

## OECD Science, Technology and Industry Working Papers

OECD Working Papers should not be reported as representing the official views of the OECD or of its member countries. The opinions expressed and arguments employed are those of the authors.

Working Papers describe preliminary results or research in progress by the author(s) and are published to stimulate discussion on a broad range of issues on which the OECD works. Comments on Working Papers are welcomed, and may be sent to OECD Directorate for Science, Technology and Innovation, OECD, 2 rue André-Pascal, 75775 Paris Cedex 16, France; e-mail: [sti.contact@oecd.org](mailto:sti.contact@oecd.org).

This document, as well as any data and any map included herein, are without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

The statistical data for Israel are supplied by and under the responsibility of the relevant Israeli authorities. The use of such data by the OECD is without prejudice to the status of the Golan Heights, East Jerusalem and Israeli settlements in the West Bank under the terms of international law.

Note by Turkey:

The information in this document with reference to “Cyprus” relates to the southern part of the Island. There is no single authority representing both Turkish and Greek Cypriot people on the Island. Turkey recognises the Turkish Republic of Northern Cyprus (TRNC). Until a lasting and equitable solution is found within the context of the United Nations, Turkey shall preserve its position concerning the “Cyprus issue”.

Note by all the European Union Member States of the OECD and the European Union:

The Republic of Cyprus is recognised by all members of the United Nations with the exception of Turkey. The information in this document relates to the area under the effective control of the Government of the Republic of Cyprus.

© OECD 2020

---

The use of this work, whether digital or print, is governed by the Terms and Conditions to be found at <http://www.oecd.org/termsandconditions>.

---

## *CO<sub>2</sub> Emissions Embodied in International Trade and Domestic Final Demand*

*Methodology and results using the OECD Inter-Country Input-Output Database*

Norihiko YAMANO and Joaquim J. M. GUILHOTO<sup>1</sup>

*This paper describes the sources and methods used to estimate carbon emissions embodied in final demand and international gross trade for 65 economies over the period 2005-2015. Earlier OECD analyses of carbon footprints, accounting for global production networks, helped raise awareness of divergences between territorial and resident principles, and between production-based and consumption-based carbon emissions. Understanding the differences in these measures is important for governments to better understand and address greenhouse gas mitigation options. Thus, a new refined methodology was applied to allocate territorial emissions to production-based emissions (industries and households) using OECD Inter-Country Input-Output tables and International Energy Agency (IEA) CO<sub>2</sub> emissions from fuel combustion statistics. In particular, this methodology introduces: 1) explicit distinctions between territorial and resident principles, economic output and final demand-based emissions and emissions embodied in gross imports and exports; 2) estimates by major fuel combustion sources; and 3) fuel purchases by non-resident industries and households.*

**Keywords:** Inter-Country Input-Output; Consumption-based accounting, CO<sub>2</sub> emissions, International trade

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

# Table of contents

Executive Summary	6
1. Introduction	8
2. Methodology	10
3. Estimation of CO <sub>2</sub> emissions factors	16
4. CO <sub>2</sub> emissions embodied in production, consumption and trade	24
5. Final Comments	35
Endnotes	37
References	38
Data Links	40
Annex A. ICIO 2018 Geographical Coverage	41
Annex B. ICIO 2018 Industry Coverage	43
Annex C. Indicators available online	45
Annex D. Production and consumption-based emissions of CO <sub>2</sub> , total (million tonnes CO <sub>2</sub> ) and per capita (tonnes per capita), 2005 and 2015 (Figure 4.1 and Figure 4.2)	46
Annex E. Share of CO <sub>2</sub> emitted abroad in total CO <sub>2</sub> embodied in domestic final demand, 2005 and 2015 (Figure 4.3)	48
Annex F. CO <sub>2</sub> embodied in gross exports and imports, from domestic and foreign sources (Million Tonnes CO <sub>2</sub> ), 2005 and 2015 (Figure 4.4)	49
Annex G. Relative intensity of CO <sub>2</sub> emissions in gross exports and imports (simple world average = 1.00), 2005, 2010 and 2015 (Figure 4.5 and Figure 4.6)	51
Annex H. Total CO <sub>2</sub> emissions embodied in gross exports, ICIO industries, Millions Tonnes CO <sub>2</sub> and Shares, 2005 and 2015 (Figure 4.7)	53
Annex I. Total CO <sub>2</sub> emissions in exports, by exporting country and main exporting industries, million tonnes CO <sub>2</sub> , 2015 (Figure 4.8)	54

## Annex J. Total CO<sub>2</sub> emissions in imports, by importing country and main exporting industries, million tonnes CO<sub>2</sub>, 2015 (Figure 4.8) 56

### Tables

Table 1.1. International databases on greenhouse gas emissions and energy demand	9
Table 2.1. Basic matrices from OECD's ICIO	11
Table 2.2. CO <sub>2</sub> Emissions from fuel combustion	12
Table 3.1. Fuel products in IEA CO <sub>2</sub> from fuel combustion database	17
Table 3.2. Concordance between CO <sub>2</sub> flows (IEA) and OECD ICIO industry classification	19
Table 3.3. Examples of detailed level input-output table for fuel combustion by industries and households	20
Table A.1. ICIO 2018 Country List	41
Table A.2. ICIO 2018 Regions List	42
Table B.1. ICIO 2018 Industry List	43
Table B.2. ICIO 2018 Industry Aggregates List	44

### Figures

Figure 2.1. Emissions embodied in trade and final demand	13
Figure 3.1. Emissions from international bunkers (million tonnes)	21
Figure 3.2. Territorial-based and production-based emissions of aviation fuel	22
Figure 4.1. CO <sub>2</sub> emissions from fuel combustion (OECD and non-OECD countries)	25
Figure 4.2. Per capita CO <sub>2</sub> emissions from fuel combustion	26
Figure 4.3. Share of CO <sub>2</sub> emitted abroad in total CO <sub>2</sub> embodied in domestic final demand	27
Figure 4.4. CO <sub>2</sub> embodied in total exports and total imports, from domestic and foreign sources, selected economies for 2005 and 2015 (Millions Tonnes of CO <sub>2</sub> )	28
Figure 4.5. CO <sub>2</sub> intensity in exports relative to simple world average, selected economies for 2005, 2010 and 2015, (simple world average = 1.0)	29
Figure 4.6. CO <sub>2</sub> intensity in imports relative to simple world average, selected economies for 2005, 2010 and 2015, (simple world average = 1.0)	30
Figure 4.7. Total CO <sub>2</sub> emissions embodied in gross exports, ICIO industries, 2005 and 2015	32
Figure 4.8. Total CO <sub>2</sub> emissions in exports and imports, main industries and countries, 2015	33

## *Executive Summary*

Earlier OECD analyses of carbon footprints, accounting for global production networks, have contributed to increased awareness of divergences between territorial and resident principles and between production-based and consumption-based (or final demand-based) carbon emissions. Understanding these measures, and how they differ, is important for governments to better understand and address greenhouse gas mitigation options. This paper provides estimates of carbon emissions embodied in final demand and international gross trade for 65 economies over the period 2005 to 2015 using a revised methodology to allocate territorial emissions to economic output-based emissions (businesses and households) following the resident principle. Using OECD's Inter-Country Input-Output (ICIO) tables, and International Energy Agency (IEA) CO<sub>2</sub> emissions from fuel combustion statistics, new estimates, benefiting from an improved methodology, have been calculated for the emissions embodied in final demand and in international trade. In particular, the following methodological extensions have been introduced: 1) explicit distinctions between territorial and resident principles, economic output and final demand-based emissions as well as emissions embodied in gross imports and exports; 2) estimates by major fuel combustion sources; and, 3) fuel purchases by non-resident industries (road transportation; international aviation and marine bunkers) and households (motor vehicles fuels consumption abroad).

Using the results it is possible to develop a clear view of the role played by international trade in the allocation of emissions to consuming and producing countries. Overall, China is the main exporter of carbon emissions and the United States the main importer. Whether or not a country is a net exporter or a net importer and how trade in emissions is concentrated, depends on the kind of goods traded and the human, natural and technological resources available within countries.

With these indicators, it is possible, for example, to observe if countries are reducing their production and consumption of emissions and the degree to which they may be outsourcing production of emissions to more carbon-intensive industrial processes in other countries. The outsourcing of emissions is partly a consequence of emerging economies seeking to accelerate their development and participate in higher stages of production of intermediate goods, while firms in developed economies aim to reduce costs due to wages and regulations.

Overall, world CO<sub>2</sub> emissions from fuel combustion increased by about 19% between 2005 and 2015, from 27.1 to 32.3 Gigatonnes (Gt) of CO<sub>2</sub> i.e., an annual growth rate of 1.8%. During the same period, the world population increased by 12.8%, i.e. an annual growth rate of 1.2%. As a result, annual world average emissions per capita increased from 4.1 to 4.4 tonnes of CO<sub>2</sub>, an increase of about 5.6%, mainly due to increases in emissions and consumption in developing countries.

Of the CO<sub>2</sub> emitted in 2015, 8.8 Gt, representing about 27% of global CO<sub>2</sub> emissions from fuel combustion, is linked to international trade. Seven industrial sectors were responsible for about two-thirds of the CO<sub>2</sub> emissions embodied in exports in 2015. Namely: 1) *Chemicals and non-metallic mineral products* (ISIC Rev.4 Divisions 19 to 23), 18.2%; 2) *Basic metals and fabricated metal products* (24 and 25), 16.1%; 3) *Computers, electronic and electrical equipment* (26 and 27), 11.6%; 4) *Mining and extraction of energy producing products* (05 and 06), 6.1%; 5) *Machinery and equipment* (28), 5.6%; 6) *Motor vehicles, trailers and semi-trailers* (29), 4.4%; and 7) *Textiles, wearing apparel, leather and related products* (13 to 15), 3.7%.

For the OECD as a whole, from 2005 to 2015, total production-based CO<sub>2</sub> emissions fell by about 9%, from 13.4 to 12.2 Gt, while consumption-based emissions decreased by about 11%, from 15.6 to 13.8 Gt. Consumption-based emissions *per capita* fell by about 17%, from 13.0 to 10.8 tonnes of CO<sub>2</sub>. There was also a 26% reduction in net imports of CO<sub>2</sub> emissions from 2.1 to 1.6 Gt. Despite this encouraging trend, OECD consumption-based emissions *per capita* was, in 2015, around 2.5 times greater than average world emissions per capita and 3.6 times greater than that for non-OECD countries

The United States is the OECD's largest emitter of CO<sub>2</sub> from fuel combustion, accounting for about 41% of OECD emissions in 2015. It is also the largest consumer, with about 42% of OECD consumption-based emissions. Reflecting the size of their economies, Japan and Germany are the second and third largest emitters, with about 10% and 6% of OECD emissions in 2015, respectively. They also account for similar shares of OECD consumption-based emissions. In general, the OECD is a net importer of CO<sub>2</sub> emissions. However, one third of OECD countries are net exporters, the largest being Korea, Poland and Canada. While there was an overall decrease in production- and consumption-based emissions across OECD between 2005 and 2015, some countries increased both their production and consumption of emissions, notably Chile, Korea and Turkey.

Over the same period, there was a general increase in emissions by non-OECD economies. Production-based CO<sub>2</sub> emissions increased by about 47%, from 13.6 to 20.1 Gt, while consumption-based emissions increased by about 61%, from 11.5 to 18.5 Gt, resulting in a 41% increase in consumption-based emissions *per capita*, from 2.2 to 3.0 tonnes of CO<sub>2</sub>. These increases are in large part linked with the need of these countries to sustain their own development. A consequence is that many of these countries are important net exporters of CO<sub>2</sub> emissions as they develop a stronger manufacturing base to meet the consumption needs of more developed nations. Despite increasing industrialisation, emissions per capita in non-OECD economies are still low compared to OECD countries.

Among non-OECD economies, China is the largest emitter of CO<sub>2</sub> from fuel combustion, accounting for about 46% of non-OECD emissions in 2015. It is also the largest consumer, with about 43% of non-OECD consumption-based emissions. India and Russia are the second and third largest emitters, with about 10% and 7% of non-OECD emissions in 2015, respectively. India also accounted for 10% of non-OECD consumption-based emissions, while Russia accounted for 6%. Many non-OECD economies are net-exporters of CO<sub>2</sub> emissions, notably China, India, Malaysia, Russia, South Africa, Chinese Taipei and Thailand. Net-importers include Brazil, Indonesia, and Saudi Arabia. While there was an overall increase in production- and consumption-based emissions across non-OECD economies between 2005 and 2015, some among them, notably non-OECD EU countries, experienced reductions.

Although developed nations have reduced their emissions, and their reliance on fossil fuels, they still have relatively high emissions intensities. For developing nations, a major challenge is how to improve the well-being of their people, while reducing emissions. For an excellent discussion of this issue see OECD (2019b) which also proposes a range of actions that could be applied to reduce emissions and increase the well-being of the world population at the same time.

## 1. Introduction

Pioneering studies on consumption-based emissions used “harmonised” *national* input-output tables (e.g. Wyckoff and Roop, 1994 and Ahmad and Wyckoff, 2003). Building on such earlier work, more recent research using *global* input-output tables (OECD, 2013; Owen *et al.*, 2014; Moran and Wood, 2014; Wiebe and Yamano, 2016) has indicated that deviations between territorial greenhouse gas (GHG) emissions and emissions embodied in final demand (consumption-based emissions) have been widening. Reliable information for different types of emissions have been frequently sought after by environment economics and climate change policy discussions (e.g. Wiedmann, 2009).

Many research papers on measuring GHGs using “consumption-based accounting” approaches have been published recently with varying geographical coverage (Wilting, 2012; Arto *et al.*, 2014; Lenzen, 2016; Duarte *et al.*, 2018; Wieland *et al.*, 2018; Weber *et al.*, 2019). However, the definitions of production-based and consumption-based emissions differ slightly across studies<sup>2</sup>. In this paper, we explicitly define types of emissions according to three allocation methods (Barrett *et al.*, 2013):

1. Territorial-based emission accounting (e.g. UNFCCC\_GHG; IEA\_CO<sub>2</sub>)
  - Fuel purchased and combusted in domestic territory. Fuels combusted by non-residents’ motor vehicles are included. In general, international bunker fuels are estimated separately from domestic navigation and aviation emissions.
  - The industry dimension is defined by fuel users in the domestic territory.
2. Production-based emission accounting (e.g. SEEA-AEA; OECD)
  - Production-based emissions in this study are differentiated from territorial emissions by allocation to the country of residence of i) fuels combusted by non-resident households; ii) fuels combusted by non-resident land transportation services; and, iii) purchases of international bunker fuel by foreign-based aviation and marine operators. In principle, allocation of these types of emissions follows 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 consumers from economic resident industries and households.
3. Final demand-based emission accounting (demand-based emissions, hereafter)
  - The emissions emitted at all production stages are captured in emissions embodied in final demand, following the resident principle.
  - The type of household consumption and capital formation expenditures defines the product dimension and the sources of emissions by origin industry and origin countries can be identified.

There are a variety of different GHG databases ranging from aggregated emissions for all countries in the world to high levels of detail for individual countries. Table 1.1 summarises the existing international databases on GHG emissions based on the submissions from their member countries using 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 170, countries and aggregate regions	T
IEA	World Energy Balances	Over 170, countries and aggregate regions	T
IEA	CO <sub>2</sub> emissions from Fuel Combustion	Over 180, countries and aggregate regions	T
Eurostat / OECD	Air Emissions Account (SEEA)	EU, OECD members and 4 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:

- The filling of gaps in the IEA CO<sub>2</sub> database for all countries to complete the coverage of CO<sub>2</sub> emissions from fuel combustion.
- Complete allocation of CO<sub>2</sub> emissions from fuel combustion by non-resident households and industries. In earlier studies, the emissions from international bunkers were not distributed across operating transportation service providers due to the lack of operators' residency details.
- The integration of estimates of CO<sub>2</sub> intensity for each bilateral trade relationship. The database allows comparisons of emissions embodied in bilateral trade by specific product.

The structure of the remainder of this paper is as follows: Section 2 presents the methodological approach taken to calculate indicators in the 2019 release of CO<sub>2</sub> emissions embodied in international trade and final demand (OECD's TECO2 database: available from <http://oe.cd/io-co2>). The third section describes the detailed estimation procedures to allocate emissions to the countries and the industries in OECD's ICIO. Section 4 presents and discusses 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<sub>2</sub> emissions embodied in international trade and final demand (TECO<sub>2</sub>) resembles the methodology used to calculate indicators of Trade in Value Added (TiVA: <http://oe.cd/tiva>) and Trade in Employment (TiM: <http://oe.cd/io-emp>). Emissions embodied in gross trade and final demand are calculated with similar equations using vectors of production-based emissions and output multipliers from OECD's Inter-Country Input-Output (ICIO) tables (See Table 2.1 for the basic equations). However, the indicators need to be selected to avoid the double counting issues associated with 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 illustrated using the three production stages (emission sector, intermediate and final producers) in Figure 2.1.

### 2.1. Final demand-based emissions

Using the ICIO components (Table 2.1) and emissions variables (Table 2.2), we estimate the emissions embodied in final demand for each country.

The output multiplier matrix (**B** in Table 2.1) from the ICIO system represents the domestic and foreign output by all upstream and final production stages required for one unit of final expenditure. The vector of output generated in all countries by final expenditure in country *s* is defined as

$$\begin{bmatrix} X^{1S} \\ X^{2S} \\ \vdots \\ X^{NS} \end{bmatrix} = \mathbf{B}Y^S \quad (1)$$

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

The emissions embodied in the final demand of a country is 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-based, production-based and demand-based emissions of a target country *s* are respectively written as:

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

$$P^S = TI^S + \sum_r DI^{rs} - \sum_r DI^{sr} \quad (2)$$

- Emissions factor vector:

$$EF^S = (TI^S + \sum_r DI^{rs} - \sum_r DI^{sr})/X^S \quad (3)$$

- Resident-based fuel combustion emissions by households:

$$HC^S = TH^S + \sum_r DH^{rs} - \sum_r DH^{sr} \quad (4)$$

- Emissions embodied in one unit of production (emissions multiplier):

$$e\mathbf{B} = \begin{bmatrix} \widehat{\mathbf{EF}}^1 & \mathbf{0} & \dots & \mathbf{0} \\ \mathbf{0} & \widehat{\mathbf{EF}}^2 & \dots & \mathbf{0} \\ \vdots & \vdots & \ddots & \vdots \\ \mathbf{0} & \mathbf{0} & \dots & \widehat{\mathbf{EF}}^N \end{bmatrix} \mathbf{B} \quad (5)$$

The estimation procedures for production-based emissions vectors ( $\widehat{\mathbf{EF}}^r$  and  $HC^r$ ) are described in next section. Emissions multiplier ( $e\mathbf{B}$ ) is defined by multiplying production-based emissions intensities (diagonalised vector  $\mathbf{EF}$  of size  $NK$ , where  $N$  is the number of countries and  $K$  the number of industries) by the global Leontief inverse  $\mathbf{B} = (\mathbf{I} - \mathbf{A})^{-1}$  (of size  $NK \times NK$ ).  $\widehat{\mathbf{EF}}^r$  is a diagonalised vector of industry-specific emission intensities for country  $r$  i.e. fuel combusted by each industry in country  $r$ .

- Production-based emissions:

$$C^S = \mathbf{EF}^S * X^S + HC^S \quad (6)$$

**Table 2.1. Basic matrices from OECD's ICIO**

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

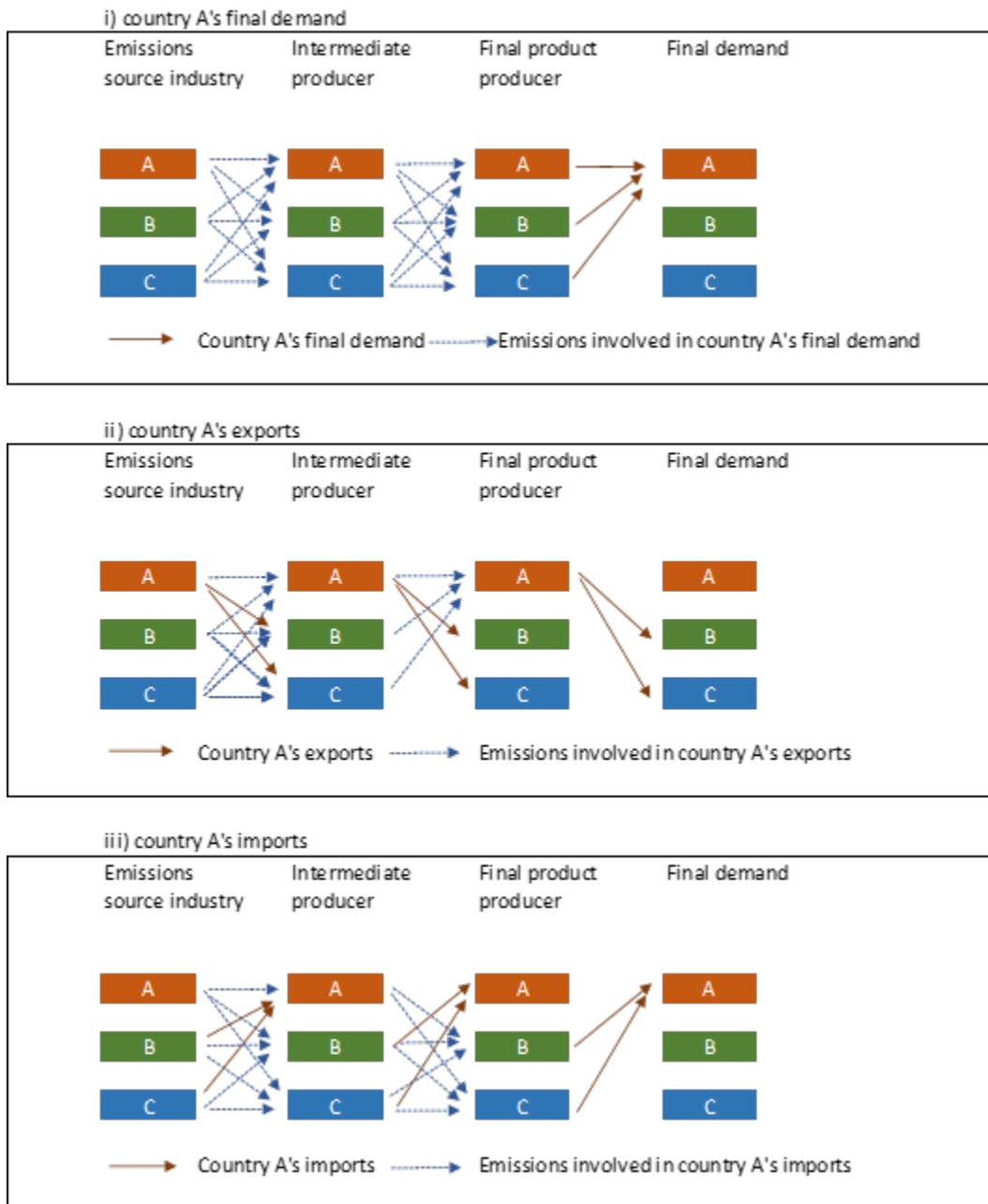
Note: N is the number of countries and K is the number of industries

Table 2.2. CO<sub>2</sub> 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	$(N * K) \times (N * K)$	Emissions allocated to fuel purchases abroad by industries, where $di_{ij}^{rs}$ is emissions from fuel product from industry $i$ of country $r$ by resident industry $j$ of country $s$
DH	$(N * K) \times N$	Emissions allocated to fuel purchases abroad by households, where $dh_i^{rs}$ is emissions from fuel product from industry $i$ of country $r$ by resident household of country $s$
CFI	$1 \times (N * K)$	Total 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 <sub>2</sub> 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 industries

Figure 2.1. Emissions embodied in trade and final demand



- Demand-based emissions:

$$C^s = eB Y^s + HC^s \quad (7a)$$

Here we focus on demand-based emissions which are estimated using an expanded matrix format for efficient calculation:

$$\begin{bmatrix} \mathbf{cc}^{11} & \mathbf{cc}^{12} & \dots & \mathbf{cc}^{1N} \\ \mathbf{cc}^{21} & \mathbf{cc}^{22} & \dots & \mathbf{cc}^{2N} \\ \vdots & \vdots & \ddots & \vdots \\ \mathbf{cc}^{N1} & \mathbf{cc}^{N2} & \dots & \mathbf{cc}^{NN} \end{bmatrix} = e\mathbf{B} \begin{bmatrix} \mathbf{y}^{11} & \mathbf{y}^{12} & \dots & \mathbf{y}^{1N} \\ \mathbf{y}^{21} & \mathbf{y}^{22} & \dots & \mathbf{y}^{2N} \\ \vdots & \vdots & \ddots & \vdots \\ \mathbf{y}^{N1} & \mathbf{y}^{N2} & \dots & \mathbf{y}^{NN} \end{bmatrix} + \begin{bmatrix} \widehat{HC}^1 & \mathbf{0} & \dots & \mathbf{0} \\ \mathbf{0} & \widehat{HC}^2 & \dots & \mathbf{0} \\ \vdots & \vdots & \ddots & \vdots \\ \mathbf{0} & \mathbf{0} & \dots & \widehat{HC}^N \end{bmatrix} \quad (7b)$$

CO<sub>2</sub> emissions,  $cc_i^{rs}$ , emitted by industry  $i$  in country  $r$ , to meet final demand in country  $s$ , are calculated by multiplying the emissions multiplier and global final demand matrix ( $\mathbf{Y}$  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  $s$  and  $\mathbf{y}^{rs}$  the demand of country  $s$  for final goods and services produced by country  $r$ , by industry.  $\mathbf{HC}$  denotes direct emissions by final demand e.g. combustion 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  $\mathbf{CC}$  plus direct emissions from final demand  $\mathbf{HC}^s$ . Similarly, production-based emissions can be calculated as row sums of matrix  $\mathbf{CC}$  (of size  $NK \times N$ ) plus direct emissions from final demand  $\mathbf{HC}^s$ . 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 by source country and industry to exports or final demand for each target year. The dimensions are

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

World total demand-based emissions and production-based emissions are the same:

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

where  $X^r$  is output of country  $r$ .

Production-based and final demand-based emissions are the 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<sub>2</sub> productivity (production-based)* calculated as real GDP generated per unit of CO<sub>2</sub> emitted (USD/kg).
- *CO<sub>2</sub> productivity (demand-based)* calculated as real GDP generated per unit of CO<sub>2</sub> emitted from final demand (USD/kg).

## 2.2. Calculating emissions embodied in trade

Using the same emissions multiplier matrix from the previous section, emissions embodied in the exports (and imports) can be calculated:

$$C = \mathbf{eB}T \quad (9)$$

where  $C$  is a vector of emissions by source industry and country,  $\mathbf{eB}$  is emissions multiplier matrix and  $T$  is a matrix of trade flows with each element being a bilateral trade flow. For example, emissions embodied in exports of product  $p$  from country 1 to the rest of the world is written as

$$\begin{bmatrix} c_1^1 \\ c_1^2 \\ \vdots \\ c_K^N \end{bmatrix} = \mathbf{eB} \begin{bmatrix} 0 & 0 & \dots & 0 \\ 0 & t_p^{12} & \dots & t_p^{1,N} \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \dots & 0 \end{bmatrix} \mathbf{u} \quad (10)$$

where  $c_i^r$  is the emissions by industry  $i$  in country  $r$ , and  $t_p^{r,s}$  is trade product  $p$  exported by country  $r$  to country  $s$  (i.e. imported by  $s$ ).  $\mathbf{u}$  is an aggregation vector (row sum) with elements of 1 ( $NK \times 1$ ).

Then, the emissions embodied in imports from all trade partners by country 2 of products from industry  $p$  is described as

$$\begin{bmatrix} c_1^1 \\ c_1^2 \\ \vdots \\ c_K^N \end{bmatrix} = \mathbf{eB} \begin{bmatrix} 0 & 0 & \dots & 0 \\ 0 & t_p^{12} & \dots & 0 \\ \vdots & \vdots & \vdots & \vdots \\ 0 & t_p^{22} & \vdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & t_p^{N2} & \dots & 0 \end{bmatrix} \mathbf{u} \quad (11)$$

where  $c_i^r$  is the vector of source CO<sub>2</sub> emissions by industry  $i$  in country  $r$  embodied in imported product  $p$  by country 2.

Using the same emissions multiplier structures, the emissions embodied in a specific country pair's gross trade flow can be estimated. An example of the emissions involved in the production stages of country 1's exports of product  $p$  to country 2 is

$$\begin{bmatrix} c_1^1 \\ c_1^2 \\ \vdots \\ c_K^N \end{bmatrix} = \mathbf{eB} \begin{bmatrix} 0 \\ t_p^{12} \\ \vdots \\ 0 \\ \vdots \\ 0 \end{bmatrix} \quad (12)$$

where  $c_i^r$  is the vector of source CO<sub>2</sub> emissions by industry  $i$  in country  $r$  embodied in imported product  $p$  by country 2 from country 1.

### 3. Estimation of CO<sub>2</sub> emissions factors

Estimation of CO<sub>2</sub> emissions embodied in international trade and final demand using the methodology described above needs emissions factors at the country and industry level. This section presents the methodology developed to obtain these factors, by combining detailed information on country and industry output from OECD's ICIO tables<sup>3</sup> with IEA's CO<sub>2</sub> emissions from fuel combustion<sup>4</sup> database.

#### 3.1. Territorial-based emissions

As with the earlier versions of OECD demand-based emissions databases, the IEA CO<sub>2</sub> emissions from fuel combustion database (IEA-CO<sub>2</sub>) remains the main data source for territorial-based emissions. Detailed emissions by fuel product and by flow (fuel combusting sectors) for over 140 individual countries and for the world as a whole are reported annually.

In the IEA-CO<sub>2</sub> database (IEA, 2018) there are: a) 46 unique fuel products - see Table 3.1; b) 34 unique flows (combustion sectors) - see Table 3.2; and c) 138 individual economies that matches the target countries in the enlarged OECD ICIO database<sup>5</sup>. To avoid rounding errors and unreported detailed information, as a first step, the original IEA dataset is rescaled to the world total and total national emissions. The rescaling procedure takes the following two steps:

- World total emissions

$$CF_R^* = CF_W - \sum_c CF_c \quad (13)$$

- Country total emissions by fuel product and by flow

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

where  $CF_c$  is CO<sub>2</sub> 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.

Table 3.1. Fuel products in IEA CO<sub>2</sub> from fuel combustion database

PRODUCTS		
Rank	Code	Name
<b>1</b>	<b>TOTAL</b>	<b>CO<sub>2</sub> Fuel Combustion</b>
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	NONBODIES *	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<sub>2</sub> emissions per unit of industry output and an emission factor  $EF^r[i]$  for each industry  $i$ . Out of a total of 34 flows in the IEA-CO<sub>2</sub> database, 11 flows have “one-to-many” relationship with the ICIO industry list (Table 3.2)<sup>6</sup>. These aggregate flows should be allocated to corresponding sectors to estimate the complete set of emissions factors. The remaining flows in the IEA-CO<sub>2</sub> database are fully compatible with specific industries used in the ICIO system.

### 3.2.1. Autoproducers of electricity and other energy industries

The difference between main Activity and autoproducers of electricity and other energy sources is defined as: “*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.*”<sup>7</sup>

The main industries who use energy input to generate electricity and heat are commodity type manufacturing industries (autoproducer).<sup>8</sup> There are four aggregate flows in IEA-CO<sub>2</sub>: Autoproducer electricity plants, autoproducer Combined Heat and Power plants, autoproducer heat plants, and other energy industry own use. The largest autoproducer industries are steel producers from coal related gases (coking coal, other bitumen coal and blast furnace gas). Thus emissions from coal fuel products of autoproducers in IEA-CO<sub>2</sub> are allocated to steel industry (ISIC Rev.4 241) and the remaining emissions in autoproducers are allocated based on the shares of other fuel types (oil, gas and petroleum) by non-steel manufacturing sectors.

### 3.2.2. Road Transportation

The emissions for road transportation in IEA-CO<sub>2</sub> include the emissions from fuel combustion from all industries and household in one flow. It is thus necessary to split and allocate this 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 produced by a 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 other countries that do not provide sufficient details of fuel products transactions, the share of gasoline and diesel (light oil) in total petroleum products for each industry are applied (Table 3.3).

$$ER^s = CFR \frac{Z(D19,s) \times REF_{road\_D19}(s)}{\sum_s (Z(D19,s) \times REF_{road\_D19}(s))}$$

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

$Z(D19,i)$  is petroleum consumption by industry and household  $s$  from balanced use table of the 2018 OECD ICIO system,  $REF_{road\_D19}(s)$  is the road transportation fuel to total petroleum input by sector  $s$  from reference countries.

Table 3.2. Concordance between CO<sub>2</sub> flows (IEA) and OECD ICIO industry classification

Rank	FLOWS		Industries
	Code	Name	
<b>1</b>	<b>CO2FCOMB</b>	<b>CO<sub>2</sub> Fuel Combustion</b>	
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 households**

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

Territorial emissions are converted to resident production-based emissions by adjusting with direct purchases abroad and direct purchases by non-resident expenditures of gasoline and diesel from Balance of Payments statistics item “Travel”, National Accounts household consumption expenditures and detailed Input-Output or Supply and Use tables.

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

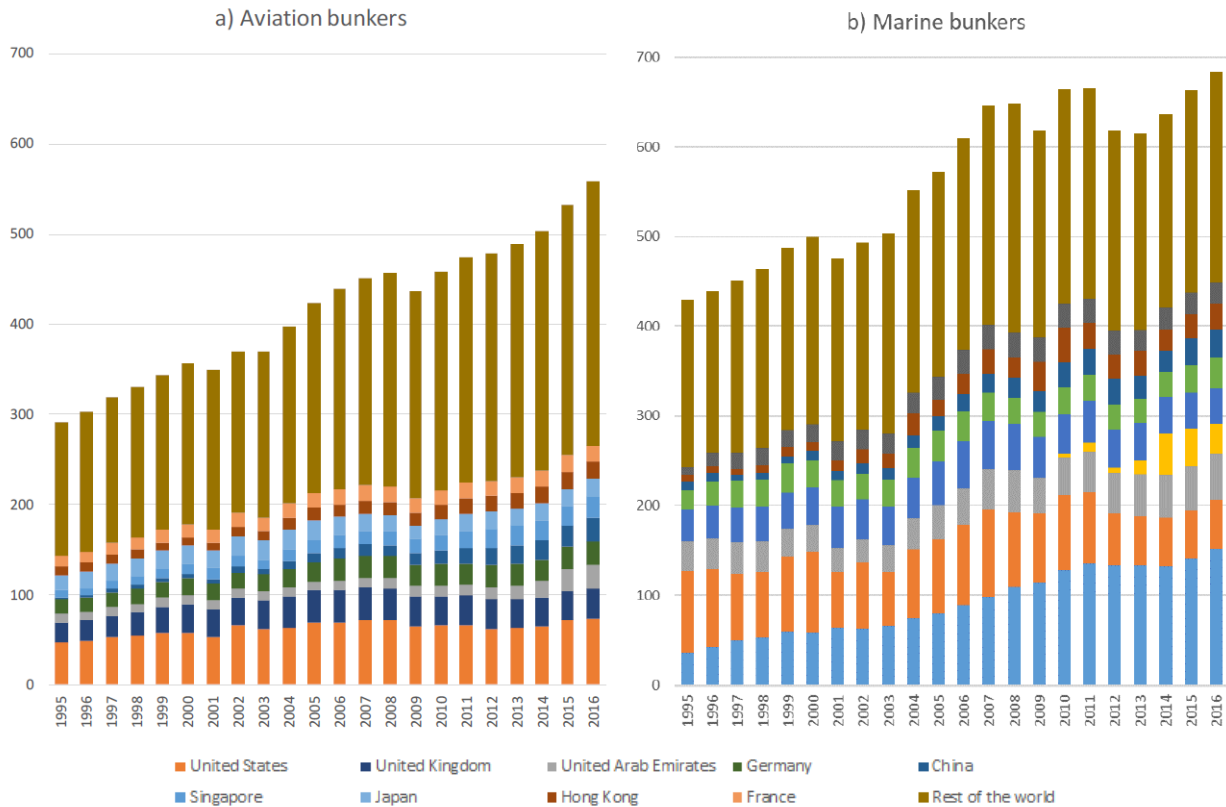
### 3.2.3. Emissions from fuel used for international transportation

The IPCC guidelines (2006) suggest that emissions from international bunkers are measured separately from other fuels used for domestic aviation and navigation activities. The IEA CO<sub>2</sub> emissions database separately reports the international aviation and marine bunker emissions in each reporting country. These 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 more concentrated in a few countries compared to international aviation bunkers (Figure 3.1). In 2015, the territorial emissions from the top five countries (Singapore, United States, United Arab Emirates, Russia and the Netherlands) accounted for half of the global emissions of marine bunkers while the share of the top five countries (United States, United Kingdom, United Arab Emirates, Germany and China) of global aviation bunkers is only 33%. Both marine and aviation bunker emissions have been steadily growing since the mid-1990s but the aviation bunker emissions are relatively less volatile. In general, in Use tables at purchasers’ prices, the

share of household final consumption expenditure in the total supply by air transportation services is relatively high compared with water transportation services.

**Figure 3.1. Emissions from international bunkers (million tonnes)**



Source: IEA (2018) CO<sub>2</sub> 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 and b) airport locations and scheduled route traffic. Note that the international aviation emissions are all allocated to air transport activities (ISIC Rev.4 Division 51). A list of privatised and low-cost-carriers airlines are summarized from ICAO Data<sup>9</sup> and the nationality of the operating airline is adjusted from headquarter-based list to establishment activity-based list that better matches the National Accounts and Use table framework. The operating bases of most international flights are usually registered either in the origin airport or the 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>).

Global total emissions from international aviation emissions is defined by the sum of emissions from all flights of all operating countries (E):

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

where  $E_p^{ab}$  are the emissions coming 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

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

and

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

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

$$E_p^{ab} = TE_a \frac{F_p^{ab}}{\sum_b \sum_p F_p^{ab}} \quad (18)$$

where  $F_p^{ab}$  is the number of flights routes between country  $a$  and country  $b$  operated by country  $p$ 's air transport industry. It is also assumed the equal number of flights are operated for the same airport pairs (i.e.  $F_p^{ab} = F_p^{ba}$ ).<sup>10</sup>

### *Marine bunkers*

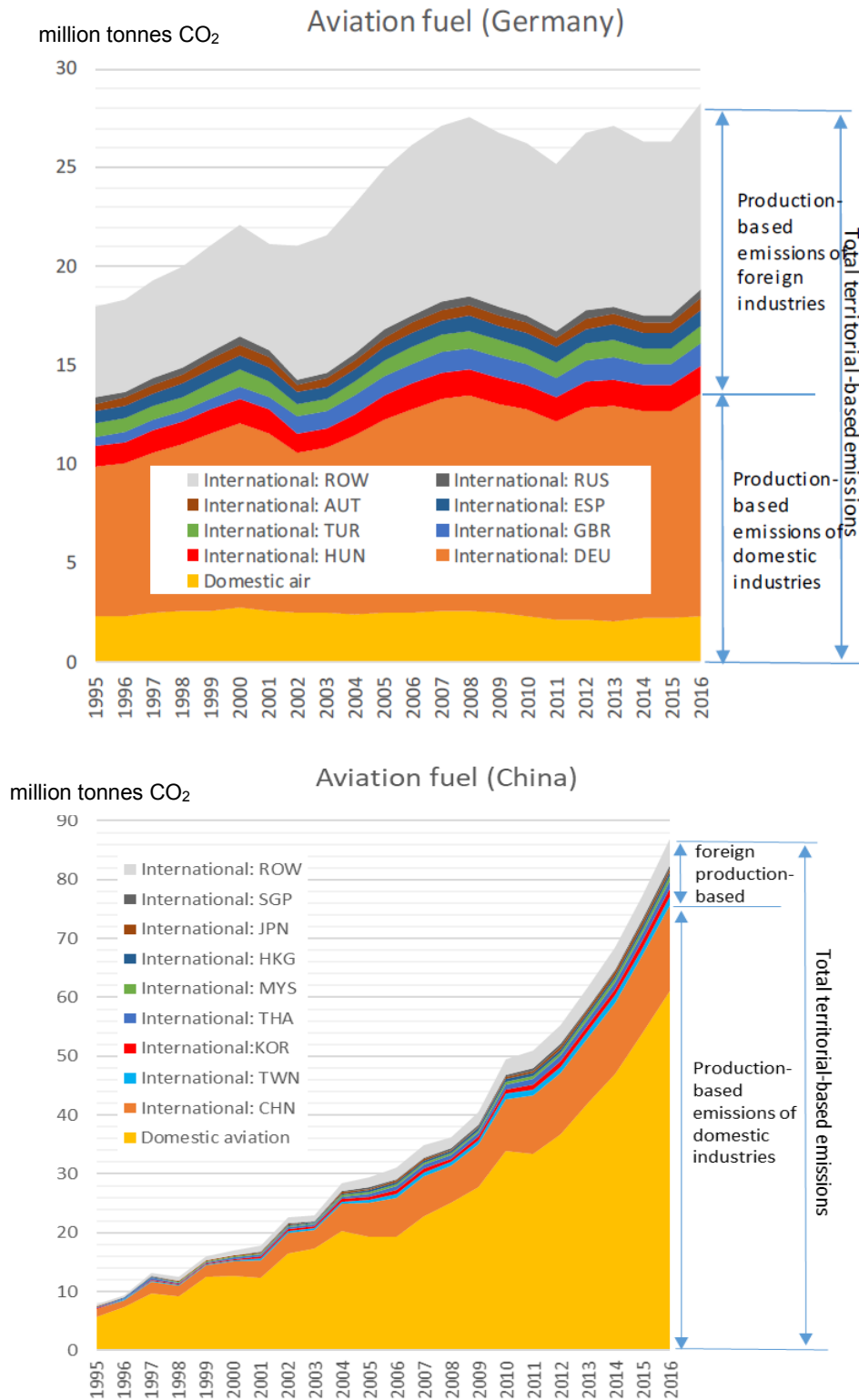
Unlike the aviation bunker emissions, the fuels purchased (loaded) in ports are not fully consumed during each journey between origin and destination ports. The international cargo transportation companies (e.g. Maersk's Global Voyage Center) choose optimized options of fuel purchases and usages by adjusting the locations of bunker fuel refill ports, vessels speed, cargo and fuel load to overall payload ratios (Lu *et al.*, 2015). Therefore, the physical movement of a voyage and the nationality of fuel loading companies do not match. Due to the lack of detailed procurement data sources, the 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 (ISIC Rev.4 Division 50).

b) The rest of the fuel is allocated according 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](http://oe.cd/icio)).

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

Figure 3.2. Territorial-based and production-based emissions of aviation fuel



Source: Authors' calculation based on IEA (2018) CO<sub>2</sub> emissions from fuel combustion.

#### 4. CO<sub>2</sub> emissions embodied in production, consumption and trade<sup>11</sup>

The methodology developed and described above is the basis to estimate the set of indicators present in OECD's Carbon dioxide (CO<sub>2</sub>) emissions embodied in international trade (TECO2) database<sup>12</sup>. Analysis using these indicators can provide insights into the role played by international trade in the allocation of emissions to consumer and producing countries. These indicators can reveal whether countries are reducing or increasing their emissions in the production and consumption process, and the degree to which they are outsourcing the production from their most polluting industries to countries who are more lenient with emissions.

Overall, world CO<sub>2</sub> emissions from fuel combustion increased by about 19% between 2005 and 2015, from 27.1 to 32.3 Gigatonnes (Gt) of CO<sub>2</sub> i.e., an annual growth rate of 1.8%. During the same period, the world population increased by 12.8%, i.e. an annual growth rate of 1.2%. As a result, annual world average per capita emissions increased from 4.1 to 4.4 tonnes of CO<sub>2</sub>, an increase of about 5.6%, mainly due to increases in emissions and consumption in developing countries.

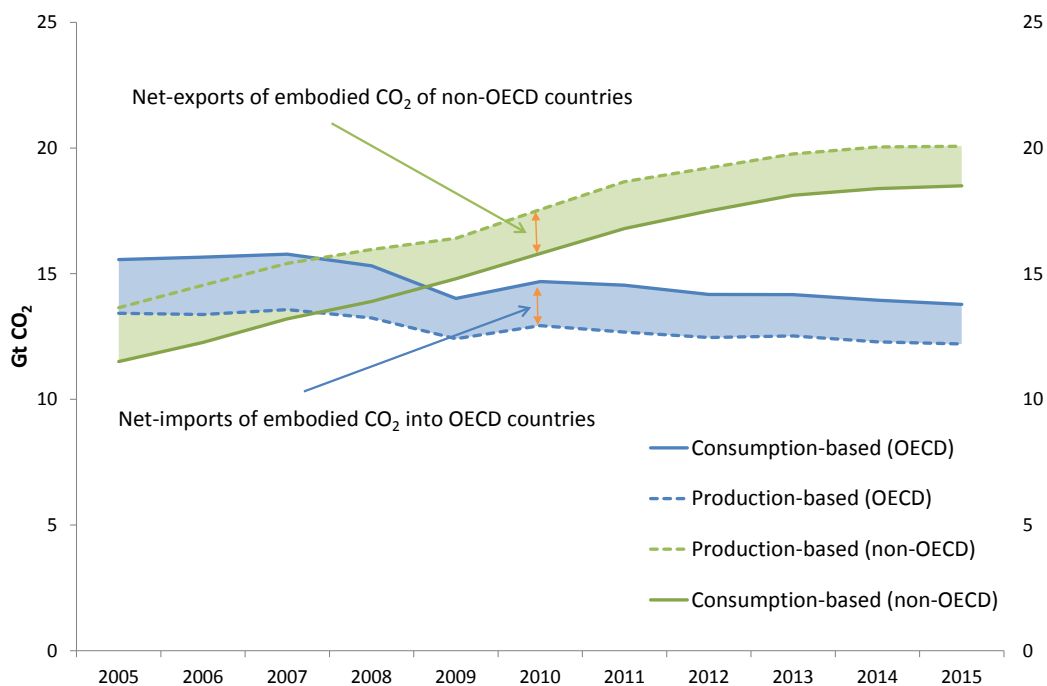
Figure 4.1 compares aggregate OECD and aggregate non-OECD production-based emissions, where CO<sub>2</sub> is allocated to the location in which the goods or services are produced; and, consumption-based emissions i.e. where CO<sub>2</sub> is allocated to the locations in which consumption occurs. For OECD countries (see Annex D) as a whole, from 2005 to 2015, total production-based CO<sub>2</sub> emissions fell by about 9%, from 13.4 to 12.2 Gt, while consumption-based emissions fell by about 11%, from 15.6 to 13.8 Gt. Consumption-based emissions *per capita* fell by about 17%, from 13.0 to 10.8 tonnes of CO<sub>2</sub> (Figure 4.2). There was also a 26% reduction in net imports of CO<sub>2</sub> emissions from fuel combustion by OECD countries from non-OECD economies, from 2.1 to 1.6 Gt. Despite this welcome improvement in performance, OECD consumption *per capita* emissions was, in 2015, around 2.5 times greater than average world per capita emissions and 3.6 times greater than that for non-OECD countries.

The United States is the OECD's largest emitter of CO<sub>2</sub> from fuel combustion, accounting for about 41% of OECD emissions in 2015. It is also the largest consumer, with about 42% of OECD consumption-based emissions. Reflecting the size of their economies, Japan and Germany are the second and third largest emitters, with about 10% and 6% of OECD emissions in 2015, respectively. They also account for similar shares of OECD consumption-based emissions. In general, the OECD is a net importer of CO<sub>2</sub> emissions. However, one third of OECD countries are net exporters, the largest being Korea, Poland and Canada. While there was an overall decrease in production- and consumption-based emissions across OECD between 2005 and 2015, some countries increased both their production and consumption of emissions, notably Chile, Korea and Turkey.

Over the same period, there was a general increase in emissions by non-OECD economies. Production-based CO<sub>2</sub> emissions increased by about 47%, from 13.6 to 20.1 Gt, while consumption-based emissions increased by about 61%, from 11.5 to 18.5 Gt, resulting in a 41% increase in consumption-based emissions *per capita*, from 2.2 to 3.0 tonnes of CO<sub>2</sub>. These increases are in large part linked with the need of these countries to sustain their own development. A consequence is that many of these countries are important net exporters of CO<sub>2</sub> emissions as they develop a stronger manufacturing base to meet the consumption needs of more developed nations. Despite increasing industrialisation, emissions per capita in non-OECD economies are still low compared to OECD countries.

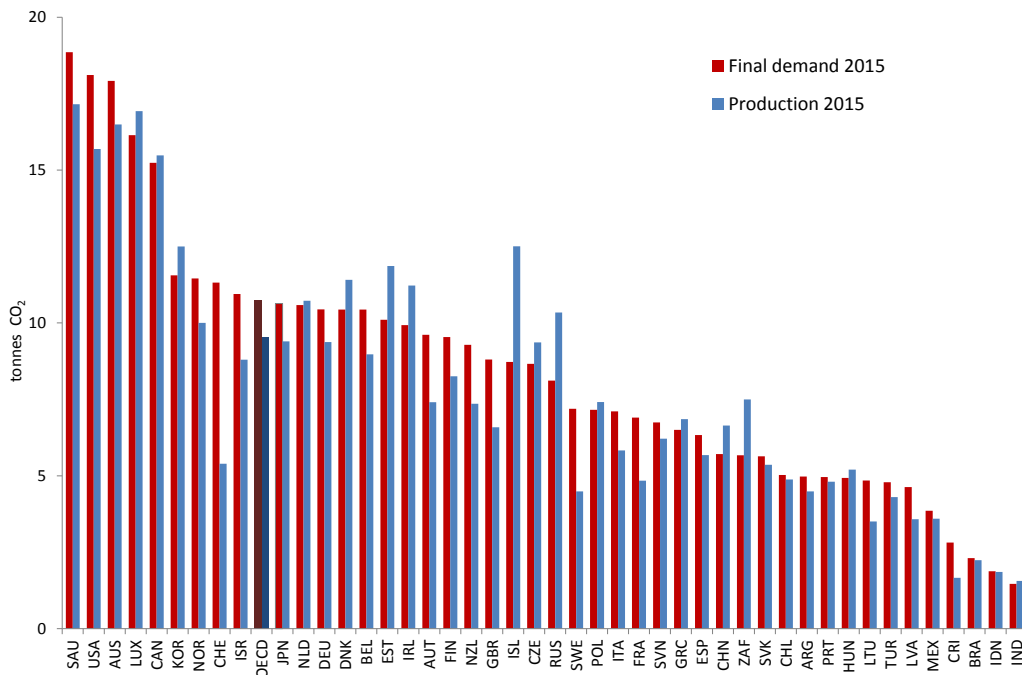
Among non-OECD economies, China is the largest emitter of CO<sub>2</sub> from fuel combustion, accounting for about 46% of non-OECD emissions in 2015. It is also the largest consumer, with about 43% of non-OECD consumption-based emissions. India and Russia are the second and third largest emitters, with about 10% and 7% of non-OECD emissions in 2015, respectively. India also accounted for 10% of non-OECD consumption-based emissions, while Russia accounted for 6%. Many non-OECD economies are net-exporters of CO<sub>2</sub> emissions, notably China, India, Malaysia, Russia, South Africa, Chinese Taipei and Thailand. Net-importers include Brazil, Indonesia, and Saudi Arabia. While there was an overall increase in production- and consumption-based emissions across non-OECD economies between 2005 and 2015, some among them, notably non-OECD EU countries, experienced reductions.

**Figure 4.1. CO<sub>2</sub> emissions from fuel combustion (OECD and non-OECD countries)**



Source: OECD's Carbon dioxide (CO<sub>2</sub>) emissions embodied in international trade (TECO2) database (<http://oe.cd/io-co2>), 2019

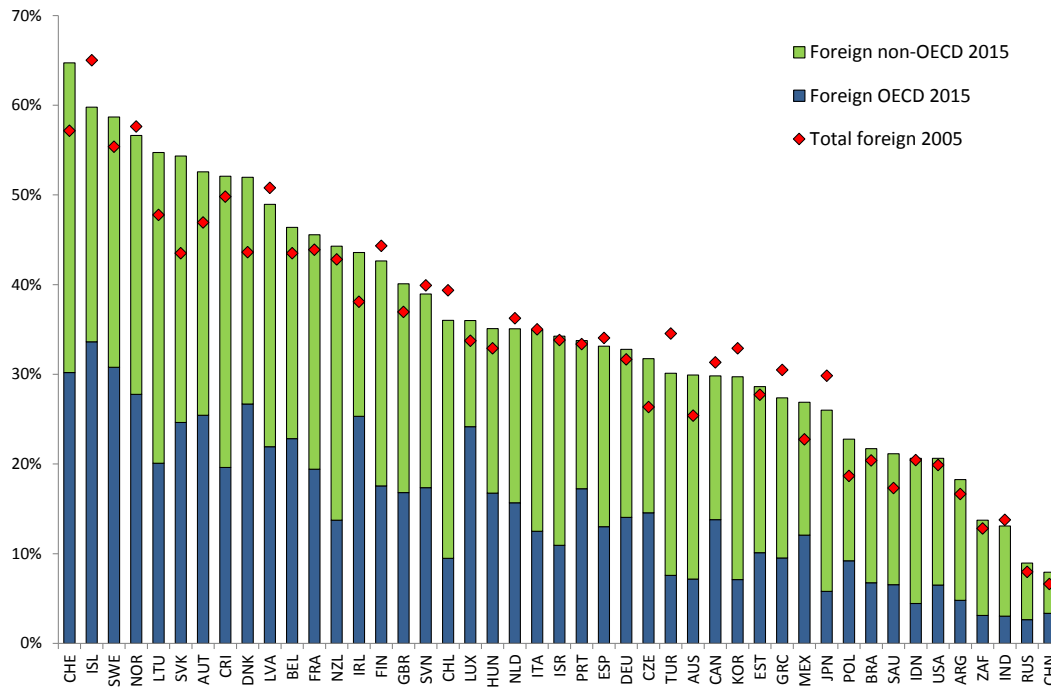


Figure 4.2. Per capita CO<sub>2</sub> emissions from fuel combustion

Source: OECD's Carbon dioxide (CO<sub>2</sub>) emissions embodied in international trade (TECO2) database (<http://oe.cd/io-co2>), 2019

Looking at only 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<sub>2</sub>, i.e. 27.2% of the world CO<sub>2</sub> emissions from fuel combustion in 2015, is linked with international trade. This high share of emissions associated with international trade is 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). The following analysis focuses on the differences among countries and the different goods traded, to 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<sub>2</sub> emitted abroad embodied in final demand, sourced from OECD and non-OECD regions, revealing differences across countries and the importance of international trade in the allocation of emissions. For the selected countries, it shows that this share, in 2015, ranged from 8%, in the case of China, to 65%, in the case of Switzerland, with smaller countries tending to have higher shares (due to higher dependencies on imported final goods). This result reflects countries' integration in regional and global production systems. Thus, larger countries that are more integrated in European regional value chains have high shares, such as France (46%) and the United Kingdom (40%) while large countries in other regions are less dependent in emissions from foreign economies as e.g. Russian Federation (9%) and India (13%).

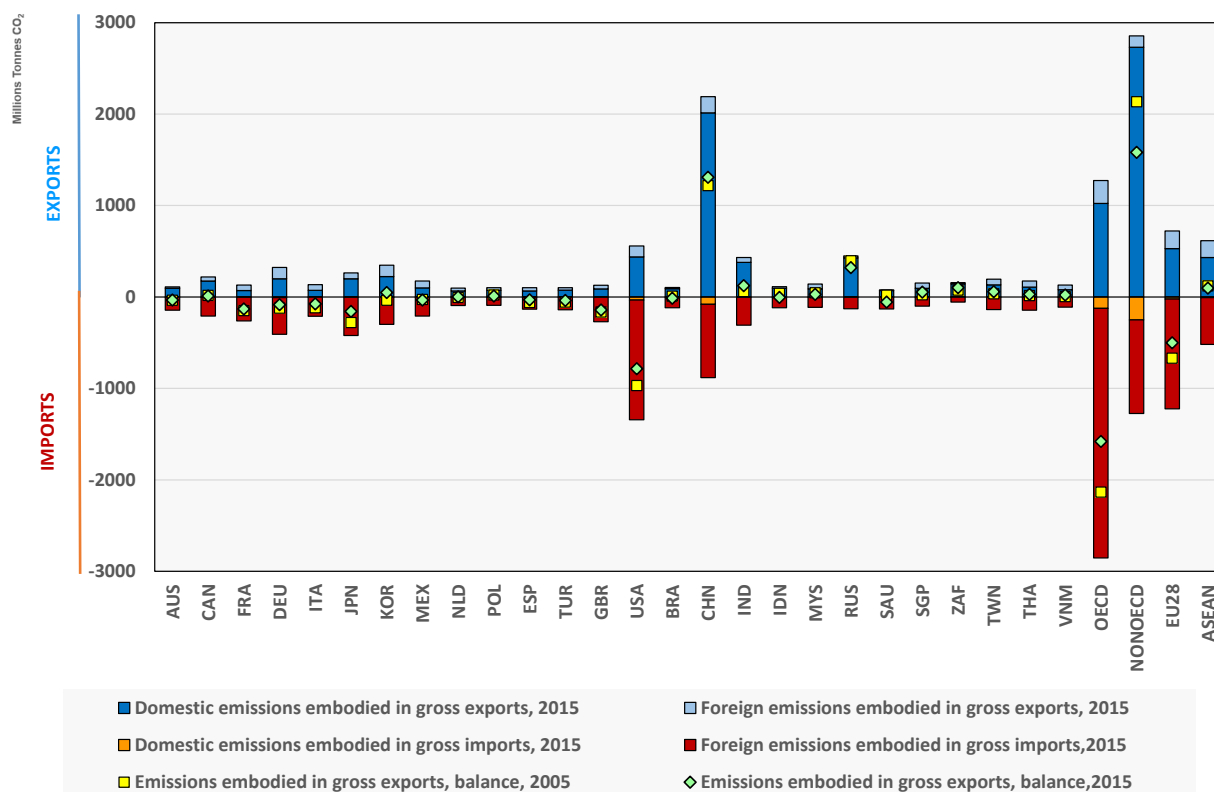
Figure 4.3. Share of CO<sub>2</sub> emitted abroad in total CO<sub>2</sub> embodied in domestic final demand

Source: OECD's Carbon dioxide (CO<sub>2</sub>) emissions embodied in international trade (TECO2) database (<http://oe.cd/io-co2>), 2019

Figure 4.4 shows the CO<sub>2</sub> embodied in total exports and imports, from domestic and foreign sources, for the main countries and regions<sup>13</sup> participating in international trade. The selected countries were responsible, in 2015, for 81% of the CO<sub>2</sub> emissions embodied in exports (7.8 Gt) and 75% of the CO<sub>2</sub> emissions embodied in imports (7.6 Gt). In terms of individual countries, in 2015 the United States was the largest net importer of CO<sub>2</sub>, 0.79 Gt, and China the largest net exporter, 1.3 Gt. Other main net importers are Japan (0.16 Gt), the 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 importers of emissions while the non-OECD and ASEAN countries are net exporters. Overall, trade balances, in absolute values, were smaller in 2015 than in 2005, exceptions were China (with a net increase in CO<sub>2</sub> exports from 1.2 to 1.3 Gt) and India (with a net increase in CO<sub>2</sub> exports from 0.06 to 0.12 Gt).

Figure 4.4 also shows the split of the CO<sub>2</sub> embodied in exports and imports between domestic and foreign origins, i.e., the foreign CO<sub>2</sub> embodied in exports shows how much imported CO<sub>2</sub> is re-exported, while the domestic CO<sub>2</sub> embodied in imports shows how much of the domestic CO<sub>2</sub> previously exported comes back. For the ICIO target countries, in 2015, the weighted average share of foreign CO<sub>2</sub> in the exports is 21.7% while the weighted share of domestic CO<sub>2</sub> in imports is 2.0%, the simple averages are respectively 32.2% and 0.6%. This is due to the largest international trading countries (notably China and the United States), having lower shares of foreign CO<sub>2</sub> in their exports than other countries and, on the other hand, a greater share of domestic CO<sub>2</sub> returning to them. 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.

**Figure 4.4. CO<sub>2</sub> embodied in total exports and total imports, from domestic and foreign sources, selected economies for 2005 and 2015 (Millions Tonnes of CO<sub>2</sub>)**

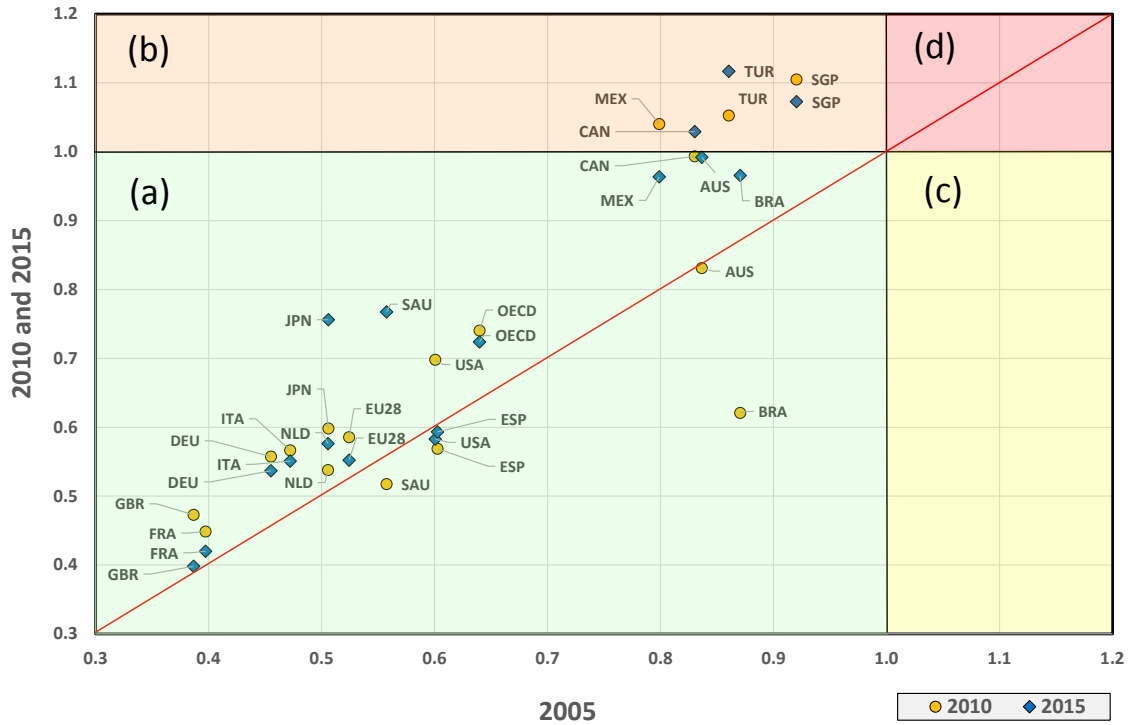


*Note:* The results presented consider the region as being a single unit, i.e., trade between countries within a given region are considered as being of domestic origin

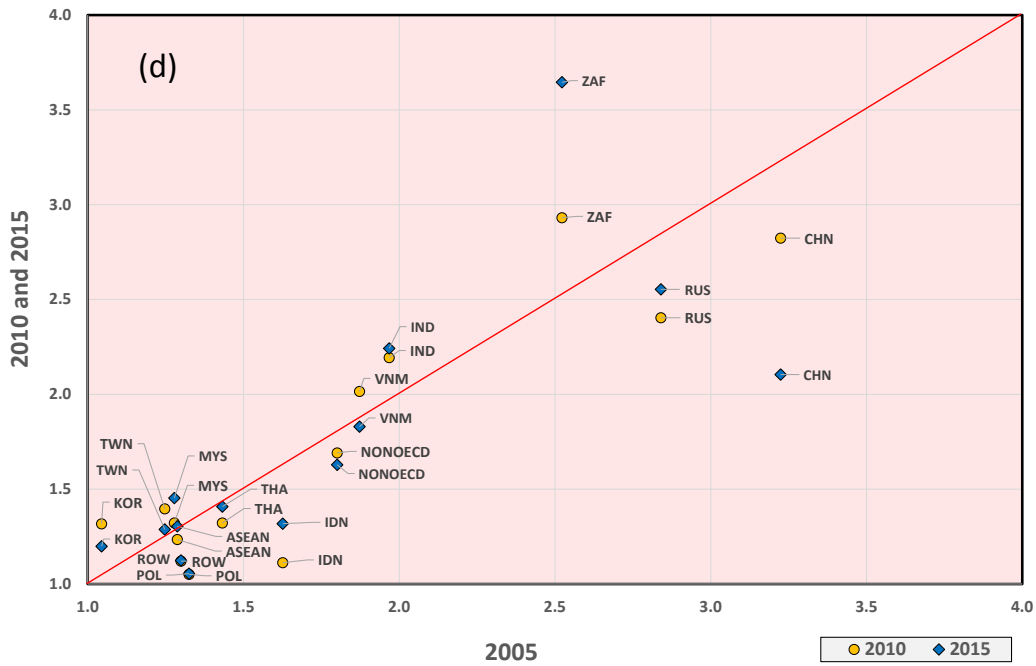
*Source:* OECD's Carbon dioxide (CO<sub>2</sub>) emissions embodied in international trade (TECO2) database (<http://oe.cd/io-co2>), 2019

Figure 4.5 and Figure 4.6 show, for the main countries and regions participating in international trade, the relative intensity of exports and imports, i.e. CO<sub>2</sub> 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 45° 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 facilitate the visualisation, the charts can have up to 4 colours for background: a) green for economies which in 2005 were below average, and remained below average in 2010 and/or 2015; b) orange for economies which in 2005 were below average, and become above average in 2010 and/or 2015, i.e., relatively more intensive in emissions than before; c) yellow for economies which in 2005 were above average, and become below average in 2010 and/or 2015, i.e., relatively less intensive in emissions than before; and, d) red is for economies which in 2005 were above average, and remained above 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<sub>2</sub> intensity in exports relative to simple world average, selected economies for 2005, 2010 and 2015, (simple world average = 1.0)

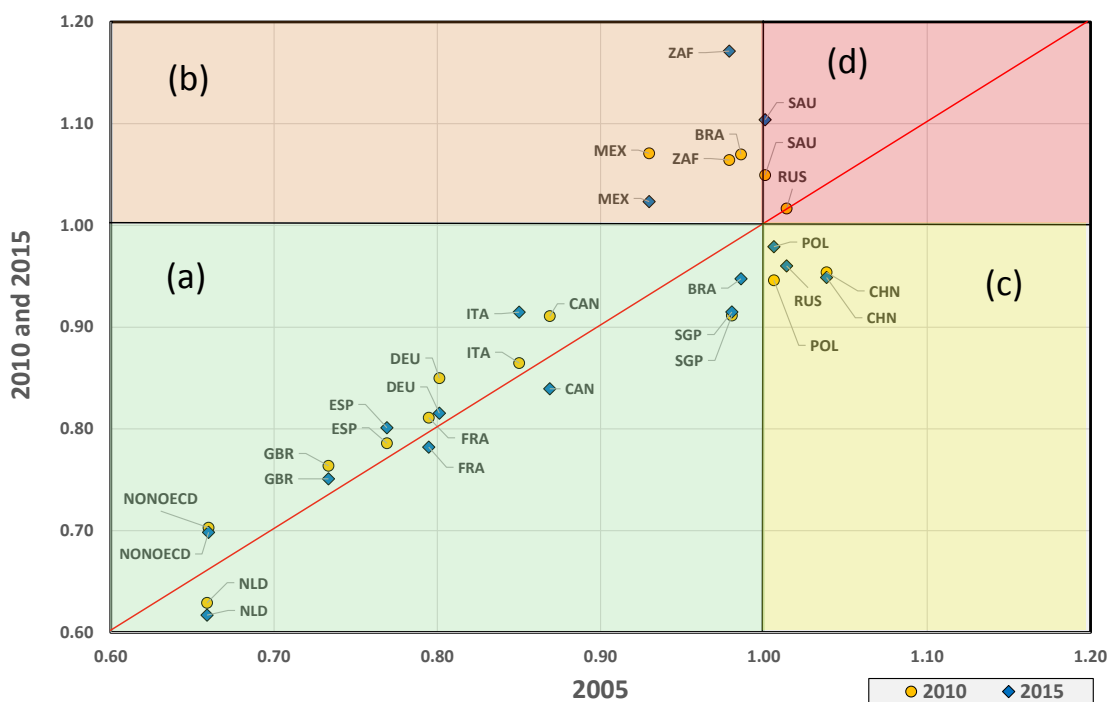


Above plot area (d) is magnified as follows

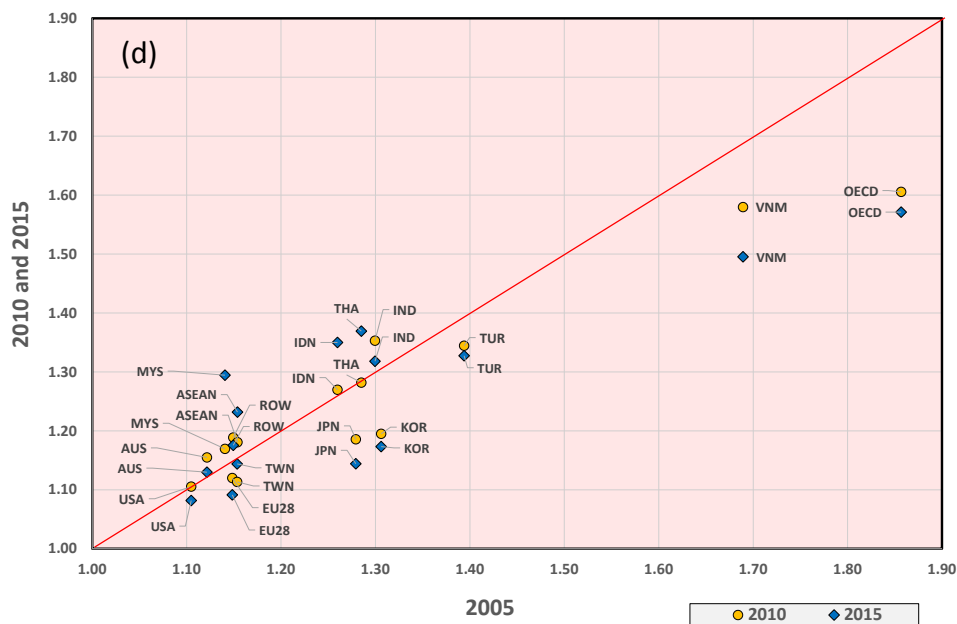


Source: OECD's Carbon dioxide (CO<sub>2</sub>) emissions embodied in international trade (TECO<sub>2</sub>) database (<http://oe.cd/io-co2>), 2019

Figure 4.6. CO<sub>2</sub> intensity in imports relative to simple world average, selected economies for 2005, 2010 and 2015, (simple world average = 1.0)



Above plot area (d) is magnified as follows



Source: OECD's Carbon dioxide (CO<sub>2</sub>) emissions embodied in international trade (TECO2) database (<http://oe.cd/io-co2>), 2019.

For the exports of the economies in the figures, relative 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 position 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, on average, non-OECD economies as a block, are relatively less intensive in emissions than the world average, this is because the exports and imports among these economies are considered as domestic flows of goods and services. The opposite is true for the OECD, EU28, and ASEAN economies as a block show a greater intensity in imports than the world average. Despite the relative high intensity of EU28 as a region, at the individual country level the selected EU28 countries 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<sub>2</sub> emissions of imports and the selected 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<sub>2</sub> emissions are embodied in the goods and services traded among the countries and the relative intensity of emissions among the exporters and importers countries, a remaining question concerns the main industries responsible for emissions embodied in trade and, the main countries exporting and importing the associated goods and services.

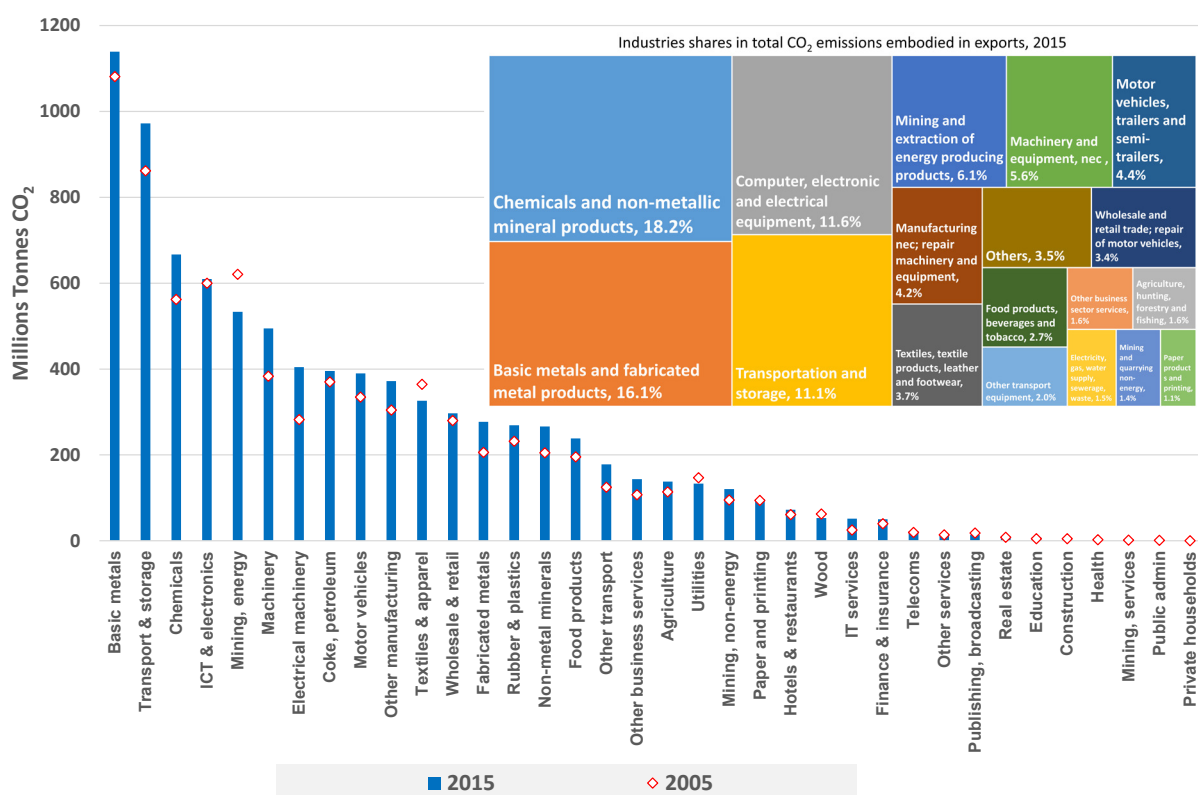
Figure 4.7 shows the total emissions embodied in exports by industry and shares by industry aggregates. We have selected 7 main industries aggregates which accounted for about two-thirds of the CO<sub>2</sub> emissions embodied in exports in 2015: 1) *Chemicals and non-metallic mineral products* (ISIC Rev.4 Divisions 19 to 23), 18.2%; 2) *Basic metals and fabricated metal products* (24 and 25), 16.1%; 3) *Computers, electronic and electrical equipment* (26 and 27), 11.6%; 4) *Mining and extraction of energy producing products* (05 and 06), 6.1%; 5) *Machinery and equipment* (28), 5.6%; 6) *Motor vehicles, trailers and semi-trailers* (29), 4.4%; and 7) *Textiles, wearing apparel, leather and related products* (13 to 15), 3.7%. Despite having a share of 11.1%, *Transportation and storage services* (49 to 53) are not included in this analysis as the emissions of this industry are effectively related and spread over the transport of the all the other industries.

The selected industry aggregates are displayed in Figure 4.8, which show the main exporter and importer countries of the goods produced by these industries, and thus reflects the information presented in Figure 4.5 and Figure 4.7. In 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 other.

For the industries presented in Figure 4.8, China usually stands out as the main exporter of emissions and the United States as the main importer. However, the set of main exporters or importers, and how the trade of emissions is concentrated depends 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 imported emissions tending to be concentrated in the G20 countries while exported emissions depend more on the good being exported. We highlight the following observations for 2015: a) For *Mining and extraction of energy producing products*, 60.8%

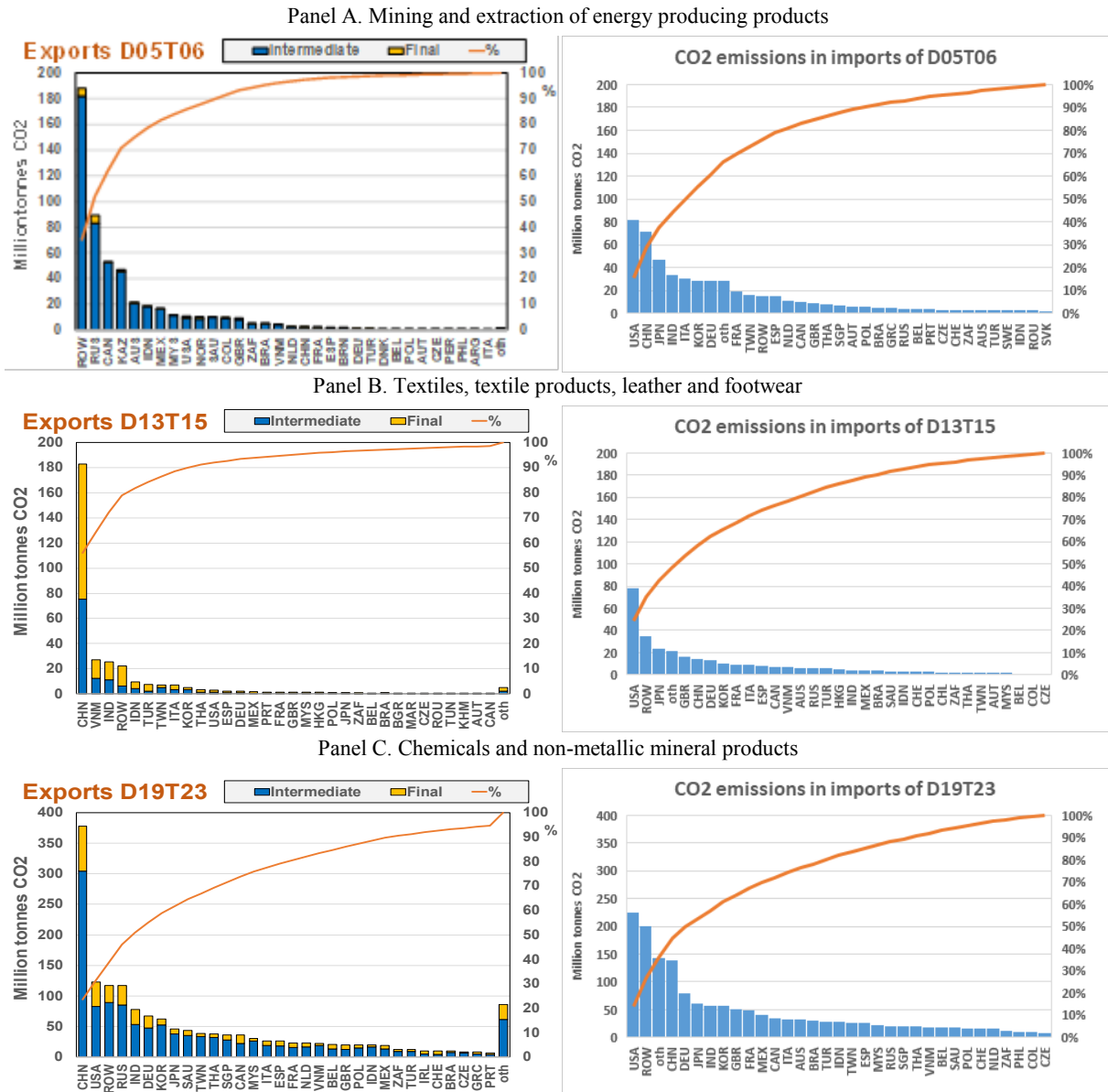
of imported emissions were concentrated in 7 countries (the United States, China, Japan, India, Italy, Korea and Germany); b) China was responsible for 56.0% of the emissions embodied in the exports of *Textiles, wearing apparel, leather and related products*; 55.9% of the emissions in exports of *Computers, electronic and electrical equipment*; and 42.8% of the emissions in exports of *Machinery and equipment*; c) For *Motor vehicles, trailers and semi-trailers*, 58.6% of the exported emissions were due to 6 countries (China, Mexico, Germany, the United States, Japan and Korea) while 51.1% of imported emissions were attributed to the United States.

Figure 4.7. Total CO<sub>2</sub> emissions embodied in gross exports, ICIO industries, 2005 and 2015



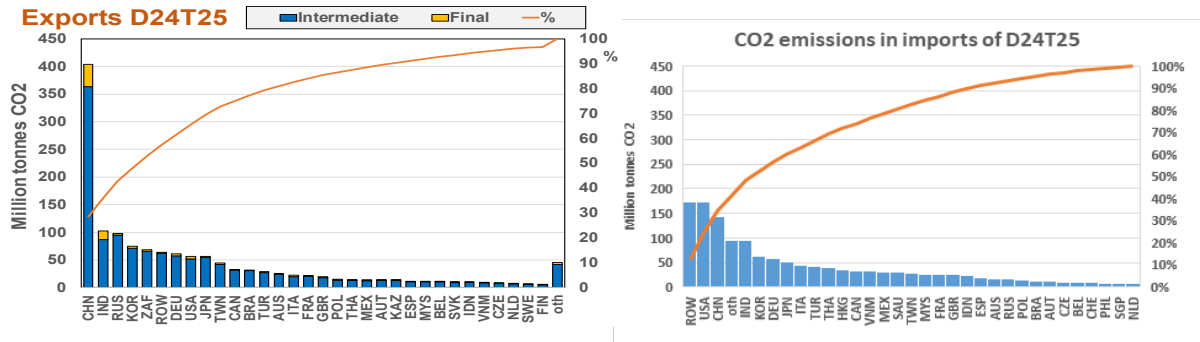
Source: OECD's Carbon dioxide (CO<sub>2</sub>) emissions embodied in international trade (TECO<sub>2</sub>) database (<http://oe.cd/io-co2>), 2019.

Figure 4.8. Total CO<sub>2</sub> emissions in exports and imports, main industries and countries, 2015

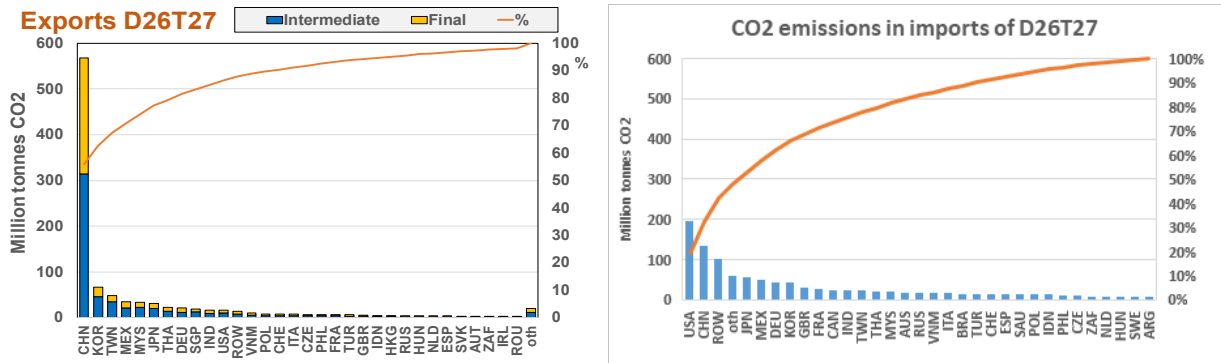




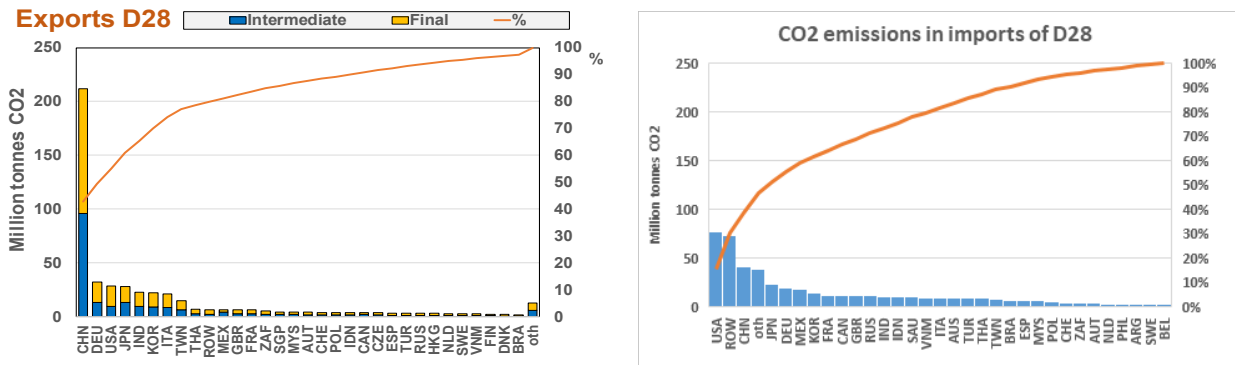
Panel D. Basic metals and fabricated metal products



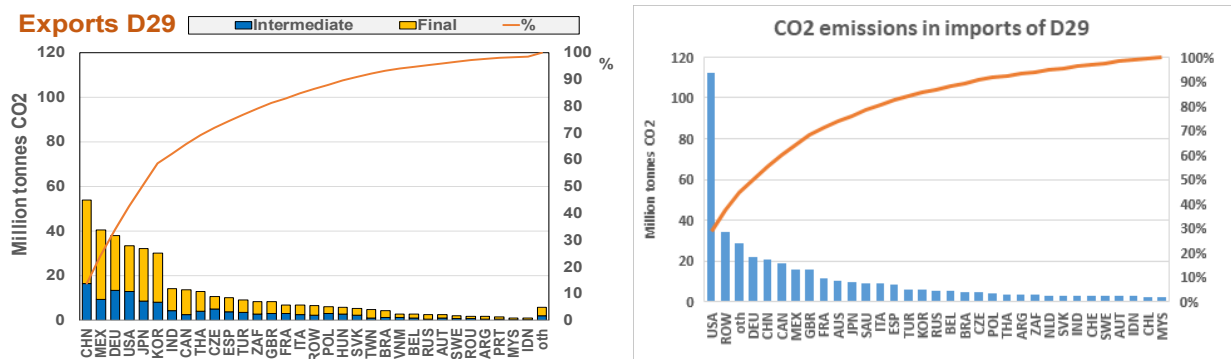
Panel E. Computer, electronic and electrical equipment



Panel F. Machinery and equipment, nec



Panel G. Motor vehicles, trailers and semi-trailers



*Note:* The sum for the ICIO countries not individually displayed in each chart is show as “oth”. ROW is the sum of non-target countries in ICIO (65th country in Table A.1).

*Source:* OECD’s Carbon dioxide (CO<sub>2</sub>) emissions embodied in international trade (TECO2) database (<http://oe.cd/io-co2>), 2019.

## 5. Final Comments

To obtain these latest estimates of CO<sub>2</sub> 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 greater use of available data than previous versions and in doing so, it uses novel approaches that, we believe, produces improved results.

For database construction, the new approaches 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 Inter-Country Use Tables (ICUTs) from the underlining ICIO system, which covers 198 economies and 75 products and 75 industries; and, b) for CO<sub>2</sub> fuel combustion emissions, we have made full use of the IEA database, considering the 138 countries which match countries in the ICUTs, and emissions related to international bunker fuels. Using this more detailed information it was possible to better allocate emissions to road transportation and fill 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 a more detailed set of industries and countries were then aggregated to match the 36 industries and 65 economies considered in the ICIO system, which was then used to estimate CO<sub>2</sub> emissions, from fuel combustion, embodied in final demand and international gross trade. The updated set of indicators based on gross exports and final demand now include bilateral and industrial dimensions.

The distinction between production-based and consumption-based emissions is directly relevant for on-going policy discussions. Recognising 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, 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).

Although developed nations have reduced their emissions, and their reliance on fossil fuels, they still have relatively high emissions intensities. For developing nations, a major challenge is how to improve the well-being of their people while reducing emissions. For an excellent discussion of this issue see OECD (2019b) which also proposes a range of actions that could be applied to reduce emissions and increase the well-being of the world population at the same time. Another 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 nations in the quest for global decarbonisation.

To better contribute to discussions on decarbonisation and climate change, and to improve the estimations of emissions embodied in final demand and trade, the next steps to be followed in this work will be a complete integration of the estimations with the Air Emissions Accounts and the inclusion of other greenhouse gas emissions.

## Endnotes

<sup>1</sup> The authors would like to thank Colin Webb for his valuable comments and ideas throughout the work on the databases and this paper. The authors also acknowledge, with thanks, the comments received from Andrew Wyckoff, Dirk Pilat, Sarah Box, Simon Buckle, Nathalie Girouard, Miguel Cardenas Rodriguez and Ivan Hascic, that helped improve this paper.

<sup>2</sup> Links to data and definitions presented in this section are available in the *Data Links* section of this paper.

<sup>3</sup> The OECD ICIO system considers: a) 65 economies and 17 regions (Annex A); and b) 36 industries and 19 industry aggregates (Annex B).

<sup>4</sup> IEA CO<sub>2</sub> Emissions from Fuel Combustion (2018 edition), <https://www.iea.org//statistics/>

<sup>5</sup> The construction of the OECD's ICIO considers in its estimation 197 countries, 75 commodities and 75 industries.

<sup>6</sup> This estimation considers the OECD's ICIO system with 75 commodities and 75 industries.

<sup>7</sup> <https://www.iea.org/statistics-questionnaires-faq> (See question 3)

<sup>8</sup> The Federation of Electric Power Companies of Japan, Electricity Statistics Information, <http://www5.fepc.or.jp/tok-bin-eng/kensaku.cgi>

<sup>9</sup> <https://www.icao.int/sustainability/Documents/LCC-List.pdf>

[https://www.icao.int/sustainability/SiteAssets/Pages/Eap\\_ER\\_Databases/FINAL\\_Airlines%20Privatization.pdf](https://www.icao.int/sustainability/SiteAssets/Pages/Eap_ER_Databases/FINAL_Airlines%20Privatization.pdf)

<sup>10</sup> Further data collection and harmonisation using Air Emissions Account is suggested for future extension.

<sup>11</sup> The data used in the Figures of this section are presented in the Annexes.

<sup>12</sup> See Annex C for the list of indicators available in <http://oe.cd/io-co2>.

<sup>13</sup> See Annex A for the list of regions.

## References

- Ahmad, N. and A. Wyckoff (2003). "Carbon dioxide emissions embodied in international trade of goods", OECD Science, Technology and Industry Working Papers, No. 2003/15, OECD Publishing, Paris. DOI: <https://dx.doi.org/10.1787/421482436815>
- Arto, I., JM Rueda-Cantuche, GP Peters (2014). Comparing the GTAP-MRIO and WIOD databases for carbon footprint analysis, *Economic Systems Research* 26 (3), 327-353. DOI: <https://doi.org/10.1080/09535314.2014.939949>
- Barrett, J., G. Peters, T. Wiedmann, K. Scott, M. Lenzen, K. Roelich and C. Le Quéré (2013). Consumption-Based GHG Emission Accounting: A UK Case Study. *Climate Policy*, 13, 451–470.
- Davis, S.J. and K. Caldeira (2010). Consumption-based accounting of CO<sub>2</sub> emissions, *Proceedings of the National Academy of Sciences of the United States of America*, 107(12), pp. 5687–5692. DOI: <https://doi.org/10.1073/pnas.0906974107>
- Duarte, R., V. Pinilla and A. Serrano (2018) Factors driving embodied carbon in international trade: a multiregional input–output gravity model, *Economic Systems Research*, 30:4, 545-566, DOI: <https://doi.org/10.1080/09535314.2018.1450226>
- EC, FAO, OECD, UN and World Bank (2014). *System of Environmental-Economic Accounting 2012: Applications and Extensions*: <http://unstats.un.org/unsd/envaccounting/pubs.asp>
- Flachenecker, F., E. Guidetti and P. Pionnier (2018). Towards global SEEA Air Emission Accounts: Description and evaluation of the OECD methodology to estimate SEEA Air Emission Accounts for CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O in Annex-I countries to the UNFCCC, OECD Statistics Working Papers, 2018/11, OECD Publishing, Paris. DOI: <https://doi.org/10.1787/7d88dfdd-en>
- Guilhoto, J.J.M., G.J.D. Hewings, N. Johnstone, C. Webb and N. Yamano (2019). Exploring Changes in World Production and Trade, Insights from the 2018 Update of OECD's ICIO/TiVA Database. *OECD Science, Technology and Industry Working Papers*. DOI: <https://doi.org/10.1787/6f9a10dc-en>
- IEA (2018). *CO<sub>2</sub> Emissions from Fuel Combustion*, International Energy Agency. Paris, France.
- Intergovernmental Panel on Climate Change (IPCC) (2006). The 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Institute for Global Environmental Strategies, Hayama. Available from: <http://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html>
- Lenzen, M. (2016) Structural analyses of energy use and carbon emissions – an overview, *Economic Systems Research*, 28:2, 119-132, DOI: <https://doi.org/10.1080/09535314.2016.1170991>
- Moran, D. and R. Wood (2014). Convergence Between the EORA, WIOD, EXIOBASE, and OpenEU's Consumption-Based Carbon Accounts, *Economic Systems Research*, 26:3, 245-261, DOI: <https://doi.org/10.1080/09535314.2014.935298>
- Nordhaus, W. (2015). Climate Clubs: Overcoming Free-riding in International Climate Policy. *American Economic Review*, 105(4):1339–1370. DOI: <https://doi.org/10.1257/aer.15000001>
- OECD (2011). *Towards Green Growth: Monitoring Progress*, OECD Publishing, Paris. DOI: <https://doi.org/10.1787/9789264111356-en>
- OECD (2013). *Carbon Dioxide Emissions Embodied in International Trade*, 2013. Available from: [http://stats.oecd.org/Index.aspx?DataSetCode=STAN\\_IO\\_GHG](http://stats.oecd.org/Index.aspx?DataSetCode=STAN_IO_GHG)
- OECD (2014; 2017). *Green Growth Indicators*.
- OECD (2019). *Carbon Dioxide Emissions Embodied in International Trade*, 2019 edition. Available from: [http://stats.oecd.org/Index.aspx?DataSetCode=STAN\\_IO\\_GHG](http://stats.oecd.org/Index.aspx?DataSetCode=STAN_IO_GHG)
- OECD (2019b), *Accelerating Climate Action: Refocusing Policies through a Well-being Lens*, OECD

- Publishing, Paris, <https://doi.org/10.1787/2f4c8c9a-en>.
- Owen, A., K. Steen-Olsen, J. Barrett, T. Wiedmann and M. Lenzen (2014). A structural decomposition approach to comparing MRIO databases, *Economic Systems Research*, 26(3), pp.262–283. DOI: <https://doi.org/10.1080/09535314.2014.935299>
- Peters, G. (2008). From production-based to consumption-based national emission inventories, *Ecological Economics*, 65(1), pp.13–23. DOI: <https://doi.org/10.1016/j.ecolecon.2007.10.014>
- Ringius, L., A. Torvanger and A. Underdal (2002). Burden Sharing and Fairness Principles in International Climate Policy. *International Environmental Agreements: Politics, Law and Economics*, 2:1-22. DOI: <https://doi.org/10.1023/A:1015041613785>
- Rose, A. (1998). Burden-sharing and climate change policy beyond Kyoto: Implications for developing countries, *Environment and Development Economics*, 3(3), 347-409. DOI: <https://doi.org/10.1017/S1355770X98300194>
- UN (2017). *World Population Prospects, the 2017 Revision*. June 2017.
- Weber, S., R. Gerlagh, N.A. Mathys, and D. Moran (2019). CO<sub>2</sub> embedded in trade: trends and fossil fuel drivers. *CESifo Working Papers No. 7562*.
- Weber, C. and G. Peters (2009). Climate change policy and international trade: Policy considerations in the US, *Energy Policy*, Volume 37, Issue 2, 432-440. DOI: <https://doi.org/10.1016/j.enpol.2008.09.073>
- Wiebe, K. and N. Yamano (2016). Estimating CO<sub>2</sub> emissions embodied in final demand and trade using the OECD ICIO 2015, *OECD Science, Technology and Industry Working Papers*, No. 2016/05, OECD Publishing, Paris. DOI: <https://doi.org/10.1787/5jlrcm216xkl-en>
- Wiedmann, T. (2009). A review of recent multi-region input–output models used for consumption-based emission and resource accounting, *Ecological Economics*, 69(2), pp.211–222. DOI: <https://doi.org/10.1016/j.ecolecon.2009.08.026>
- Wieland, H., S. Giljum, M. Bruckner, A. Owen and R. Wood (2018). Structural production layer decomposition: a new method to measure differences between MRIO databases for footprint assessments, *Economic Systems Research*, 30:1, 61-84, DOI: <https://doi.org/10.1080/09535314.2017.1350831>
- Wilting, H.C. (2012). Sensitivity and Uncertainty Analysis in MRIO Modelling; Some Empirical Results with Regard to the Dutch Carbon Footprint. *Economic Systems Research*, 24, 141–171. DOI: <https://doi.org/10.1080/09535314.2011.628302>.
- Wyckoff, A.W. and J.M. Roop (1994). "The embodiment of carbon in imports of manufactured products: Implications for international agreements on greenhouse gas emissions", *Energy Policy*, 22(3), pp.187–194. DOI: [https://dx.doi.org/10.1016/0301-4215\(94\)90158-9](https://dx.doi.org/10.1016/0301-4215(94)90158-9)

## *Data Links*

**IEA\_CO<sub>2</sub>**, IEA (2018). *CO<sub>2</sub> Emissions from Fuel Combustion*, International Energy Agency. Paris, France, September 2018  
<https://www.iea.org/statistics/co2emissions/>

**OECD Air emissions accounts**  
<https://stats.oecd.org/Index.aspx?QueryId=72560>

**OECD\_ICIO**: OECD (2018) Inter-country Input-Output Database.  
<http://oe.cd/icio>

**OECD\_TECO<sub>2</sub>** Carbon dioxide (CO<sub>2</sub>) 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  
<https://unfccc.int/process-and-meetings/transparency-and-reporting/greenhouse-gas-data/ghg-data-unfccc/ghg-data-from-unfccc>

**UNPOP**: UN (2017). World Population Prospects, the 2017 Revision. June 2017.  
<https://www.un.org/development/desa/publications/world-population-prospects-the-2017-revision.html>

## Annex A. ICIO 2018 Geographical Coverage

Table A.1. 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

\* **Note by Turkey:** The information in this document with reference to “Cyprus” relates to the southern part of the Island. There is no single authority representing both Turkish and Greek Cypriot people on the Island. Turkey recognises the Turkish Republic of Northern Cyprus (TRNC). Until a lasting and equitable solution is found within the context of the United Nations, Turkey shall preserve its position concerning the “Cyprus issue”. **Note by all the European Union Member States of the OECD and the European Union:** The Republic of Cyprus is recognised by all members of the United Nations with the exception of Turkey. The information in this document relates to the area under the effective control of the Government of the Republic of Cyprus.



Table A.2. 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 <sup>1</sup>	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 <sup>2</sup>	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
<b>World divided into regions</b>			
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.

*Note:* 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.

\* **Note by Turkey:** The information in this document with reference to “Cyprus” relates to the southern part of the Island. There is no single authority representing both Turkish and Greek Cypriot people on the Island. Turkey recognises the Turkish Republic of Northern Cyprus (TRNC). Until a lasting and equitable solution is found within the context of the United Nations, Turkey shall preserve its position concerning the “Cyprus issue”. **Note by all the European Union Member States of the OECD and the European Union:** The Republic of Cyprus is recognised by all members of the United Nations with the exception of Turkey. The information in this document relates to the area under the effective control of the Government of the Republic of Cyprus.

## Annex B. ICIO 2018 Industry Coverage

**Table B.1. 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

Table B.2. 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

<b>Core indicators</b>
FD_CO2: CO <sub>2</sub> emissions embodied in domestic final demand, by source country and industry
PROD_CO2: CO <sub>2</sub> emissions based on domestic production
EXGR_TCO2: Total CO <sub>2</sub> emissions embodied in gross exports
IMGR_TCO2: Total CO <sub>2</sub> emissions embodied in gross imports
FD_PCCO2: CO <sub>2</sub> emissions embodied in domestic final demand per capita
PROD_PCCO2: CO <sub>2</sub> emissions per capita based on domestic production
EXGR_TCO2int: Intensity of CO <sub>2</sub> emissions embodied in total gross exports
IMGR_TCO2int: Intensity of CO <sub>2</sub> emissions embodied in gross imports
<b>Additional indicators</b>
BALCO2_FD: CO <sub>2</sub> embodied in final demand, balance
FFD_DCO2: Domestic CO <sub>2</sub> emissions embodied in foreign final demand
DFD_FCO2: Foreign CO <sub>2</sub> emissions embodied in domestic final demand
FD_CO2_SH: CO <sub>2</sub> emissions embodied in domestic final demand, shares by country and industry of origin (emitter)
FFD_DCO2pSH: Domestic CO <sub>2</sub> emissions embodied in foreign final demand, partner shares
DFD_FCO2pSH: Foreign CO <sub>2</sub> emissions embodied in domestic final demand, partner shares
EXGR_DCO2: Domestic CO <sub>2</sub> emissions embodied in gross exports
EXGR_DCO2pSH: Domestic CO <sub>2</sub> emissions embodied in gross exports, partner shares
EXGR_FCO2: Foreign CO <sub>2</sub> emissions embodied in gross exports
EXGR_FCO2pSH: Foreign CO <sub>2</sub> emissions embodied in gross exports, partner shares
EXGR_TCO2pSH: Total CO <sub>2</sub> emissions embodied in gross exports, partner shares
EXGR_INTDCO2: Domestic CO <sub>2</sub> emissions embodied in gross exports of intermediate products
EXGR_INTDCO2pSH: Domestic CO <sub>2</sub> emissions embodied in gross exports of intermediate products, partner shares
EXGR_INTFCO2: Foreign CO <sub>2</sub> emissions embodied in gross exports of intermediate products
EXGR_INTFCO2pSH: Foreign CO <sub>2</sub> emissions embodied in gross exports of intermediate products, partner shares
EXGR_INTTCO2: Total CO <sub>2</sub> emissions embodied in gross exports of intermediate products
EXGR_INTTCO2pSH: Total CO <sub>2</sub> emissions embodied in gross exports of intermediate products, partner shares
EXGR_INTTCO2int: Intensity of CO <sub>2</sub> emissions embodied in total gross exports of intermediate products
EXGR_FNLDCO2: Domestic CO <sub>2</sub> emissions embodied in gross exports of final products
EXGR_FNLDCO2pSH: Domestic CO <sub>2</sub> emissions embodied in gross exports of final products, partner shares
EXGR_FNLFCO2: Foreign CO <sub>2</sub> emissions embodied in gross exports of final products
EXGR_FNLFCO2pSH: Foreign CO <sub>2</sub> emissions embodied in gross exports of final products, partner shares
EXGR_FNLTCO2: Total CO <sub>2</sub> emissions embodied in gross exports of final products
EXGR_FNLTCO2pSH: Total CO <sub>2</sub> emissions embodied in gross exports of final products, partner shares
EXGR_FNLTCO2int: Intensity of CO <sub>2</sub> emissions embodied in total gross exports of final products
IMGR_DCO2: Domestic CO <sub>2</sub> emissions embodied in gross imports
IMGR_DCO2SH: Domestic CO <sub>2</sub> emissions share of gross imports
IMGR_FCO2: Foreign CO <sub>2</sub> emissions embodied in gross imports
BALCO2_GR: CO <sub>2</sub> embodied in gross exports, balance

*Note:* Indicator definitions are available in the metadata section of [https://stats.oecd.org/Index.aspx?DataSetCode=IO\\_GHG\\_2019](https://stats.oecd.org/Index.aspx?DataSetCode=IO_GHG_2019)

### Annex D. Production and consumption-based emissions of CO<sub>2</sub>, total (million tonnes CO<sub>2</sub>) and per capita (tonnes per capita), 2005 and 2015 (Figure 4.1 and Figure 4.2)

Country or Region	Total Emissions (Million tonnes CO <sub>2</sub> )				Emissions per capita (Tonnes per capita)			
	Production		Consumption		Production		Consumption	
	2005	2015	2005	2015	2005	2015	2005	2015
<i>OECD member</i>	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

Country or Region	Total Emissions (Million tonnes CO <sub>2</sub> )				Emissions per capita (Tonnes per capita)			
	Production		Consumption		Production		Consumption	
	2005	2015	2005	2015	2005	2005	2015	2015
<i>Non-OECD</i>	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<sub>2</sub>) emissions embodied in international trade (TECO2) database (<http://oe.cd/io-co2>), 2019.

\* **Note by Turkey:** The information in this document with reference to "Cyprus" relates to the southern part of the Island. There is no single authority representing both Turkish and Greek Cypriot people on the Island. Turkey recognises the Turkish Republic of Northern Cyprus (TRNC). Until a lasting and equitable solution is found within the context of the United Nations, Turkey shall preserve its position concerning the "Cyprus issue". **Note by all the European Union Member States of the OECD and the European Union:** The Republic of Cyprus is recognised by all members of the United Nations with the exception of Turkey. The information in this document relates to the area under the effective control of the Government of the Republic of Cyprus.

### Annex E. Share of CO<sub>2</sub> emitted abroad in total CO<sub>2</sub> 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%	<i>Non-OECD</i>	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<sub>2</sub>) emissions embodied in international trade (TECO<sub>2</sub>) database (<http://oe.cd/io-co2>), 2019.

\* **Note by Turkey:** The information in this document with reference to "Cyprus" relates to the southern part of the Island. There is no single authority representing both Turkish and Greek Cypriot people on the Island. Turkey recognises the Turkish Republic of Northern Cyprus (TRNC). Until a lasting and equitable solution is found within the context of the United Nations, Turkey shall preserve its position concerning the "Cyprus issue". **Note by all the European Union Member States of the OECD and the European Union:** The Republic of Cyprus is recognised by all members of the United Nations with the exception of Turkey. The information in this document relates to the area under the effective control of the Government of the Republic of Cyprus.

### Annex F. CO<sub>2</sub> embodied in gross exports and imports, from domestic and foreign sources (Million Tonnes CO<sub>2</sub>), 2005 and 2015 (Figure 4.4)

Country or region	2015		2015		2005	2015
	Domestic CO <sub>2</sub> emissions embodied in gross exports	Foreign CO <sub>2</sub> emissions embodied in gross exports	Domestic CO <sub>2</sub> emissions embodied in gross imports	Foreign CO <sub>2</sub> emissions embodied in gross imports	CO <sub>2</sub> embodied in gross exports, balance	CO <sub>2</sub> 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



Country or region	2015		2015		2005	2015
	Domestic CO <sub>2</sub> emissions embodied in gross exports	Foreign CO <sub>2</sub> emissions embodied in gross exports	Domestic CO <sub>2</sub> emissions embodied in gross imports	Foreign CO <sub>2</sub> emissions embodied in gross imports	CO <sub>2</sub> embodied in gross exports, balance	CO <sub>2</sub> 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<sub>2</sub>) emissions embodied in international trade (TECO2) database (<http://oe.cd/io-co2>), 2019.

\* **Note by Turkey:** The information in this document with reference to "Cyprus" relates to the southern part of the Island. There is no single authority representing both Turkish and Greek Cypriot people on the Island. Turkey recognises the Turkish Republic of Northern Cyprus (TRNC). Until a lasting and equitable solution is found within the context of the United Nations, Turkey shall preserve its position concerning the "Cyprus issue". **Note by all the European Union Member States of the OECD and the European Union:** The Republic of Cyprus is recognised by all members of the United Nations with the exception of Turkey. The information in this document relates to the area under the effective control of the Government of the Republic of Cyprus.

**Annex G. Relative intensity of CO<sub>2</sub> emissions in gross exports and imports (simple world average = 1.00), 2005, 2010 and 2015 (Figure 4.5 and Figure 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

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<sub>2</sub>) emissions embodied in international trade (TECO2) database (<http://oe.cd/io-co2>), 2019.

\* **Note by Turkey:** The information in this document with reference to "Cyprus" relates to the southern part of the Island. There is no single authority representing both Turkish and Greek Cypriot people on the Island. Turkey recognises the Turkish Republic of Northern Cyprus (TRNC). Until a lasting and equitable solution is found within the context of the United Nations, Turkey shall preserve its position concerning the "Cyprus issue". **Note by all the European Union Member States of the OECD and the European Union:** The Republic of Cyprus is recognised by all members of the United Nations with the exception of Turkey. The information in this document relates to the area under the effective control of the Government of the Republic of Cyprus.

## Annex H. Total CO<sub>2</sub> emissions embodied in gross exports, ICIO industries, Millions Tonnes CO<sub>2</sub> and Shares, 2005 and 2015 (Figure 4.7)

Industry	Million Tonnes CO <sub>2</sub>		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<sub>2</sub>) emissions embodied in international trade (TECO<sub>2</sub>) database (<http://oe.cd/io-co2>), 2019.

### Annex I. Total CO<sub>2</sub> emissions in exports, by exporting country and main exporting industries, million tonnes CO<sub>2</sub>, 2015 (Figure 4.8)

Country or region	CO <sub>2</sub> Emissions embodied in exports, exporting industry, million tonnes CO <sub>2</sub>						
	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

Country or region	CO <sub>2</sub> Emissions embodied in exports, exporting industry, million tonnes CO <sub>2</sub>						
	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<sub>2</sub>) emissions embodied in international trade (TECO2) database (<http://oe.cd/io-co2>), 2019.

\* **Note by Turkey:** The information in this document with reference to "Cyprus" relates to the southern part of the Island. There is no single authority representing both Turkish and Greek Cypriot people on the Island. Turkey recognises the Turkish Republic of Northern Cyprus (TRNC). Until a lasting and equitable solution is found within the context of the United Nations, Turkey shall preserve its position concerning the "Cyprus issue". **Note by all the European Union Member States of the OECD and the European Union:** The Republic of Cyprus is recognised by all members of the United Nations with the exception of Turkey. The information in this document relates to the area under the effective control of the Government of the Republic of Cyprus.

### Annex J. Total CO<sub>2</sub> emissions in imports, by importing country and main exporting industries, million tonnes CO<sub>2</sub>, 2015 (Figure 4.8)

Country or region	CO <sub>2</sub> Emissions embodied in imports, exporting industry, million tonnes CO <sub>2</sub>						
	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

Country or region	CO <sub>2</sub> Emissions embodied in imports, exporting industry, million tonnes CO <sub>2</sub>						
	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<sub>2</sub>) emissions embodied in international trade (TECO2) database (<http://oe.cd/io-co2>), 2019.

\* **Note by Turkey:** The information in this document with reference to "Cyprus" relates to the southern part of the Island. There is no single authority representing both Turkish and Greek Cypriot people on the Island. Turkey recognises the Turkish Republic of Northern Cyprus (TRNC). Until a lasting and equitable solution is found within the context of the United Nations, Turkey shall preserve its position concerning the "Cyprus issue". **Note by all the European Union Member States of the OECD and the European Union:** The Republic of Cyprus is recognised by all members of the United Nations with the exception of Turkey. The information in this document relates to the area under the effective control of the Government of the Republic of Cyprus.