels speed, cargo and fuel load to overall payload ratios (Lu *et al*., 2015). Therefore, the voyage physical movement and the nationality of fuel loading companies do not match. Due to the lack of detailed procurement data sources, following assumptions are made to estimate the bunker fuels purchased by foreign companies.

a) 10% of international marine bunker fuel of all countries are first allocated to domestic water transportation industry (ISIC4 – 50).

b) The rest of fuel is allocated accordingly to the nationality of water transportation activities. The petroleum products purchase shares by water transportation industries are developed from the intermediate use tables estimated for the OECD ICIO database (Http://oe.cd/icio).

Note that emissions for fuel consumed by military ships are excluded from this category.

4. CO2 emissions embodied in production, consumption and trade[10]

The methodology developed and described above is the bases to estimate the set of indicators present in OECD's Carbon dioxide (CO_2) emissions embodied in international trade (TECO2) database[11]. From the analysis of the results presented in these indicators it's possible to have a clear view of the role played by the international trade in the allocation of emissions to consumer and producing countries. Through these indicators, e.g., it is possible to observe if the countries are reducing, or not, they emissions in the production and consumption process, and the degree to which they maybe outsourcing the production made by their most pollutant industries to countries more lenient with emissions. In such a way, this outsourcing of emissions maybe possible due to the need of the developing economies to speed-up their development and improve the poor conditions of their population.

Overall the world CO_2 emissions from fuel combustions has increased by 19.2% between 2005 and 2015 (from 27.07 Gigatonnes (Gt) to 32.28 Gt), i.e., a yearly growth rate of 1.78% against a world population increase of 12.85%, i.e., a yearly growth rate of 1.22% in the same period. As a result, in this time lag the yearly world average per capita emission has increased from 4.13 tonnes of CO_2 to 4.37 tonnes of CO_2, an increase of 5.65%, as it will be show below, mainly due to the emissions and consumption increase in the developing countries.

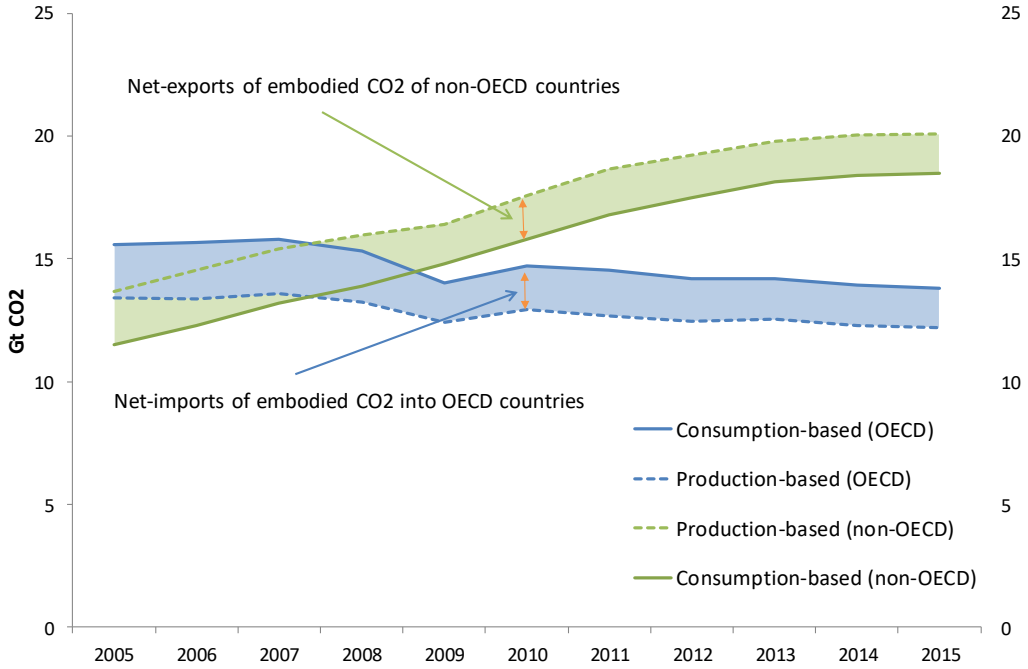
Figure 4-1, drawing from the production-based and consumption-based emissions indicators, compares aggregate OECD and aggregate non-OECD production-based emissions, where CO_2 is allocated to the location in which the goods or services are produced; and, consumption-based emissions i.e. where CO_2 is allocated to the locations in which consumption occurs. For the OECD countries (see Annex D) we observe a decrease in both the total production-based emission, from 13.42 Gt to 12.20 Gt, and the consumption based emission, from 15.56 Gt to 13.78 Gt, i.e., there is an absolute decrease in total consumption and production based emission. As result of these decreases, consumption based per-capita emissions decreased from 13.0 tonnes of CO_2 to 10.8 tonnes of CO_2 (Figure 4-2), and net imports of CO_2 emissions from fuel combustion by OECD countries from non-OECD countries decreased from 2.1 to 1.6 Gigatonnes (Gt) between 2005 and 2015. Despite this welcomed performance, the consumption per-capita emissions of the OECD countries are around 2.5 times greater than the average world per-capita emission and 3.6 times greater than the non-OECD countries.

By its turn, the non-OECD countries show an increase in all of the above indicators, with production emissions increasing from 13.65 Gt to 20.07 Gt, consumption emissions from 11.51 Gt to 18.50 Gt, and per-capita consumption based emissions increasing from 2.2 tonnes CO_2 to 3.0 tonnes CO_2. These increases are in great part linked with the need of these countries to sustain their own development and to improve the quality of life of their population, but also that these countries are important net suppliers of CO_2 emissions to attend the consumption needs of more of developed nations, as showed above. The non-OECD countries per-capita emissions, of 3.0 tonnes of CO_2 in 2015, is still low when compared to the OECD countries.

[10] The data used in the Figures of this section is presented in the Annexes.

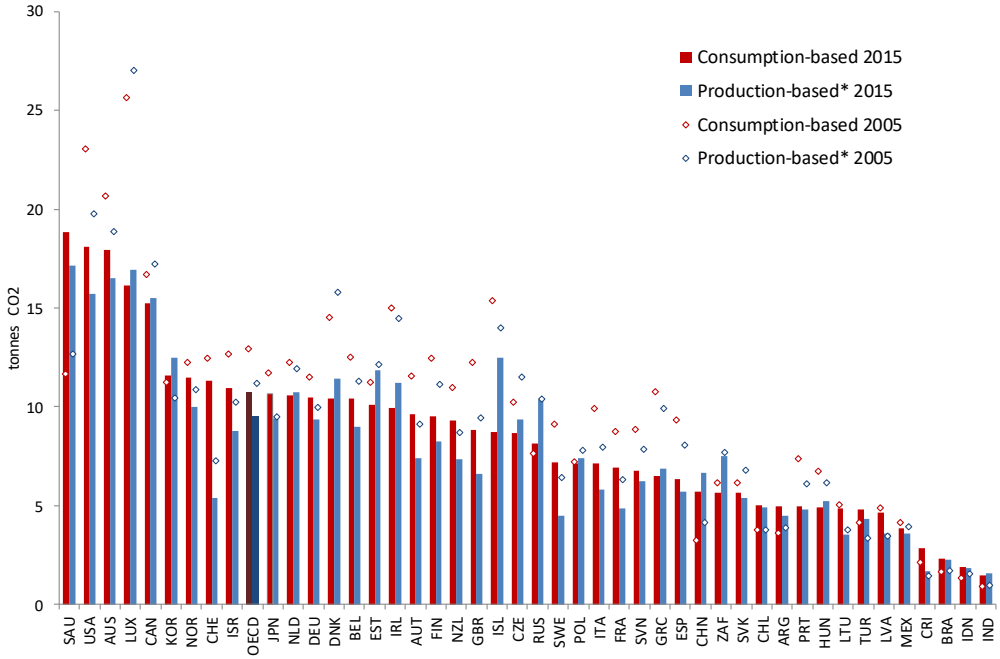
[11] See Annex C for the list of indicators available in http://oe.cd/io-co2.

Figure 4-1. CO_2 emissions from fuel combustion (OECD and non-OECD countries)



Source: OECD's Carbon dioxide (CO_2) emissions embodied in international trade (TECO2) database (http://oe.cd/io-co2), 2019.

Figure 4-2. Per capita CO_2 emissions from fuel combustion

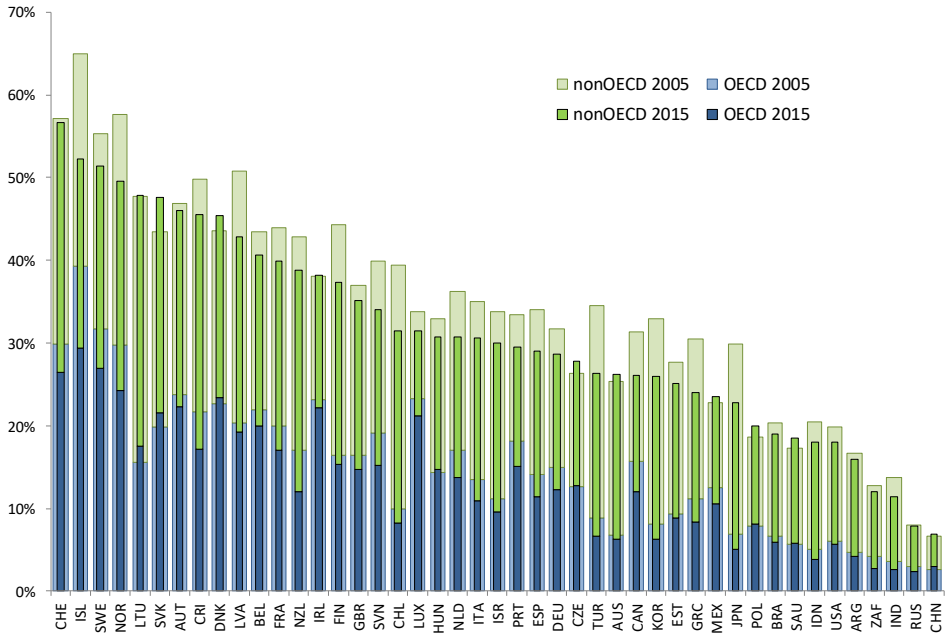


Source: OECD's Carbon dioxide (CO_2) emissions embodied in international trade (TECO2) database (http://oe.cd/io-co2), 2019.

The above looking only at two blocs of countries, OECD and non-OECD, shows a partial picture of the role played by the international trade in the allocation of emissions among the countries, as 8.8 Gt of CO_2, i.e. 27.2% of the world CO_2 emissions from fuel combustion in 2015, is linked with international trade. This high share of emissions associated with the international trade are due in part to the outsourcing and fragmentation of production in the world and the different patterns of production and consumption among the countries (see Guilhoto et al, 2019). As such, the analysis to follow, by focusing on the differences among countries and the different goods traded, will shed some additional light on the role played by the international trade on the allocation of emissions.

Figure 4-3 shows the share of CO_2 emitted abroad embodied in final demand, sourced from OECD and non-OECD regions, revealing these countries differences and the importance of international trade in the allocation of emissions. For the selected countries, it shows that this share, in 2015, could go from 8%, in the case of China, to 57%, in the case of Switzerland, with the smaller countries tending to have higher shares. This result is also a reflex of the countries integration in the international trade and production. In such a way, countries more integrate in the global value chains will have high shares, like France with 46%, United Kingdom with 40% and Germany with 33%, while big countries, rich in natural results will have a smaller share, like Brazil with 22% and the USA with 21%.

Figure 4-3. Share of CO_2 emitted abroad in total CO_2 embodied in domestic final demand



Source: OECD's Carbon dioxide (CO_2) emissions embodied in international trade (TECO2) database (http://oe.cd/io-co2), 2019.

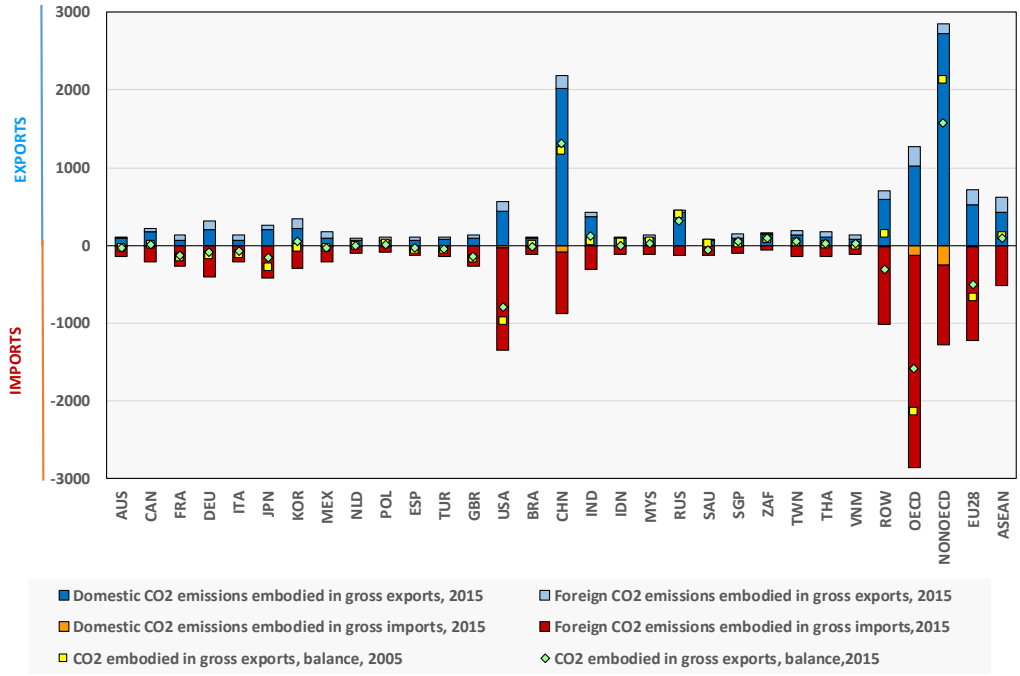
Before we go on, as it has implication for the analysis and better understanding of the results, it is important to let clear how the flows of CO_2 embodied in goods and services traded among the countries in a given region are treated. For example, in the results for the OECD region the imports of France from the USA can either be considered as being from domestic or foreign origin. By considering the flows as being of foreign origin, the foreign content of exports will be higher and the domestic content will be lower, in the case of being of domestic origin, the opposite will be true. In the analysis to follow, the results presented consider the region as being a single unit, i.e., the trade among the countries in a given region are considered as being of domestic origin.

Figure 4-4 shows the CO_2 embodied in total exports and imports, from domestic and foreign sources, for the main countries and regions[12] participating in the international trade. The selected countries, including the rest of the world, were responsible, in 2015, for 89% of the CO_2 emissions embodied in exports (7.8 Gt) and 86.6% of the CO_2 emissions embodied in imports (7.6 Gt). In terms of individual countries, in 2015 the USA was the largest net importer of CO_2, 0.79 Gt, and China the largest net exporter, 1.3 Gt. Other main net importers are Japan (0.16 Gt), United Kingdom (0.14 Gt), and France (0.13 Gt) while other main net exporters are Russia (0.32 Gt), India (0.12 Gt) and South Africa (0.1 Gt). Reflecting the previous analysis of consumption based emissions, the majority of selected OECD and EU 28 countries are net imports of emissions while the non-OECD and ASEAN countries are net exports. Overall, the trade balance of the countries, in absolute values, is smaller in 2015 than in 2005, exceptions are China (with a net CO_2 exports increase from 1.2 Gt to 1.3Gt), India (with a net CO_2 exports increase from 0.06 Gt to 0.12 Gt), and the Rest of the World (which went form a net export of 0.15 Gt in 2005 to a net importer of 0.31 Gt in 2015).

Figure 4-4 also shows the split of the CO_2 embodied in exports and imports between domestic and foreign origins, i.e., the foreign CO_2 embodied in exports shows how much of the CO_2 imported is re-exported, while the domestic CO_2 embodied in imports shows how much of the domestic CO_2 exported comes back. For countries, in 2015, the weighted average share of foreign CO_2 in the exports is 21.7% while the weighted share of domestic CO_2 in imports is 2.0%, the simple averages are respectively 32.2% and 0.6%; implying that the largest countries on the international trade, on the export side have lower share of foreign CO_2 in exports than the other countries, and on the other hand, they have a greater share of domestic CO_2 returning to them, these results are influenced by the results of the USA and China, main players in the international trade. For the OECD and the USA the shares of foreign CO2 in exports is close to the countries average, i.e., respectively 21.5% and 19.7% in 2015, however they have higher shares of domestic CO_2 in imports, 2.4% for the USA and 4.3% for the OECD. The results for the EU28 in 2014 are a share of 26.8% of foreign CO_2 in exports and of 1.9% of domestic CO_2 in imports. The non-OECD countries, being a mirror of the results presented for the OECD countries, show a share of 4.3% of foreign CO_2 in export and of 19.7% of domestic CO_2 on imports. The same numbers for China are respectively 8% and 9%, indicating a low content of foreign emissions in Chinese exports and a relative high content of domestic emissions that returns to China in imports. These results help to shed some light on explaining how emissions and their intensity can contribute to the international trade and its fragmentation, and vice-versa.

[12] See Annex A for the list of regions.

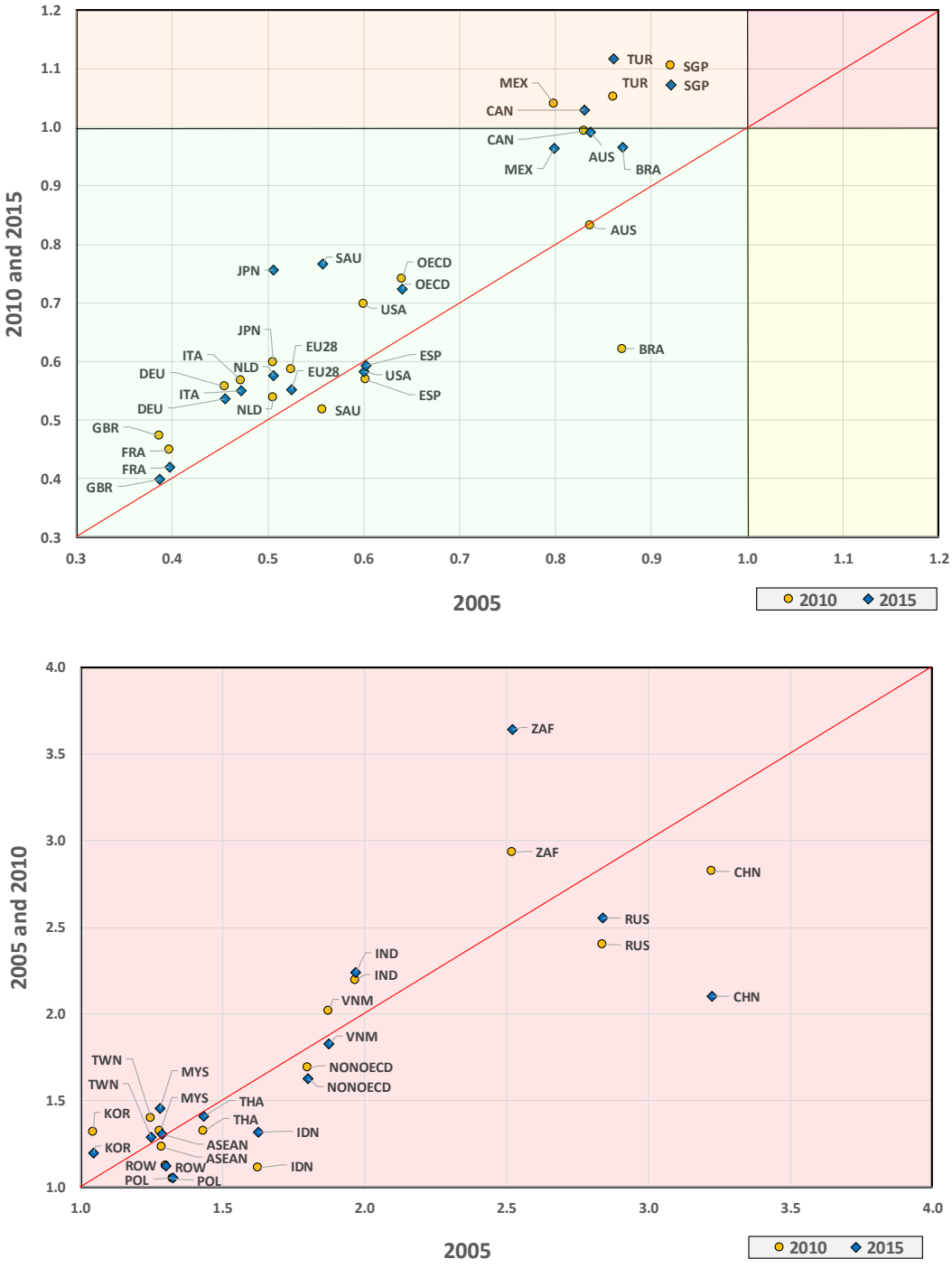
Figure 4-4. CO_2 embodied in total exports and total imports, from domestic and foreign sources, selected economies for 2005 and 2015 (Millions Tonnes of CO_2)



Source: OECD's Carbon dioxide (CO_2) emissions embodied in international trade (TECO2) database (http://oe.cd/io-co2), 2019.

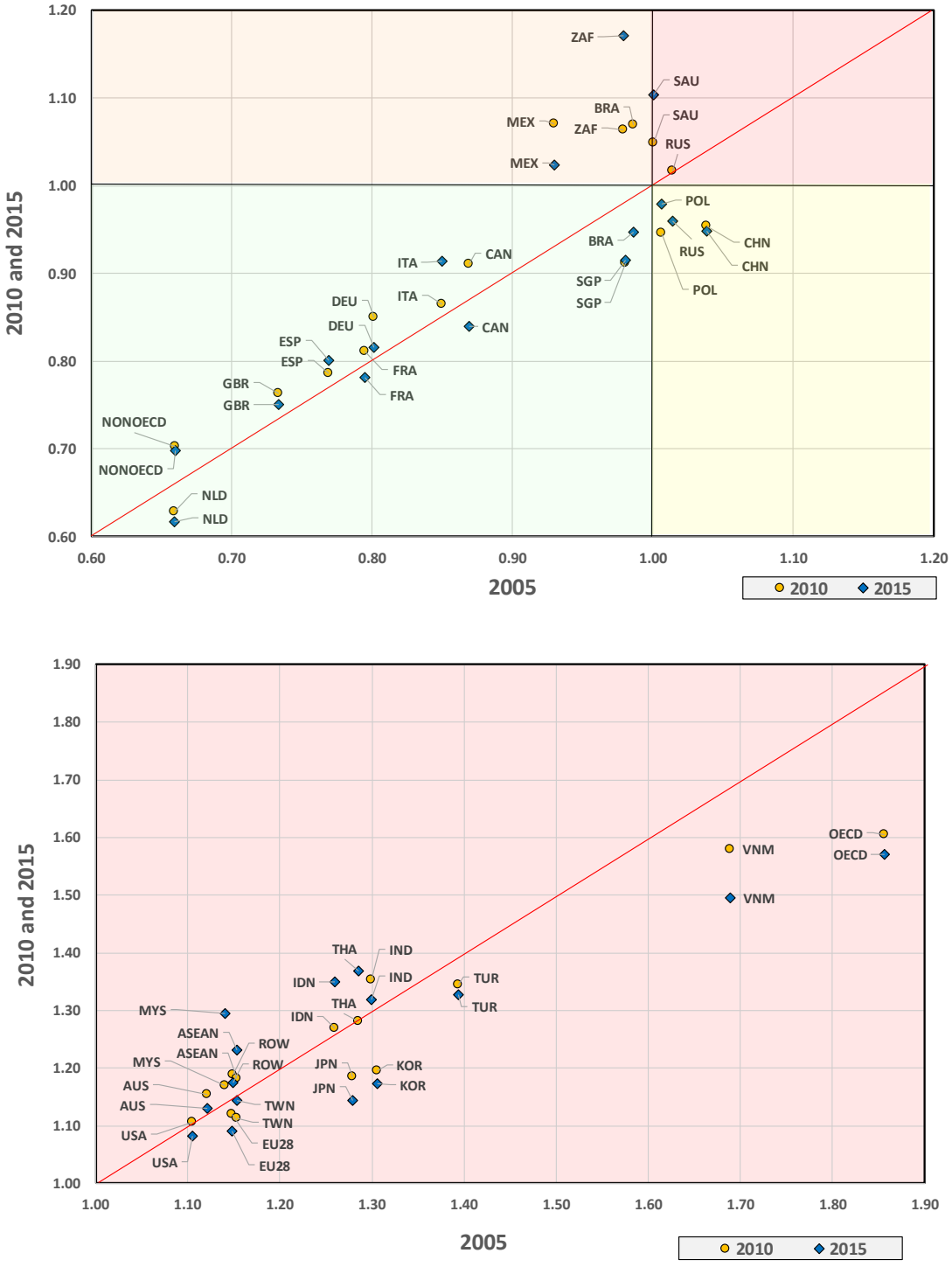
Figure 4-5 and Figure 4-6 show, for the main countries and regions participating in the international trade, the relative intensity of exports and imports, i.e. CO_2 emissions per US dollar, export or imported, relative to the world unweighted intensity average for 2005, 2010 and 2015. By normalizing in relation to the mean, the world average becomes 1.0, such that values below or above 1.0 indicates that the country, or region, has an emission intensity below or above the world average. In these figures, points below the 45º red line are economies which, in relation to the mean, become less intensive in emissions in 2010 and/or 2015 in comparison to 2005. To facilitated the visualization, the charts can have up to 4 colours for background: a) the green is for economies which in 2005 were below the average, and remained below the average in 2010 and/or 2005; b) the orange is for economies which in 2005 were below the average, and become above the average in 2010 and/or 2015, i.e., relatively more intensive in emissions than before; c) the yellow for economies which in 2005 were above the average, and become below the average in 2010 and/or 2005, i.e., relatively less intensive in emissions than before; and d) the red is for economies which in 2005 were above the average, and remained above the average in 2010 and/or 2015. Each of these figures has two charts, the first one is for economies in which in at least one of the years considered they have an intensity of emissions in exports or imports below the average, and the second one is for economies with emissions intensity above the mean in all the years considered.

Figure 4-5. CO_2 intensity in exports relative to simple world average, selected economies for 2005, 2010 and 2015, (simple world average = 1.0)



Source: OECD's Carbon dioxide (CO_2) emissions embodied in international trade (TECO2) database (http://oe.cd/io-co2), 2019.

Figure 4-6. CO_2 intensity in imports relative to simple world average, selected economies for 2005, 2010 and 2015, (simple world average = 1.0)



Source: OECD's Carbon dioxide (CO_2) emissions embodied in international trade (TECO2) database (http://oe.cd/io-co2), 2019.

For the exports of the economies in the figures, relatively to the world average, overall they are more intensive in emissions in 2010 than in 2005 and they show a relative reduction in emissions from 2010 to 2015. The OECD, and EU28 economies, as observed above for the consumption and production based emissions, have an intensity of emissions below the world average, while the non-OECD, and ASEAN economies, show an emission intensity above the average. Despite the still relatively high positon of China in the intensity of export emissions, 110% higher than the world average in 2015, it decreased considerably, as its intensity of emissions was 232% higher than the average in 2005.

From the import side, overall the average intensity of the non-OECD economies as a block, are relatively less intensive in emissions than the world average, this happens because the exports and imports among these economies are considered as domestic, The opposite is true for the OECD, EU28, and ASEAN economies as a block show a greater intensity in the imports than the world average. Despite the relative high intensity of EU28 as a region, at the individual country level the select countries from EU28 show below average intensity, as there is a relative high trade among the countries in this region. For the same reason of the integration of the countries in the region, the intensity of CO_2 emissions of imports and the select ASEAN countries are above average. The relative intensity of imports of China decreased from being 4% above the world average in 2005 to being 5% below in 2015.

After having an overall picture of how the CO_2 emissions are embodied in the goods and services traded among the countries and the relative intensity of emissions among the exporters and importers countries, still a question to answer is what are the main industries in trade which are responsible for emissions, and which are the main countries exporting and importing these goods and services, which can be observed in Figure 4-7 and Figure 4-8.

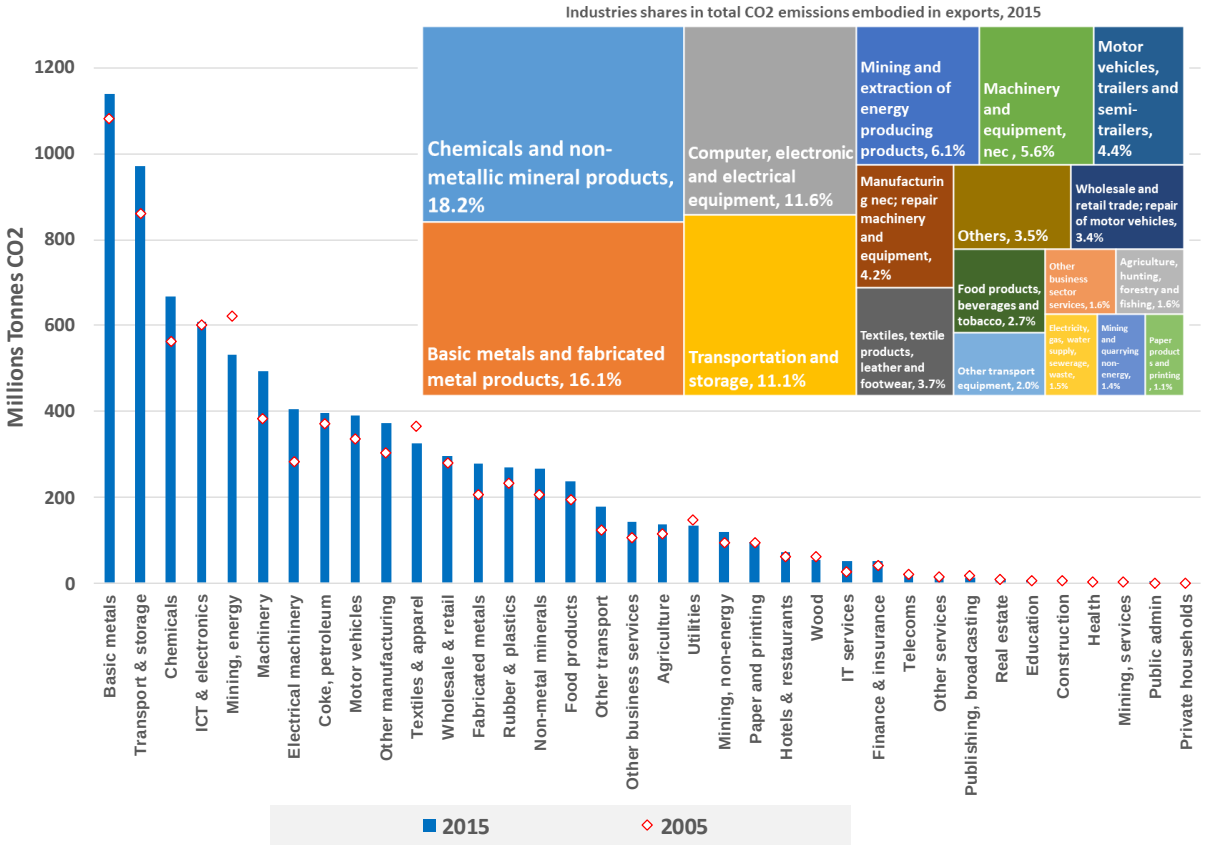
From Figure 4-7, which show the total emissions embodied in exports by industry and shares by industry aggregates, we have selected 7 main industries aggregates which responded for around 2/3 of the CO_2 emissions embodied in exports in 2015: a) mining and extraction of energy producing products, D05T06, 6.1%; b) textiles, wearing apparel, leather and related products, D13T15, 3.7%; c) chemicals and non-metallic mineral products, D19T23, 18.2%; d) basic metals and fabricated metal products, D24T25, 16.1%; e) computers, electronic and electrical equipment, D26T27, 11.6%; f) machinery and equipment, D28, 5.6%; and g) motor vehicles, trailers and semi-trailers, D29, 4.4%. Despite the share of 11.1% of the industry D49T53, transportation and storage, as the emissions of this industry are effectively related and spread over the transport of the all the other industries, no specific analysis is made here for this sector.

The selected industries aggregates are displayed in Figure 4-8, which show the main exporter and importer countries of the goods produced by these industries, such that this figure is a reflex of the information presented in Figure 4-5 and Figure 4-7. On the charts presented in this figure, the left axis display the emissions embodied in the exports or imports, while the right axis displays the cumulative shares. Only the main countries are displayed in each chart, the sum for the ICIO countries not individually displayed in each chart is show as “oth”.

For the industries presented in Figure 4-8, its stand out the fact that China usually appears as the main exporter of emissions and the USA as the main importer. However, the set of main exporter or importers, ant how the trade of emissions is concentrated will depend on the kind of good traded and the human, natural and technological resources available in the countries. Overall, emissions are relatively more widespread among importing than among

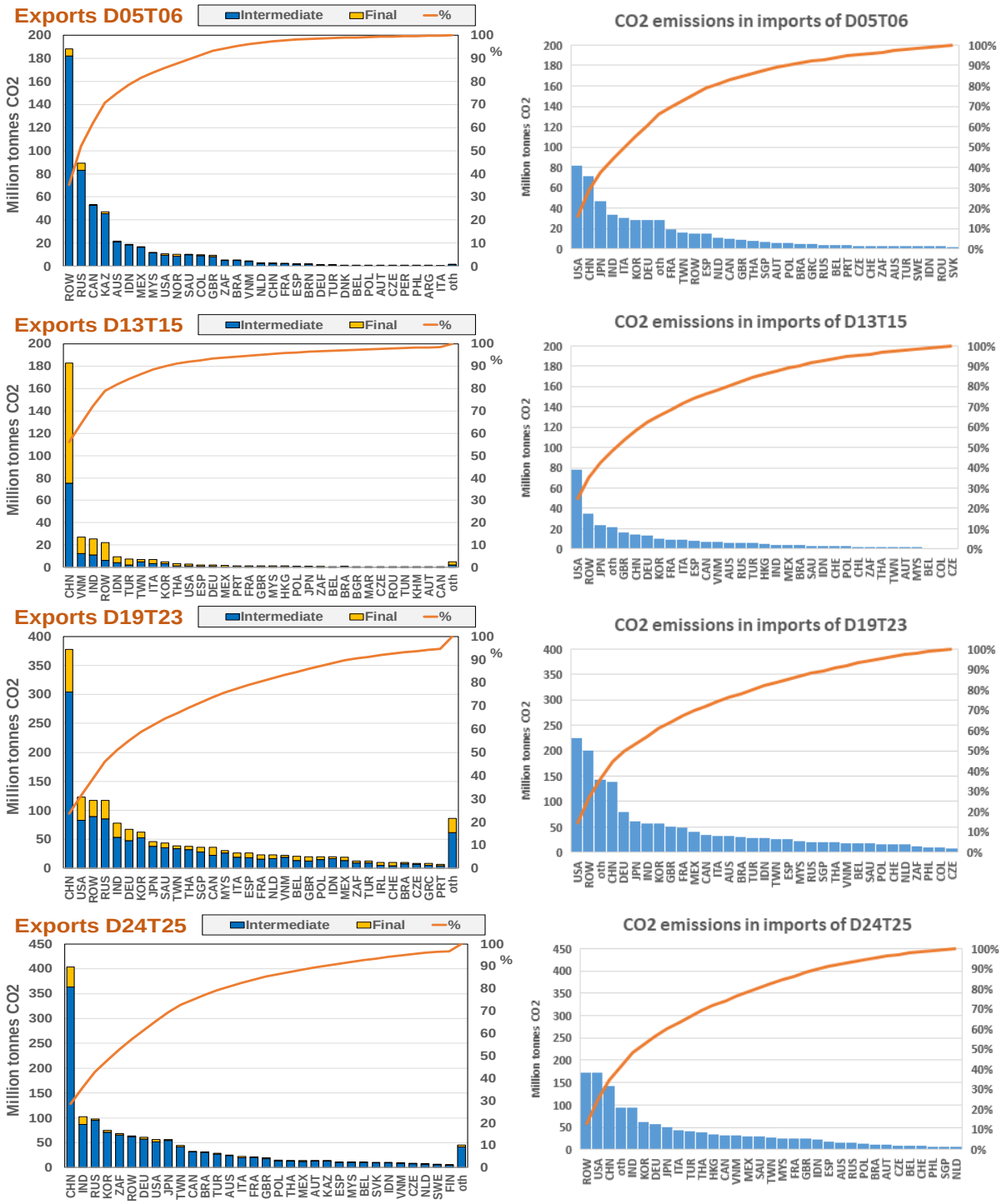
exporting countries, with a tendency to the concentration of imports on the G20 countries while the exports are more dependable on the good being exported. We call attention for the following particularities of industries and countries: a) Mining and extraction of energy producing products, in which around 60.8% of the imported emissions is concentrated in 7 countries (USA, CHN, JPN, IND, ITA, KOR, DEU); b) China being responsible for 56.0% the emissions embodied in the exports of Textiles, wearing apparel, leather and related products; 55.9% of the emissions in Computers, electronic and electrical equipment; and 42.8% of the emissions in Machinery and equipment; c) Motor vehicles, trailers and semi-trailers in which 58.6% of the exported emissions is due to 6 countries (CHN, MEX, DEU, USA, JPN, KOR) and 51.1% of the imported emissions is done by the USA.

Figure 4-7. Total CO2 emissions embodied in gross exports, ICIO industries, 2005 and 2015



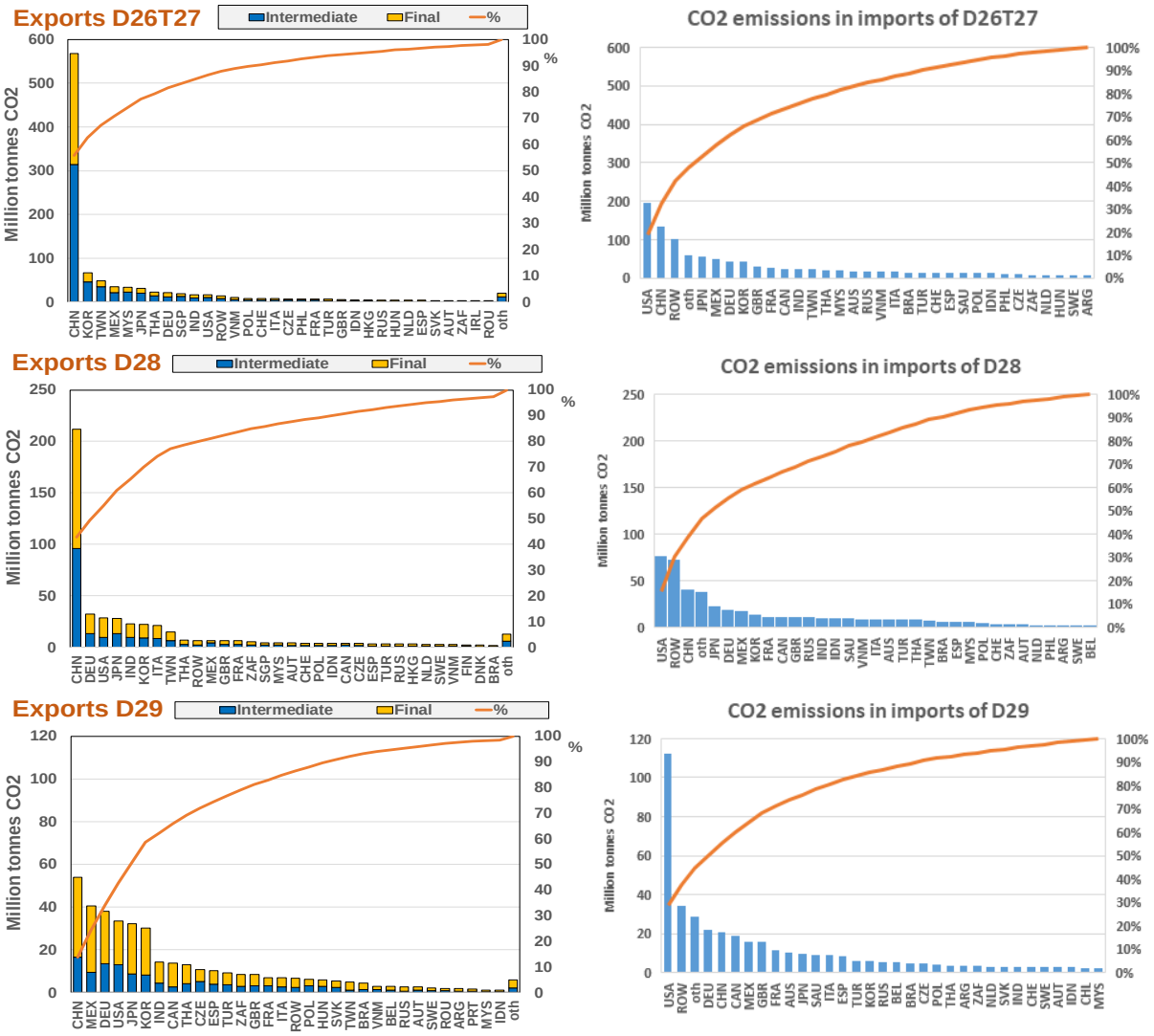
Source: OECD's Carbon dioxide (CO_2) emissions embodied in international trade (TECO2) database (http://oe.cd/io-co2), 2019.

Figure 4-8. Total CO_2 emissions in exports and imports, main exports industries and countries, 2015



Continue …

Figure 4-8 continued



Note: The sum for the ICIO countries not indiviadually displayed in each chart is show as "oth".
Source: OECD's Carbon dioxide (CO_2) emissions embodied in international trade (TECO2) database (http://oe.cd/io-co2), 2019.

5. Final Comments

To obtain the latest estimation of CO_2 emissions from fuel combustion, embodied in final demand and international gross trade, for 65 economies in the period from 2005 to 2015, this paper makes full use of the data availability; in doing so, it presents novelties in relation to previous estimation, which, in our believe, allows for better and improved results.

On the databases work, the novelties are mainly related to the allocation of emissions to industries, and to residents and non-residents: a) from the productive structure and demand side, we have made use of the underlining ICIO system of Inter-Country Use Tables, (ICUT), which considers 198 economies with details for 75 products and 75 industries; b) from the CO_2 fuel combustion emissions side we have made full use of the IEA database, considering the 138 countries which match the countries in the ICUT database, and also considering emissions of international bunker fuels. From the use of this more detailed information is was possible to better allocate emissions to road transportation and filling the gaps to estimate territorial emissions. The revised production-based emissions are now fully compatible (in principle) with the national accounts framework (SEEA) by adjusting non-resident households and non-resident transportation operators (road, aviation and marine). The resulting allocation of emissions to the more detailed set of industries and countries were then aggregate to match the 36 industries and 65 economies considered in the ICIO system, which was then used to estimate CO_2 emissions, from fuel combustion, embodied in final demand and international gross trade. These series of indicators on gross exports and final demand now includes bilateral and industrial dimensions.

The distinction between production-based and consumption-based emissions is directly relevant for on-going policy discussions. Recognizing that developed countries were principally responsible for the high levels of GHGs in the atmosphere at the time of signing of the Kyoto Protocol in 1997, the Protocol placed a heavier burden on developed nations under the principle of "common but differentiated responsibilities." (See Rose et al., 1998; Ringius et al., 2002). This language has spawned a lively debate about what constitutes a “fair” allocation of rights to emit GHGs and the burden associated with its mitigation, and such debates have informed subsequent negotiations at meetings of the Conference of the Parties (COPs).

Even if consumption-based emissions accounting is not considered to be appropriate for the allocation of rights and burdens, it can be helpful to better understand the forces that are driving trends and patterns in global emission levels. Indeed, a comparison of disaggregated production-based and consumption-based measures of emissions is arguably the most appropriate means to assess the importance of carbon leakage in a world of heterogeneous climate policy settings. Countries with ambitious climate mitigation targets may achieve decoupling of production-based emissions from economic growth by offshoring domestic production abroad, with some of the emissions coming home through the “back door” in the form of carbon-intensive imports (Weber and Peters, 2009).

The good news is that the developed nations are emitting less and finding their way in being less intense in emissions, the bad news is that they still have a high intensity of emissions and there is the need to accelerate the process of decarbonisation of these economies. However, the big challenge still to be faced by the nations is how to improve the quality of life in developing countries, and reduce their income disparities and emissions at the same time. The development and diffusion of new technologies for sure plays an important role

in this process, however, a most crucial element is the political determination of the nations and as Nordhaus (2015) pointed out, when he introduces the notion of "Climate Clubs", is to find a way to effectively engage all of them in the decarbonisation process of the world.

To better contribute to the discussions on the decarbonisation of the nations and climate change, and to improve the estimations of emissions embodied in consumption and trade, the next steps to be follow in this work will be a complete integration of the estimations with the Air Emissions Accounts and the inclusion of the remaining Greenhouse Gas Emissions (GHG).

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OECD_ICIO: OECD (2019) Inter-country Input-Output Database.
http://oe.cd/icio

OECD_ TECO2 Carbon dioxide (CO2) emissions embodied in international trade database 2019
http://oe.cd/io-co2

SEEA-AEA: System of Environmental Economic Account, EUROSTAT Air emissions accounts
https://ec.europa.eu/eurostat/web/environment/emissions-of-greenhouse-gases-and-air-pollutants/air-emissions-accounts

UNFCC_GHG: UNFCCC, GHG data from UNFCCC
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Annex A. ICIO 2018 Geographical Coverage

ICIO 2018 Country List

N.	Code	Country	N.	Code	Country
1	AUS	Australia	37	ARG	Argentina
2	AUT	Austria	38	BRA	Brazil
3	BEL	Belgium	39	BRN	Brunei Darussalam
4	CAN	Canada	40	BGR	Bulgaria
5	CHL	Chile	41	KHM	Cambodia
6	CZE	Czech Republic	42	CHN	China (People's Republic of)
7	DNK	Denmark	43	COL	Colombia
8	EST	Estonia	44	CRI	Costa Rica
9	FIN	Finland	45	HRV	Croatia
10	FRA	France	46	CYP	Cyprus
11	DEU	Germany	47	IND	India
12	GRC	Greece	48	IDN	Indonesia
13	HUN	Hungary	49	HKG	Hong Kong, China
14	ISL	Iceland	50	KAZ	Kazakhstan
15	IRL	Ireland	51	MYS	Malaysia
16	ISR	Israel	52	MLT	Malta
17	ITA	Italy	53	MAR	Morocco
18	JPN	Japan	54	PER	Peru
19	KOR	Korea	55	PHL	Philippines
20	LVA	Latvia	56	ROU	Romania
21	LTU	Lithuania	57	RUS	Russian Federation
22	LUX	Luxembourg	58	SAU	Saudi Arabia
23	MEX	Mexico	59	SGP	Singapore
24	NLD	Netherlands	60	ZAF	South Africa
25	NZL	New Zealand	61	TWN	Chinese Taipei
26	NOR	Norway	62	THA	Thailand
27	POL	Poland	63	TUN	Tunisia
28	PRT	Portugal	64	VNM	Viet Nam
29	SVK	Slovak Republic	65	ROW	Rest of the World
30	SVN	Slovenia			
31	ESP	Spain			
32	SWE	Sweden			
33	CHE	Switzerland			
34	TUR	Turkey			
35	GBR	United Kingdom			
36	USA	United States			

Note: Countries 1 to 36, in blue, are OECD member countries

ICIO 2018 Regions List

N.	Region	Heading	Countries
1	OECD	OECD member countries	Countries 01 to 36
2	NONOECD	Non-OECD economies and aggregates	Countries 37 to 65
3	APEC	Asia-Pacific Economic Cooperation[1]	AUS, CAN, CHL, JPN, KOR, MEX, NZL, USA, BRN, CHN, HKG, IDN, MYS, PER, PHL, RUS, SGP, THA, TWN, VNM
4	ASEAN	Association of South East Asian Nations[2]	BRN, IDN, KHM, MYS, PHL, SGP, THA, VNM
5	EASIA	Eastern Asia	JPN, KOR, CHN, HKG, TWN
6	EU28	European Union (28 countries)	AUT, BEL, CZE, DNK, EST, FIN, FRA, DEU, GRC, HUN, IRL, ITA, LVA, LTU, LUX, NLD, POL, PRT, SVK, SVN, ESP, SWE, GBR, BGR, CYP, HRV, MLT, ROU
7	EU15	European Union (15 countries)	AUT, BEL, DNK, FIN, FRA, DEU, GRC, IRL, ITA, LUX, NLD, PRT, ESP, SWE, GBR
8	EU13	EU28 excluding EU15	CZE, EST, HUN, LVA, LTU, POL, SVK, SVN, BGR, CYP, HRV, MLT, ROU
9	EA19	Euro area (19 countries)	AUT, BEL, EST, FIN, FRA, DEU, GRC, IRL, ITA, LVA, LTU, LUX, NLD, PRT, SVK, SVN, ESP, CYP, MLT
10	EA12	Euro area (12 countries)	AUT, BEL, FIN, FRA, DEU, GRC, IRL, ITA, LUX, NLD, PRT, ESP
11	G20	Group of Twenty	AUS, CAN, JPN, KOR, MEX, TUR, USA, ARG, BRA, CHN, IND, IDN, RUS, SAU, ZAF, EU28
World divided into regions			
N.	**Region**	**Heading**	**Countries**
12	ZEUR	Europe	AUT, BEL, CZE, DNK, EST, FIN, FRA, DEU, GRC, HUN, ISL, IRL, ITA, LVA, LTU, LUX, NLD, NOR, POL, PRT, SVK, SVN, ESP, SWE, CHE, GBR, BGR, CYP, HRV, MLT, ROU, RUS
13	ZASI	East and South East Asia	JPN, KOR, BRN, CHN, HKG, IDN, KHM, MYS, PHL, SGP, THA, TWN, VNM
14	ZNAM	North American Free Trade Association	CAN, MEX, USA
15	ZOTH	Other regions	AUS, ISR, NZL, TUR, IND, KAZ, MAR, SAU, TUN, ZAF, ROW
16	ZSCA	South and Central America	CHL, ARG, BRA, COL, CRI, PER
17	WLD	World	
18	DXD	Domestic	Dummy partner used in the diagonal for some indicators.

Notes: OECD member countries are in blue; 1. APEC country not included in 2018 TiVA database: Papua New Guinea; 2. ASEAN countries not included in 2018 TiVA database: Lao PDR and Myanmar.

Annex B. ICIO 2018 Industry Coverage

ICIO 2018 Industry List

N.	Code	Industry	ISIC Rev.4
1	D01T03	Agriculture, hunting, forestry and fishing	01, 02, 03
2	D05T06	Mining and extraction of energy producing products	05, 06
3	D07T08	Mining and quarrying of non-energy producing products	07, 08
4	D09	Services to mining and quarrying	09
5	D10T12	Food products, beverages and tobacco	10, 11, 12
6	D13T15	Textiles, textile products, leather and footwear	13, 14, 15
7	D16	Wood and products of wood and cork	16
8	D17T18	Paper products and printing	17, 18
9	D19	Coke and refined petroleum products	19
10	D20T21	Chemicals and chemical products	20, 21
11	D22	Rubber and plastics products	22
12	D23	Other non-metallic mineral products	23
13	D24	Basic metals	24
14	D25	Fabricated metal products	25
15	D26	Computer, electronic and optical equipment	26
16	D27	Electrical machinery and apparatus, nec	27
17	D28	Machinery and equipment, nec	28
18	D29	Motor vehicles, trailers and semi-trailers	29
19	D30	Other transport equipment	30
20	D31T33	Manufacturing nec; repair of machinery and equipment	31, 32, 33
21	D35T39	Electricity, gas, water supply, sewerage, waste and rem. svcs	35,36, 37, 38, 39
22	D41T43	Construction	41, 42, 43
23	D45T47	Wholesale and retail trade; repair of motor vehicles	45, 46, 47
24	D49T53	Transportation and storage	49, 50, 51, 52, 53
25	D55T56	Accommodation and food services	55, 56
26	D58T60	Publishing, audiovisual and broadcasting activities	58, 59, 60
27	D61	Telecommunications	61
28	D62T63	IT and other information services	62, 63
29	D64T66	Financial and insurance activities	64, 65, 66
30	D68	Real estate activities	68
31	D69T82	Other business sector services	69, 70, 71, 72, 73, 74, 75, 77, 78, 79, 80, 81, 82
32	D84	Public admin. and defence; compulsory social security	84
33	D85	Education	85
34	D86T88	Health and social work	86, 87, 88
35	D90T96	Other community, social and personal services	90, 91, 92, 93,94,95, 96
36	D97T98	Private households with employed persons	97, 98

ICIO 2018 Industry Aggregates List

N.	Code	Industry Aggregate	Industry
1	D05T09	Mining and quarrying	D05T06, D07T08, D09
2	D10T33	Total Manufacturing	D10T12, D13T15, D16, D17T18, D19, D20T21, D22, D23, D24,D25, D26, D27, D28, D29, D30, D31T33
3	D16T18	Wood and paper products and printing	D16, D17T18
4	D19T23	Chemicals and non-metallic mineral products	D19, D20T21, D22, D23
5	D24T25	Basic metals and fabricated metal products	D24, D25
6	D26T27	Computer, electronic and electrical equipment	D26, D27
7	D29T30	Transport equipment	D29, D30
8	D45T82	Total Business Sector Services	D45T47, D49T53, D55T56, D58T60, D61, D62T63, D64T66,D68, D69T82
9	D45T56	Distributive trade, transport, accommodation and food services	D45T47, D49T53, D55T56
10	D58T63	Information services	D58T60, D61, D62T63
11	D84T98	Public admin, education, health and other personal services	D84, D85, D86T88, D90T96, D97T98
12	D84T88	Public admin, defence; education and health	D84, D85, D86T88
13	D90T98	Other social and personal services	D90T96, D97T98
14	D05T39	Industry (Mining, Manufactures and Utilities)	D05T06, D07T08, D09, D10T12, D13T15, D16, D17T18, D19, D20T21, D22, D23, D24, D25, D26, D27, D28, D29, D30, D31T33, D35T39
15	D45T98	Total Services	D45T47, D49T53, D55T56, D58T60, D61, D62T63, D64T66,D68, D69T82, D84, D85, D86T88, D90T96, D97T98
16	D58T82	Information, Finance, Real Estate and other business services	D58T60, D61, D62T63, D64T66, D68, D69T82
17	D41T98	Total Services (incl. construction)	D41T43, D45T47, D49T53, D55T56, D58T60, D61, D62T63,D64T66, D68, D69T82, D84, D85, D86T88, D90T96, D97T98
18	DINFO	Information industries	D26, D58T60, D61, D62T63
19	DTOTAL	TOTAL	All industries

Annex C. Indicators available online

Core indicators
FD_CO2: CO2 emissions embodied in domestic final demand, by source country and industry
PROD_CO2: CO2 emissions based on domestic production
EXGR_TCO2: Total CO2 emissions embodied in gross exports
IMGR_TCO2: Total CO2 emissions embodied in gross imports
FD_PCCO2: CO2 emissions embodied in domestic final demand per capita
PROD_PCCO2: CO2 emissions per capita based on domestic production
EXGR_TCO2int: Intensity of CO2 emissions embodied in total gross exports
IMGR_TCO2int: Intensity of CO2 emissions embodied in gross imports

Additional indicators
BALCO2_FD: CO2 embodied in final demand, balance
FFD_DCO2: Domestic CO2 emissions embodied in foreign final demand
DFD_FCO2: Foreign CO2 emissions embodied in domestic final demand
FD_CO2_SH: CO2 emissions embodied in domestic final demand, shares by country and industry of origin (emitter)
FFD_DCO2pSH: Domestic CO2 emissions embodied in foreign final demand, partner shares
DFD_FCO2pSH: Foreign CO2 emissions embodied in domestic final demand, partner shares
EXGR_DCO2: Domestic CO2 emissions embodied in gross exports
EXGR_DCO2pSH: Domestic CO2 emissions embodied in gross exports, partner shares
EXGR_FCO2: Foreign CO2 emissions embodied in gross exports
EXGR_FCO2pSH: Foreign CO2 emissions embodied in gross exports, partner shares
EXGR_TCO2pSH: Total CO2 emissions embodied in gross exports, partner shares
EXGR_INTDCO2: Domestic CO2 emissions embodied in gross exports of intermediate products
EXGR_INTDCO2pSH: Domestic CO2 emissions embodied in gross exports of intermediate products, partner shares
EXGR_INTFCO2: Foreign CO2 emissions embodied in gross exports of intermediate products
EXGR_INTFCO2pSH: Foreign CO2 emissions embodied in gross exports of intermediate products, partner shares
EXGR_INTTCO2: Total CO2 emissions embodied in gross exports of intermediate products
EXGR_INTTCO2pSH: Total CO2 emissions embodied in gross exports of intermediate products, partner shares
EXGR_INTTCO2int: Intensity of CO2 emissions embodied in total gross exports of intermediate products
EXGR_FNLDCO2: Domestic CO2 emissions embodied in gross exports of final products
EXGR_FNLDCO2pSH: Domestic CO2 emissions embodied in gross exports of final products, partner shares
EXGR_FNLFCO2: Foreign CO2 emissions embodied in gross exports of final products
EXGR_FNLFCO2pSH: Foreign CO2 emissions embodied in gross exports of final products, partner shares
EXGR_FNLTCO2: Total CO2 emissions embodied in gross exports of final products
EXGR_FNLTCO2pSH: Total CO2 emissions embodied in gross exports of final products, partner shares
EXGR_FNLTCO2int: Intensity of CO2 emissions embodied in total gross exports of final products
IMGR_DCO2: Domestic CO2 emissions embodied in gross imports
IMGR_DCO2SH: Domestic CO2 emissions share of gross imports
IMGR_FCO2: Foreign CO2 emissions embodied in gross imports
BALCO2_GR: CO2 embodied in gross exports, balance

Note: Definitions of each indicators are available at metadata section of https://stats.oecd.org/Index.aspx?DataSetCode=IO_GHG_2019

Annex D. Production and consumption-based emissions of CO_2, total (million tonnes CO_2) and per capita (tonnes per capita), 2005 and 2015 (Figures 4-1 and 4-2)

Country or Region	Total Emissions (Million tonnes CO2)				Emissions per capita (Tonnes per capita)			
	Production		Consumption		Production		Consumption	
	2005	2015	2005	2015	2005	2005	2015	2015
OECD member	*13 424.7*	*12 204.2*	*15 563.1*	*13 781.2*	*11.2*	*9.5*	*13.0*	*10.8*
Australia	382.1	392.5	418.4	426.4	18.9	16.5	20.7	17.9
Austria	75.3	64.3	95.3	83.4	9.1	7.4	11.5	9.6
Belgium	118.9	101.3	131.7	117.8	11.3	9.0	12.5	10.4
Canada	555.4	556.4	539.8	547.9	17.2	15.5	16.7	15.2
Chile	61.3	86.7	61.1	89.2	3.8	4.9	3.8	5.0
Czech Republic	118.3	99.3	104.7	91.8	11.5	9.4	10.2	8.7
Denmark	85.7	64.9	78.7	59.4	15.8	11.4	14.5	10.4
Estonia	16.5	15.6	15.2	13.3	12.2	11.9	11.2	10.1
Finland	58.5	45.2	65.4	52.3	11.1	8.3	12.4	9.5
France	385.4	311.9	536.2	445.0	6.3	4.8	8.8	6.9
Germany	814.1	765.7	940.2	853.4	10.0	9.4	11.5	10.4
Greece	112.3	76.9	121.6	73.0	9.9	6.9	10.8	6.5
Hungary	62.3	50.9	68.1	48.3	6.2	5.2	6.8	4.9
Iceland	4.1	4.1	4.5	2.9	14.0	12.5	15.4	8.7
Ireland	60.9	52.8	63.3	46.7	14.5	11.2	15.0	9.9
Israel	67.7	71.0	83.8	88.3	10.2	8.8	12.7	10.9
Italy	466.7	346.8	584.5	423.0	7.9	5.8	9.9	7.1
Japan	1 220.8	1 202.3	1 502.0	1 361.0	9.5	9.4	11.7	10.6
Korea	509.6	632.5	546.9	584.8	10.5	12.5	11.2	11.6
Latvia	7.8	7.1	10.9	9.2	3.5	3.6	4.9	4.6
Lithuania	12.6	10.3	16.8	14.2	3.8	3.5	5.0	4.8
Luxembourg	12.4	9.6	11.7	9.1	27.1	16.9	25.6	16.1
Mexico	423.6	453.0	449.4	485.5	3.9	3.6	4.1	3.9
Netherlands	195.6	181.7	200.8	179.2	12.0	10.7	12.3	10.6
New Zealand	35.9	33.9	45.5	42.8	8.7	7.4	11.0	9.3
Norway	50.3	52.0	56.6	59.6	10.9	10.0	12.2	11.5
Poland	298.7	283.7	276.6	273.8	7.8	7.4	7.2	7.2
Portugal	64.6	50.1	77.9	51.7	6.1	4.8	7.4	5.0
Slovak Republic	36.7	29.2	33.1	30.6	6.8	5.4	6.1	5.6
Slovenia	15.7	12.9	17.7	14.0	7.8	6.2	8.9	6.7
Spain	354.0	263.3	411.7	293.8	8.0	5.7	9.3	6.3
Sweden	57.8	43.8	82.7	70.2	6.4	4.5	9.1	7.2
Switzerland	53.7	44.9	92.4	94.2	7.2	5.4	12.5	11.3
Turkey	227.1	336.9	281.6	374.9	3.3	4.3	4.1	4.8
United Kingdom	569.1	430.8	737.4	575.8	9.4	6.6	12.2	8.8
United States	5 833.6	5 020.0	6 798.8	5 794.5	19.8	15.7	23.0	18.1

Continue ...

Table continued

Country or Region	Total Emissions (Million tonnes CO2)				Emissions per capita (Tonnes per capita)			
	Production		Consumption		Production		Consumption	
	2005	2015	2005	2015	2005	2005	2015	2015
Non-OECD	*13 644.9*	*20 071.8*	*11 506.5*	*18 494.8*	*2.6*	*3.3*	*2.2*	*3.0*
Argentina	152.3	195.0	141.2	216.0	3.9	4.5	3.6	5.0
Brazil	321.1	461.2	312.8	475.4	1.7	2.2	1.7	2.3
Brunei Darussalam	5.2	6.7	4.1	6.4	14.1	16.1	11.2	15.3
Bulgaria	47.1	43.6	39.3	34.8	6.1	6.1	5.1	4.8
Cambodia	3.0	8.8	6.2	12.6	0.2	0.6	0.5	0.8
China	5 478.1	9 280.8	4 261.0	7 977.9	4.1	6.6	3.2	5.7
Colombia	56.5	82.8	63.6	97.4	1.3	1.7	1.5	2.0
Costa Rica	6.2	8.0	9.0	13.5	1.5	1.7	2.1	2.8
Croatia	19.3	15.3	24.4	17.1	4.4	3.6	5.6	4.0
Cyprus	10.4	7.3	10.9	7.9	10.1	6.3	10.6	6.8
Hong Kong, China	59.4	70.4	71.8	104.3	8.7	9.7	10.5	14.4
India	1 081.1	2 043.4	1 021.7	1 918.8	0.9	1.6	0.9	1.5
Indonesia	343.7	479.4	304.4	484.6	1.5	1.9	1.3	1.9
Kazakhstan	157.9	226.5	101.2	180.2	10.2	12.8	6.5	10.2
Malaysia	170.1	238.4	123.6	209.5	6.6	7.8	4.8	6.8
Malta	3.6	3.1	3.0	2.6	8.8	7.3	7.3	6.1
Morocco	42.6	59.2	46.5	66.6	1.4	1.7	1.5	1.9
Peru	28.7	49.2	31.3	63.6	1.0	1.6	1.1	2.0
Philippines	76.6	110.8	79.3	135.2	0.9	1.1	0.9	1.3
Romania	93.2	71.0	87.7	72.5	4.3	3.6	4.1	3.6
Russian Federation	1 495.8	1 487.6	1 099.2	1 167.5	10.4	10.3	7.7	8.1
Saudi Arabia	303.4	541.4	279.2	595.1	12.7	17.2	11.7	18.9
Singapore	73.4	122.4	51.0	70.5	16.4	22.1	11.3	12.7
South Africa	375.6	414.5	300.6	313.5	7.7	7.5	6.2	5.7
Chinese Taipei	269.4	268.2	235.1	210.9	11.9	11.4	10.4	9.0
Thailand	213.5	267.7	196.8	235.4	3.3	3.9	3.0	3.4
Tunisia	21.5	27.5	21.6	29.1	2.1	2.4	2.1	2.6
Viet Nam	82.1	173.3	78.2	152.5	1.0	1.9	0.9	1.6
Rest of the World	2 654.0	3 308.3	2 502.0	3 623.5	1.5	1.6	1.4	1.7

Source: OECD's Carbon dioxide (CO_2) emissions embodied in international trade (TECO2) database (http://oe.cd/io-co2), 2019.

Annex E. Share of CO_2 emitted abroad in total CO2 embodied in domestic final demand, 2005 and 2015 (Figure 4-3)

Country or Region	Year		Country or Region	Year		Country or Region	Year	
	2005	2015		2005	2015		2005	2015
OECD	*17.4%*	*18.1%*	Mexico	22.7%	26.9%	Croatia	38.5%	32.4%
Australia	25.4%	29.9%	Netherlands	36.2%	35.1%	Cyprus	37.6%	42.6%
Austria	46.9%	52.6%	New Zealand	42.8%	44.3%	Hong Kong, China	61.2%	64.7%
Belgium	43.5%	46.4%	Norway	57.6%	56.6%	India	13.8%	13.1%
Canada	31.3%	29.8%	Poland	18.7%	22.8%	Indonesia	20.4%	20.6%
Chile	39.4%	36.0%	Portugal	33.4%	33.8%	Kazakhstan	17.9%	15.2%
Czech Republic	26.3%	31.8%	Slovak Republic	43.5%	54.3%	Malaysia	31.3%	28.3%
Denmark	43.6%	52.0%	Slovenia	39.9%	39.0%	Malta	39.9%	44.3%
Estonia	27.7%	28.6%	Spain	34.1%	33.1%	Morocco	26.2%	26.5%
Finland	44.3%	42.6%	Sweden	55.4%	58.7%	Peru	32.4%	36.6%
France	43.9%	45.6%	Switzerland	57.2%	64.7%	Philippines	24.7%	32.7%
Germany	31.7%	32.8%	Turkey	34.5%	30.1%	Romania	23.1%	28.2%
Greece	30.5%	27.4%	United Kingdom	37.0%	40.1%	Russian Federation	8.0%	9.0%
Hungary	32.9%	35.1%	United States	19.9%	20.6%	Saudi Arabia	17.3%	21.1%
Iceland	65.0%	59.8%	*Non-OECD*	*4.9%*	*4.9%*	Singapore	60.6%	60.9%
Ireland	38.1%	43.6%	Argentina	16.7%	18.3%	South Africa	12.8%	13.7%
Israel	33.8%	34.3%	Brazil	20.4%	21.7%	Chinese Taipei	37.3%	35.3%
Italy	35.0%	34.9%	Brunei Darussalam	29.2%	29.2%	Thailand	34.3%	34.1%
Japan	29.8%	26.0%	Bulgaria	21.8%	26.5%	Tunisia	27.3%	24.4%
Korea	32.9%	29.7%	Cambodia	59.9%	44.8%	Viet Nam	37.5%	38.4%
Latvia	50.8%	48.9%	China, PR	6.6%	7.9%	Rest of the World	21.5%	24.6%
Lithuania	47.8%	54.7%	Colombia	29.6%	34.0%			
Luxembourg	33.7%	36.0%	Costa Rica	49.8%	52.1%			

Source: OECD's Carbon dioxide (CO_2) emissions embodied in international trade (TECO2) database (http://oe.cd/io-co2), 2019.

Annex F. CO_2 embodied in gross exports and imports, from domestic and foreign sources (Million Tonnes CO_2), 2005 and 2015 (Figure 4-4)

Country or region	2015		2015		2005	2015
	Domestic CO2 emissions embodied in gross exports	Foreign CO2 emissions embodied in gross exports	Domestic CO2 emissions embodied in gross imports	Foreign CO2 emissions embodied in gross imports	CO2 embodied in gross exports, balance	CO2 embodied in gross exports, balance
OECD	1 022.9	250.9	123.5	2 731.3	-2 134.6	-1 581.1
NONOECD	2 731.3	123.5	250.9	1 022.9	2 134.6	1 581.1
EU28	528.3	193.8	23.6	1 200.3	-669.3	-501.8
ASEAN	431.4	185.0	7.5	511.6	121.8	97.4
AUS	94.1	16.3	0.9	142.9	-36.1	-33.3
AUT	24.4	22.4	0.3	66.0	-20.0	-19.5
BEL	38.2	32.4	0.3	86.2	-12.4	-15.9
CAN	174.3	44.5	3.0	205.9	16.3	9.8
CHL	29.6	5.9	0.1	37.9	0.1	-2.5
CZE	36.7	25.3	0.4	54.4	13.3	7.3
DNK	36.5	20.6	0.2	51.2	7.1	5.6
EST	6.1	2.6	0.0	6.4	1.3	2.3
FIN	15.3	9.8	0.1	31.9	-6.9	-7.0
FRA	71.0	58.7	1.6	259.7	-149.4	-131.6
DEU	199.9	122.6	7.9	399.1	-122.8	-84.6
GRC	23.5	7.7	0.0	27.5	-9.9	3.6
HUN	19.5	17.8	0.1	34.6	-6.0	2.5
ISL	3.0	0.9	0.0	2.5	-0.4	1.3
IRL	26.4	20.3	0.1	40.4	-2.0	6.2
ISR	12.9	7.8	0.0	37.8	-16.0	-17.1
ITA	72.2	62.1	0.9	209.3	-117.2	-75.8
JPN	198.7	64.0	3.7	417.4	-279.4	-158.2
KOR	223.5	124.4	2.5	297.2	-36.8	48.2
LVA	2.4	1.6	0.0	6.1	-3.1	-2.1
LTU	3.8	4.7	0.0	12.5	-4.3	-3.9
LUX	2.5	8.1	0.0	11.3	-0.3	-0.8
MEX	98.4	77.1	1.1	207.0	-26.3	-32.6
NLD	65.5	30.4	0.6	92.8	-4.9	2.6
NZL	9.7	3.4	0.0	22.3	-9.9	-9.2
NOR	26.2	7.7	0.2	41.0	-6.1	-7.3
POL	72.4	28.8	0.7	91.0	22.1	9.6
PRT	15.4	9.0	0.1	26.3	-13.5	-1.9
SVK	15.2	15.5	0.2	32.1	3.6	-1.5
SVN	4.4	4.4	0.0	9.8	-2.1	-1.1

Continue ...

Table continued

Country or region	2015		2015		2005	2015
	Domestic CO2 emissions embodied in gross exports	Foreign CO2 emissions embodied in gross exports	Domestic CO2 emissions embodied in gross imports	Foreign CO2 emissions embodied in gross imports	CO2 embodied in gross exports, balance	CO2 embodied in gross exports, balance
ESP	65.4	35.6	0.8	132.3	-59.5	-32.1
SWE	14.6	15.7	0.2	56.4	-24.8	-26.2
CHE	11.4	32.1	0.1	92.2	-38.5	-48.8
TUR	74.3	27.3	0.5	140.0	-55.0	-38.9
GBR	87.3	41.6	1.7	269.7	-165.3	-142.5
USA	438.5	120.0	32.9	1 310.9	-969.6	-785.3
ARG	18.4	2.8	0.0	42.2	11.0	-20.9
BRA	89.4	14.5	0.5	116.7	8.8	-13.3
BRN	2.2	0.3	0.0	2.1	1.1	0.3
BGR	17.9	6.5	0.0	15.7	7.7	8.7
KHM	1.8	1.6	0.0	7.3	-3.1	-3.8
CHN	2 014.3	175.9	79.2	802.3	1 217.5	1 308.8
COL	18.3	3.2	0.1	36.0	-7.3	-14.6
CRI	1.5	1.6	0.0	8.6	-2.8	-5.5
HRV	3.6	1.8	0.0	7.3	-5.6	-1.9
CYP	2.8	1.7	0.0	5.0	-0.5	-0.6
HKG	33.7	23.9	0.1	91.0	-12.0	-33.6
IND	377.5	54.0	2.8	304.6	59.3	124.2
IDN	95.3	16.2	0.9	116.0	39.3	-5.3
KAZ	73.7	3.0	0.2	30.3	56.8	46.3
MYS	88.1	53.0	0.7	111.9	45.7	28.6
MLT	1.7	1.1	0.0	2.2	0.6	0.5
MAR	10.3	4.4	0.0	22.0	-3.9	-7.3
PER	8.7	2.6	0.0	25.9	-2.6	-14.6
PHL	19.6	10.7	0.1	54.3	-2.6	-24.1
ROU	19.0	6.9	0.1	27.3	5.5	-1.5
RUS	427.0	22.5	3.0	125.7	396.9	320.7
SAU	70.7	6.0	0.4	131.4	20.6	-55.0
SGP	95.3	57.7	0.6	99.9	22.9	52.5
ZAF	143.8	12.4	0.3	55.3	74.5	100.6
TWN	131.9	63.1	0.8	137.0	34.5	57.2
THA	108.8	64.9	0.5	144.9	14.6	28.4
TUN	5.4	2.5	0.0	9.5	-0.0	-1.6
VNM	79.5	51.8	0.3	110.3	4.0	20.8
ROW	594.6	107.9	22.6	992.7	153.8	-312.8

Source: OECD's Carbon dioxide (CO_2) emissions embodied in international trade (TECO2) database (http://oe.cd/io-co2), 2019.

Annex G. Relative intensity of CO_2 emissions in gross exports and imports (simple world average = 1.00), 2005, 2010 and 2015 (Figures 4-5 and 4-6)

Country or Region	Exports			Imports		
	2005	2010	2015	2005	2010	2015
WORLD	1.00	1.00	1.00	1.00	1.00	1.00
OECD	0.64	0.74	0.72	1.86	1.61	1.57
NONOECD	1.80	1.69	1.63	0.66	0.70	0.70
EU28	0.52	0.59	0.55	1.15	1.12	1.09
ASEAN	1.29	1.23	1.30	1.15	1.18	1.23
AUS	0.84	0.83	0.99	1.12	1.16	1.13
AUT	0.47	0.60	0.57	0.77	0.86	0.85
BEL	0.52	0.59	0.58	0.68	0.69	0.70
CAN	0.83	0.99	1.03	0.87	0.91	0.84
CHL	0.88	0.88	1.07	1.16	1.14	1.09
CZE	1.10	1.01	1.01	0.93	0.96	0.95
DNK	0.78	0.92	0.89	0.81	0.87	0.90
EST	1.40	1.65	1.28	1.10	0.99	0.97
FIN	0.68	0.85	0.69	0.92	0.89	0.82
FRA	0.40	0.45	0.42	0.79	0.81	0.78
DEU	0.46	0.56	0.54	0.80	0.85	0.82
GRC	0.99	0.93	1.26	0.90	0.89	1.00
HUN	0.74	0.85	0.82	0.85	0.88	0.82
ISL	0.95	1.06	0.98	0.78	0.86	0.76
IRL	0.37	0.38	0.33	0.48	0.45	0.37
ISR	0.61	0.60	0.53	1.09	1.07	1.05
ITA	0.47	0.57	0.55	0.85	0.86	0.91
JPN	0.51	0.60	0.76	1.28	1.19	1.14
KOR	1.04	1.32	1.20	1.31	1.20	1.17
LVA	0.91	0.95	0.77	1.24	1.32	1.14
LTU	0.95	0.88	0.83	1.29	1.13	1.15
LUX	0.23	0.24	0.19	0.31	0.27	0.24
MEX	0.80	1.04	0.96	0.93	1.07	1.02
NLD	0.51	0.54	0.58	0.66	0.63	0.62
NZL	0.58	0.64	0.61	1.02	1.02	1.04
NOR	0.40	0.45	0.53	0.79	0.79	0.74
POL	1.33	1.05	1.05	1.01	0.95	0.98
PRT	0.55	0.57	0.71	0.70	0.68	0.74
SVK	1.23	1.07	0.96	1.06	1.07	1.01
SVN	0.72	0.77	0.73	0.91	0.91	0.93
ESP	0.60	0.57	0.59	0.77	0.79	0.80
SWE	0.37	0.41	0.35	0.72	0.76	0.72
CHE	0.28	0.31	0.26	0.67	0.70	0.67

Continue …

Table continued

Country or Region	Exports			Imports		
	2005	2010	2015	2005	2010	2015
TUR	0.86	1.05	1.12	1.39	1.34	1.33
GBR	0.39	0.47	0.40	0.73	0.76	0.75
USA	0.60	0.70	0.58	1.10	1.11	1.08
ARG	1.19	0.86	0.66	1.15	1.11	1.15
BRA	0.87	0.62	0.97	0.99	1.07	0.95
BRN	0.61	0.91	0.82	1.07	1.08	1.21
BGR	2.28	1.88	1.81	1.02	1.04	1.10
KHM	0.70	0.90	0.96	1.72	1.76	1.71
CHN	3.22	2.82	2.10	1.04	0.95	0.95
COL	0.80	0.65	1.06	1.12	1.11	1.11
CRI	0.53	0.54	0.41	1.01	1.06	1.09
HRV	0.61	0.66	0.65	0.95	1.01	0.88
CYP	0.82	0.89	0.96	0.87	0.92	1.04
HKG	0.91	1.13	0.98	1.32	1.30	1.37
IND	1.97	2.19	2.24	1.30	1.35	1.32
IDN	1.63	1.11	1.32	1.26	1.27	1.35
KAZ	3.94	3.36	3.35	1.57	1.33	1.49
MYS	1.28	1.32	1.45	1.14	1.17	1.29
MLT	0.62	0.50	0.44	0.48	0.38	0.37
MAR	0.82	0.93	1.00	0.95	0.94	1.01
PER	0.68	0.67	0.62	1.12	1.21	1.18
PHL	1.03	0.83	0.78	0.99	1.05	1.14
ROU	1.59	0.98	0.90	1.00	0.93	0.89
RUS	2.84	2.40	2.55	1.01	1.02	0.96
SAU	0.56	0.52	0.77	1.00	1.05	1.10
SGP	0.92	1.11	1.07	0.98	0.91	0.91
ZAF	2.52	2.93	3.65	0.98	1.06	1.17
TWN	1.25	1.40	1.29	1.15	1.11	1.14
THA	1.43	1.32	1.41	1.29	1.28	1.37
TUN	0.84	1.08	1.09	0.88	0.94	1.00
VNM	1.87	2.02	1.83	1.69	1.58	1.50
ROW	1.30	1.12	1.12	1.15	1.19	1.18

Source: OECD's Carbon dioxide (CO_2) emissions embodied in international trade (TECO2) database (http://oe.cd/io-co2), 2019.

Annex H. Total CO_2 emissions embodied in gross exports, ICIO industries, Millions Tonnes CO_2 and Shares, 2005 and 2015 (Figure 4-7)

Industry	Million Tonnes CO_2		Shares (%)	
	2005	2015	2005	2015
D01T03	114	138	1.5	1.6
D05T06	621	533	7.9	6.1
D07T08	95	120	1.2	1.4
D09	2	3	0.0	0.0
D10T12	196	239	2.5	2.7
D13T15	364	326	4.7	3.7
D16	63	53	0.8	0.6
D17T18	94	97	1.2	1.1
D19	370	395	4.7	4.5
D20T21	562	667	7.2	7.6
D22	232	269	3.0	3.1
D23	205	266	2.6	3.0
D24	1 081	1 139	13.8	13.0
D25	206	277	2.6	3.2
D26	600	610	7.7	7.0
D27	283	405	3.6	4.6
D28	383	494	4.9	5.6
D29	335	390	4.3	4.4
D30	125	178	1.6	2.0
D31T33	305	372	3.9	4.2
D35T39	147	133	1.9	1.5
D41T43	5	5	0.1	0.1
D45T47	280	297	3.6	3.4
D49T53	862	972	11.0	11.1
D55T56	61	73	0.8	0.8
D58T60	18	14	0.2	0.2
D61	20	22	0.3	0.3
D62T63	25	51	0.3	0.6
D64T66	40	50	0.5	0.6
D68	8	9	0.1	0.1
D69T82	107	143	1.4	1.6
D84	1	2	0.0	0.0
D85	5	8	0.1	0.1
D86T88	2	3	0.0	0.0
D90T96	14	16	0.2	0.2
D97T98	0	0	0.0	0.0
DTOTAL	7 828	8 772	100.0	100.0

Source: OECD's Carbon dioxide (CO_2) emissions embodied in international trade (TECO2) database (http://oe.cd/io-co2), 2019.

Annex I. Total CO_2 emissions in exports, by exporting country and main exporting industries, million tonnes CO_2, 2015 (Figure 4-8)

Country or region	CO_2 Emissions embodied in exports, exporting industry, million tonnes CO_2						
	D05T06	D13T15	D19T23	D24T25	D26T27	D28	D29
OECD	18.8	13.6	213.6	228.0	118.7	86.8	60.3
NONOECD	229.8	197.5	488.8	404.7	460.9	157.6	72.4
AUS	21.7	0.3	5.7	25.3	0.9	0.7	0.7
AUT	0.6	0.4	6.5	13.7	2.6	4.2	2.6
BEL	0.7	0.7	20.7	10.9	0.8	1.3	2.8
CAN	53.2	0.4	36.3	32.3	2.1	3.9	13.7
CHL	0.1	0.1	2.4	1.2	0.1	0.2	0.2
CZE	0.6	0.6	8.6	8.4	7.0	3.9	10.7
DNK	0.8	0.1	2.9	0.9	0.7	2.1	0.1
EST	0.1	0.2	0.7	0.6	1.0	0.2	0.1
FIN	0.0	0.1	4.0	5.1	1.7	2.4	0.2
FRA	2.5	1.4	23.3	20.8	6.7	6.3	7.0
DEU	0.9	2.2	67.2	61.3	21.1	32.4	38.1
GRC	0.0	0.3	8.3	2.4	0.3	0.2	0.0
HUN	0.1	0.2	6.1	3.0	4.2	1.5	5.9
ISL	0.0	0.0	0.0	0.6	0.0	0.0	0.0
IRL	0.0	0.1	10.2	1.5	2.3	0.6	0.0
ISR	0.0	0.2	5.6	1.0	1.4	0.7	0.1
ITA	0.4	7.0	26.4	22.2	7.4	21.1	6.8
JPN	0.0	0.9	45.7	56.5	31.5	28.2	32.2
KOR	0.0	4.9	62.5	74.8	66.9	22.2	30.2
LVA	0.0	0.0	0.3	0.2	0.1	0.1	0.0
LTU	0.0	0.1	4.0	0.2	0.1	0.1	0.0
LUX	0.0	0.1	0.5	0.8	0.0	0.2	0.0
MEX	16.6	1.6	19.0	14.0	34.9	6.5	40.6
NLD	3.2	0.3	23.3	7.6	4.1	3.0	0.9
NZL	0.2	0.1	0.9	1.1	0.1	0.2	0.0
NOR	10.2	0.0	2.3	2.8	0.5	0.6	0.1
POL	0.7	1.1	20.1	15.4	8.2	4.0	6.2
PRT	0.2	1.4	6.6	2.2	1.0	0.6	1.5
SVK	0.1	0.3	5.1	10.0	3.3	1.4	5.4
SVN	0.0	0.1	1.4	1.7	0.7	0.4	0.6
ESP	2.1	2.2	26.4	11.7	4.0	3.6	10.2
SWE	0.0	0.1	5.0	5.7	1.5	2.6	2.2
CHE	0.0	0.3	10.0	2.0	8.0	4.1	0.2
TUR	0.9	7.5	12.6	28.8	6.1	3.5	9.3
GBR	9.4	1.3	20.3	19.3	4.7	6.4	8.5
USA	10.7	2.8	122.7	56.7	16.3	28.4	33.6

Continue …

Table continued

Country or region	CO_2 Emissions embodied in exports, exporting industry, million tonnes CO_2						
	D05T06	D13T15	D19T23	D24T25	D26T27	D28	D29
ARG	0.5	0.2	2.5	2.1	0.1	0.2	1.9
BRA	5.3	0.7	9.7	31.1	1.3	2.0	4.3
BRN	1.8	0.0	0.0	0.0	0.0	0.0	0.0
BGR	0.0	0.7	4.8	4.1	0.8	0.7	0.2
KHM	0.0	0.5	0.2	0.2	0.2	0.1	0.0
CHN	3.1	182.7	378.0	404.1	567.4	211.9	53.9
COL	9.8	0.3	5.0	3.1	0.3	0.1	0.1
CRI	0.0	0.0	0.3	0.3	0.1	0.0	0.0
HRV	0.0	0.1	1.1	0.2	0.1	0.1	0.0
CYP	0.0	0.0	0.3	0.0	0.0	0.0	0.0
HKG	0.0	1.2	2.0	1.4	4.3	3.2	0.0
IND	0.1	25.5	77.8	102.6	16.7	22.7	14.1
IDN	19.1	9.5	20.1	9.9	4.5	3.9	1.1
KAZ	47.3	0.0	4.4	13.3	0.2	0.1	0.1
MYS	11.8	1.2	30.9	11.5	34.0	4.6	1.2
MLT	0.0	0.0	0.1	0.0	0.3	0.0	0.0
MAR	0.0	0.7	2.3	0.4	1.2	0.0	0.4
PER	0.5	0.3	2.0	1.6	0.0	0.1	0.0
PHL	0.5	0.3	1.5	1.7	6.9	0.6	1.0
ROU	0.0	0.6	3.7	3.4	2.2	1.5	1.9
RUS	89.4	0.3	116.9	98.0	4.3	3.3	2.6
SAU	10.0	0.2	43.5	2.4	0.5	0.2	0.0
SGP	0.0	0.1	36.4	1.8	18.3	4.6	0.4
ZAF	5.5	0.8	12.9	68.2	2.6	5.6	8.5
TWN	0.0	7.2	38.5	44.3	48.4	14.7	4.8
THA	0.1	3.5	38.2	14.1	22.5	6.9	12.9
TUN	0.3	0.5	2.1	0.3	1.2	0.2	0.3
VNM	4.5	27.0	21.9	9.4	10.0	2.6	2.8
ROW	187.9	22.4	117.3	63.7	13.3	6.6	6.6
WLD	533.3	326.1	1 597.9	1 416.3	1 014.4	494.4	389.9

Source: OECD's Carbon dioxide (CO_2) emissions embodied in international trade (TECO2) database (http://oe.cd/io-co2), 2019.

Annex J. Total CO_2 emissions in imports, by importing country and main exporting industries, million tonnes CO_2, 2015 (Figure 4-8)

Country or region	CO_2 Emissions embodied in imports, exporting industry, million tonnes CO_2						
	D05T06	D13T15	D19T23	D24T25	D26T27	D28	D29
OECD	229.8	197.5	488.8	404.7	460.9	157.6	72.4
NONOECD	18.8	13.6	213.6	228.0	118.7	86.8	60.3
AUS	3.2	6.8	32.5	17.6	16.8	9.6	9.9
AUT	6.7	1.9	9.2	11.4	4.7	3.6	2.5
BEL	4.3	1.8	18.1	9.7	3.7	3.0	5.2
CAN	10.4	7.4	35.5	32.6	22.5	11.8	18.6
CHL	1.9	2.8	8.9	5.1	4.7	2.6	2.3
CZE	3.6	1.6	9.4	9.9	7.5	2.8	4.2
DNK	0.6	0.7	6.9	3.2	1.9	1.6	1.0
EST	0.1	0.2	1.4	0.8	0.7	0.3	0.2
FIN	2.5	0.9	6.3	4.4	3.2	1.6	1.0
FRA	19.6	9.6	49.9	25.8	25.5	12.2	11.4
DEU	28.8	13.4	81.1	57.9	42.4	19.6	21.7
GRC	5.1	0.7	5.1	3.0	1.1	1.1	0.4
HUN	2.7	0.4	6.7	5.4	5.6	2.6	2.1
ISL	0.1	0.0	0.6	0.2	0.2	0.1	0.1
IRL	1.1	0.8	5.2	1.9	2.2	1.4	1.1
ISR	2.4	1.0	5.4	3.4	2.9	1.4	1.2
ITA	30.9	9.1	34.1	44.4	14.5	9.6	8.5
JPN	46.9	23.6	62.6	50.3	53.9	23.4	9.3
KOR	29.1	10.8	58.1	63.4	39.9	14.3	5.5
LVA	0.2	0.2	1.4	0.9	0.3	0.2	0.1
LTU	2.5	0.2	2.8	0.7	0.4	0.3	0.2
LUX	0.5	0.1	0.7	0.1	0.2	0.2	0.1
MEX	0.5	4.8	41.7	30.9	48.6	18.1	15.6
NLD	11.6	1.6	16.1	7.2	6.8	3.3	2.9
NZL	0.9	0.9	4.6	2.3	2.7	1.2	1.2
NOR	0.8	1.4	4.9	4.1	3.6	2.1	1.3
POL	6.1	3.2	16.5	15.4	10.8	5.5	3.9
PRT	4.3	1.2	5.1	3.8	1.6	0.9	1.4
SVK	2.8	1.0	5.1	4.9	4.5	1.8	2.9
SVN	0.2	0.4	2.2	2.6	0.8	0.3	0.5
ESP	15.3	8.3	26.8	18.5	11.3	6.8	8.3
SWE	3.0	1.5	9.4	6.9	5.1	3.1	2.6
CHE	3.5	3.5	16.5	9.0	11.5	4.6	2.6
TUR	3.2	6.0	29.7	43.1	12.0	9.4	5.6
GBR	9.4	16.6	52.0	24.9	27.4	11.3	15.3
USA	82.0	78.7	226.1	173.4	193.5	76.9	111.8

Continue …

Table continued

Country or region	CO_2 Emissions embodied in imports, exporting industry, million tonnes CO_2						
	D05T06	D13T15	D19T23	D24T25	D26T27	D28	D29
ARG	1.5	0.8	8.1	4.4	5.0	3.2	3.1
BRA	5.2	4.0	32.0	13.1	13.4	7.3	4.7
BRN	0.0	0.0	0.4	0.4	0.1	0.1	0.1
BGR	1.9	0.1	3.7	2.8	0.8	0.8	0.4
KHM	0.0	1.2	1.2	0.9	0.2	0.4	0.1
CHN	72.0	14.6	139.4	143.8	132.2	40.8	20.4
COL	0.2	1.6	10.7	5.3	4.5	2.7	1.8
CRI	0.0	0.2	2.9	1.2	0.8	0.4	0.4
HRV	0.6	0.3	1.5	1.0	0.4	0.3	0.2
CYP	0.0	0.1	0.9	0.2	0.1	0.1	0.1
HKG	1.6	5.4	6.1	35.2	1.5	0.3	1.0
IND	34.5	4.9	58.4	94.0	21.9	11.2	2.7
IDN	3.0	3.5	29.3	24.6	10.7	10.9	2.4
KAZ	0.3	0.5	6.6	6.8	2.5	2.8	1.3
MYS	2.1	1.9	22.5	26.9	18.4	6.6	2.3
MLT	0.0	0.0	0.3	0.2	0.1	0.1	0.0
MAR	0.9	0.8	6.1	2.8	1.7	0.9	0.8
PER	0.4	1.2	6.0	4.2	2.9	1.9	1.9
PHL	1.6	1.0	11.7	8.5	8.7	3.3	2.1
ROU	2.9	0.8	6.4	3.8	2.1	2.0	1.2
RUS	4.7	6.5	21.9	17.1	15.1	11.2	5.4
SAU	0.1	3.8	18.0	30.3	11.3	10.4	9.0
SGP	7.8	0.7	21.7	8.1	0.8	2.8	1.0
ZAF	3.3	2.1	12.0	6.7	7.1	4.3	3.0
TWN	16.7	1.9	26.9	27.6	21.0	7.8	2.2
THA	8.9	2.0	21.4	39.7	20.3	9.3	3.6
TUN	0.2	0.4	2.6	1.4	1.0	0.5	0.4
VNM	0.3	7.3	19.4	32.0	14.9	9.8	1.2
ROW	15.9	35.1	201.7	173.7	100.3	73.9	34.2
WLD	533.3	325.9	1 597.9	1 416.3	1 014.4	494.4	389.9

Source: OECD's Carbon dioxide (CO_2) emissions embodied in international trade (TECO2) database (http://oe.cd/io-co2), 2019.