CO2 EMISSIONS EMBODIED IN FINAL DEMAND AND TRADE USING THE ICIO OF THE OECD

EMISIONES DE CO2 INCRUSTADAS EN LA DEMANDA FINAL Y

EL COMERCIO UTILIZANDO LA MATRIZ DE INSUMO

PRODUCTO DE LA OCDE

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Input Output Tables as a tool for Trade and Industrial Policies in Latin America and the Caribbean and its linkages with Asia Pacific,
Santo Domingo, Dominican Republic

11-13 September 2019

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Uses of harmonised SUT and IOT for globalisation analyses

Tables	Example indicator analysis
Supply and Use at pu	National Accounts estimates i.e. GDP (output, expenditure and income approaches)
Use domestic and import tables at basic prices	• Import penetration by using industry and household • Outsourcing and offshoring
Symmetric IO total	Conventional Leontief multiplier with economic impact analysis ($X = (I-A)^{-1}F$)
Symmetric IO domestic (non-competitive IO)	• Domestic and foreign impact analysis ($Xd = (I-Ad)^{-1}FD$) • Import contents share of exports • Foreign contents in domestic consumption
Inter-country IO (MRIO)	• Bilateral economic impact analysis • Trade in value added (TiVA) • Trade in employment, environment

History of OECD's I-O studies

Edition	Target	Methodology	Application
1995 2003 2006-2009	Every 5yrs 10 - 40+	Collection, sector classification Industry-by-industry format	Vertical specialisation Carbon footprint
2011-12	2000,2005 48cou	Connecting symmetric import tables	Demand-based CO_2 GVC analyses
2013	95/00/05/08/09 53cou+row	Connecting use imp at basic prices CHN hetero.	TiVA
2015	95/00/05/08-11 61cou+row	Connecting use at pu prices MEX/CHN hetero.	TiVA +Jobs / CO_2 ICIO published
2016 - 2017	1995-2011 63cou+row	Additional countries	TiVA +Jobs & skills / CO_2
2018-	2005-2015	SNA2008 / ISIC4	Steel industry Tourism industry

The mainstreaming of IO at the OECD

- Analyses of GVCs *(OECD Committee for Industry and Entrepreneurship)*

- Numerous Trade policy papers *(OECD Trade Committee)*

- OECD Country Studies *(Economic Policy Committee)*

- OECD Skills outlook *(Education Committee)*

- Steel and GVCs *(OECD Steel Committee)*

- Shipbuilding *(OECD Shipbuilding Committee)*

- Tourism *(OECD Tourism Committee)*

- Embodied CO2 and material flows *(OECD Environment Committee)*

- Role of SMEs in GVCs *(Committee for Statistics and Statistical Policy*

- Digital economy? *(OECD Committee for Digital Economy Policy)*

- Innovation spillovers? *(OECD Committee for Science and Technology)*

Country coverage

|	
OECD	All OECD 36 countries
BRIICS	Brazil, China, India, Indonesia, Russian Federation, South Africa
Other EU28	Bulgaria, Croatia, Cyprus, Malta, Romania
Other G20	Argentina, Saudi Arabia
Other South Eastern Asia	Brunei Darussalam, Cambodia, Malaysia, Philippines, Singapore, Thailand, Viet Nam
Other Eastern Asia	Chinese Taipei, Hong Kong China
Other	Columbia, Costa Rica, Kazakhstan, Tunisia, Peru, Morocco, RoW
Region groups	OECD, Non-OECD, APEC, ASEAN, Eastern Asia,EU28, Euro Area, North America, etc

Gross exports

2017 — Intermediate, Consumption

Source: OECD (2019) BTDIXE DATABASE
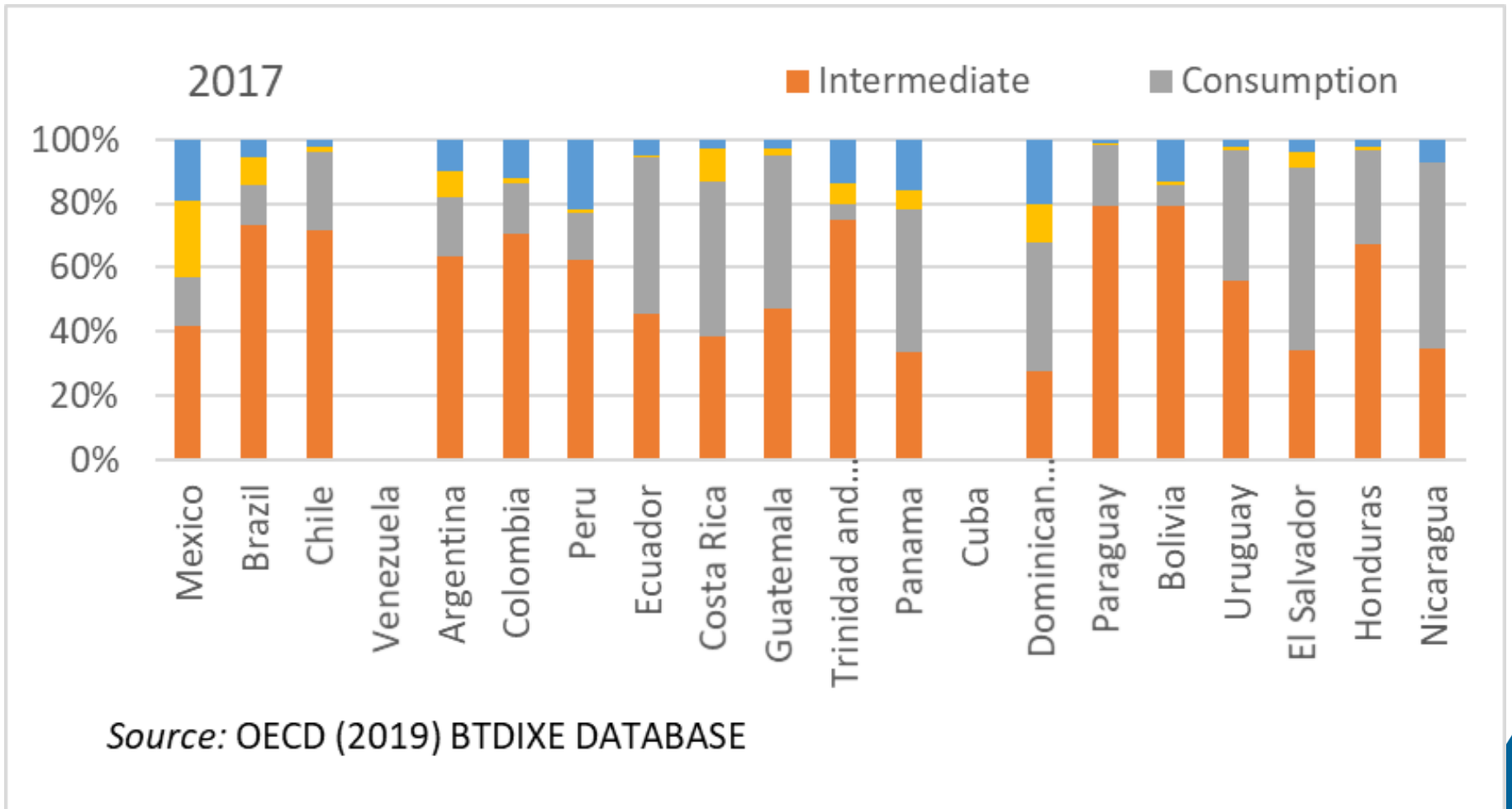
Europe - Domestic value added in exports (primary, manufacturing and services contents)

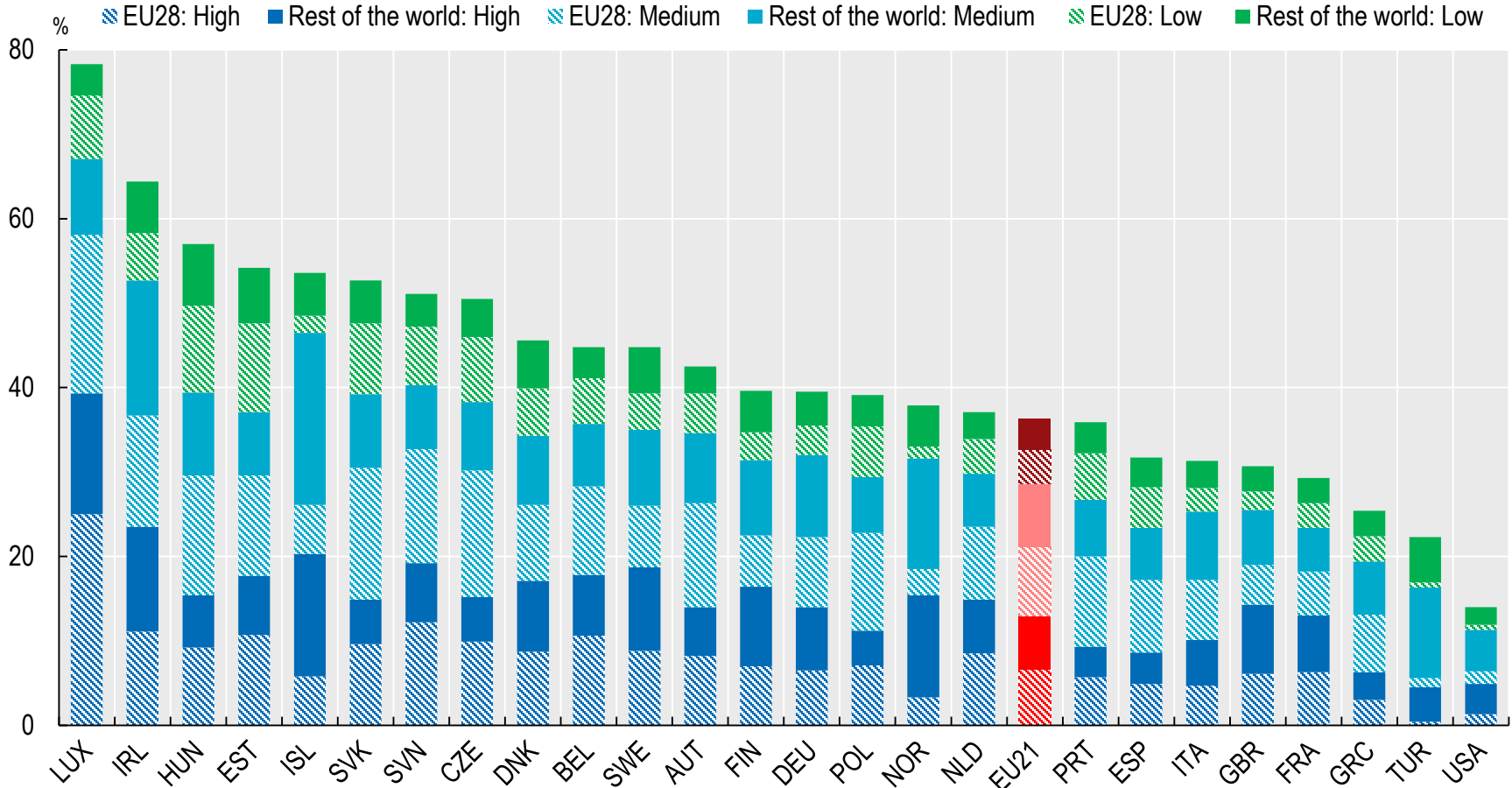Domestic and foreign value added in gross exports (% of gross exports)
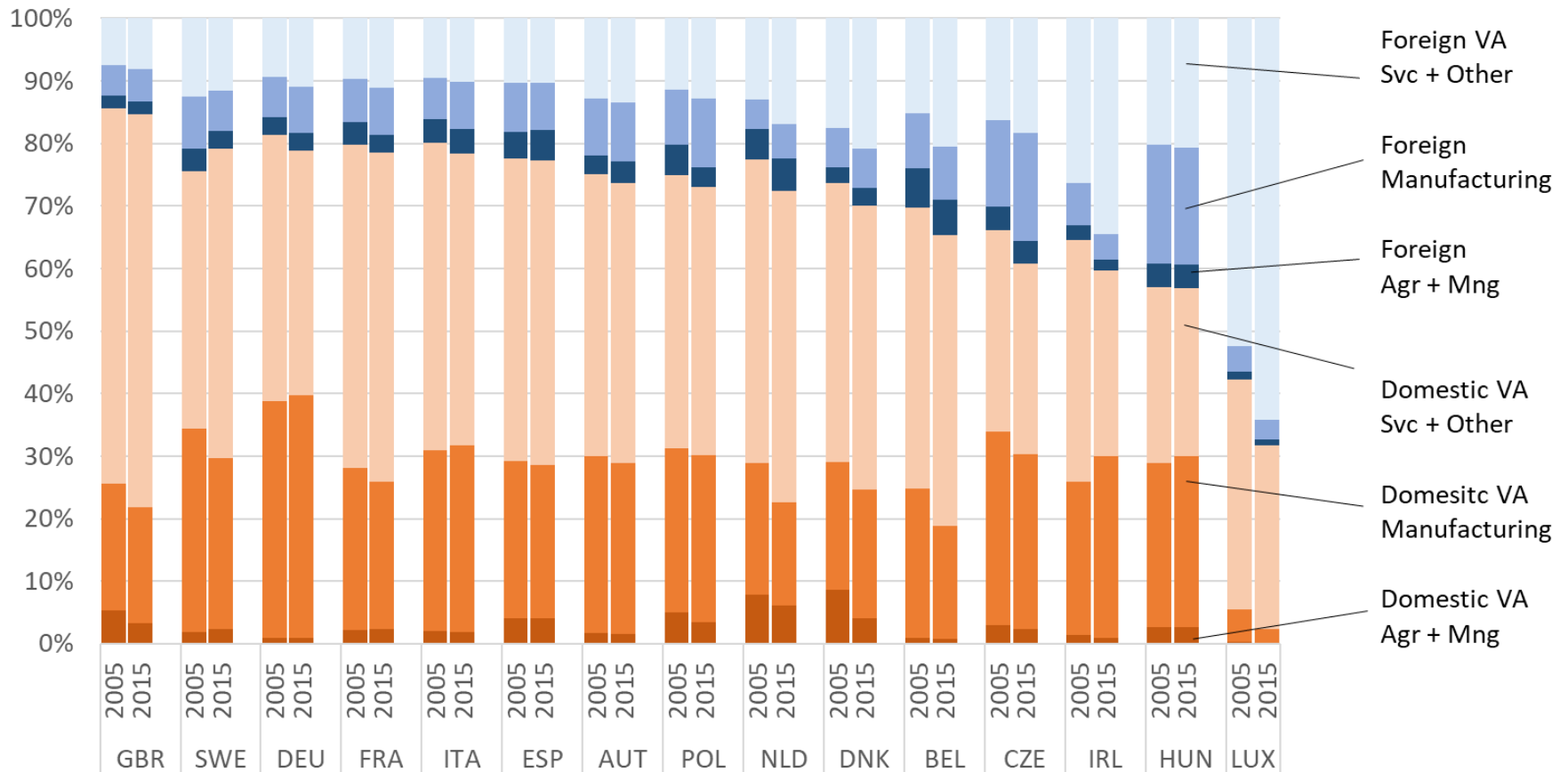
OECD (2018) TiVA
Note: Value added includes taxes less subsidies on intermediate products

Jobs sustained by foreign final demand, by skill intensity, 2011

As a percentage of total business sector employment

Legend: EU28: High · Rest of the world: High · EU28: Medium · Rest of the world: Medium · EU28: Low · Rest of the world: Low

Source: OECD (2015), *OECD Science, Technology and Industry Scoreboard 2015: Innovation for Growth*, OECD Publishing, doi: http://dx.doi.org/10.1787/sti_scoreboard-2015-en.
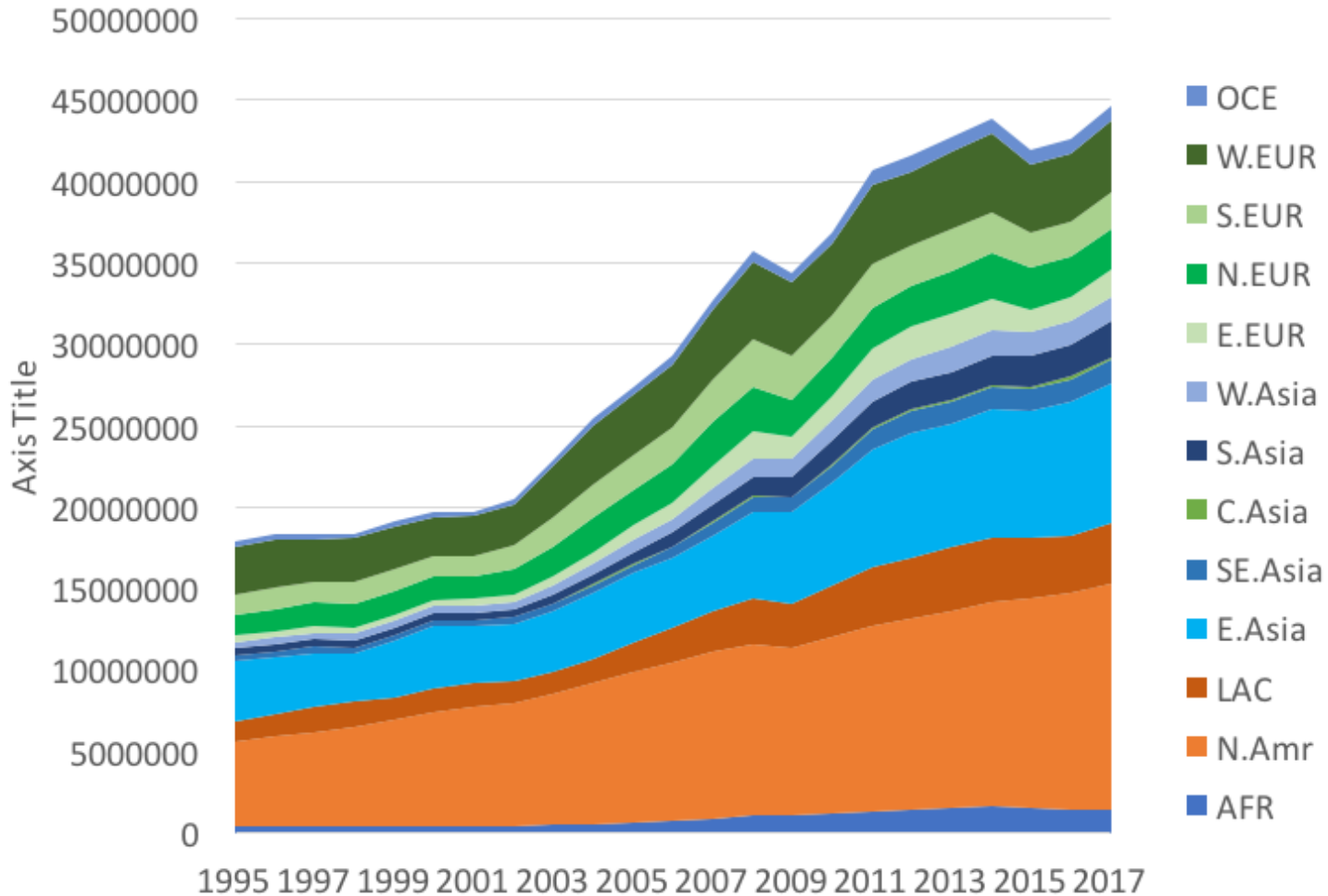
The business sector is defined according to ISIC Rev. 3 Divisions 10 to 74.

TiVA Country coverage by United Nations Geog. Region

GDP by UN geog region (current million USD)

Legend: OCE, W.EUR, S.EUR, N.EUR, E.EUR, W.Asia, S.Asia, C.Asia, SE.Asia, E.Asia, LAC, N.Amr, AFR

2017	GDP
Africa	20.43%
N.Amr	99.97%
LAC	80.26%
E.Asia	99.69%
SE.Asia	96.67%
C.Asia	66.16%
S.Asia	67.66%
W.Asia	64.68%
E.EUR	93.16%
N.EUR	100.00%
S.EUR	97.19%
W.EUR	99.85%
Oceania	98.08%
World	92.23%

UN National Accounts (official country and Main Aggregate Database)

TiVA 2018 Industry list

	ISIC 4	Industry		ISIC 4	Industry
0		Total	21	35 to 39	Utilities
1	01, 02, 03	Agriculture	22	41,42,43	Construction
2	05,06	Mining, energy	23	45,46,47	Wholesale & retail
3	07,08	Mining, non-energy	24	49 to 53	Transport & storage
4	09	Mining, services *	25	55, 56	Hotels & restaurants
5	10,11,12	Food products	26	58,59,60	Publishing, broadcasting
6	13,14,15	Textiles & apparel	27	61	Telecoms
7	16	Wood	28	62,63	IT services
8	17,18	Paper and printing	29	64,65,66	Finance & insurance
9	19	Coke, petroleum	30	68	Real estate
10	20,21	Chemicals	31	69 to 82	Other business services
11	22	Rubber & plastics	32	84	Public admin
12	23	Non-metal minerals	33	85	Education
13	24	Basic metals	34	86,87,88	Health
14	25	Fabricated metals	35	90 to 96	Other services
15	26	ICT & electronics	36	97,98	Private households *
16	27	Electrical machinery			
17	28	Machinery			
18	29	Motor vehicles		16 manufacturing activities	
19	30	Other transport		14 service activities	
20	31,32,33	Other manufacturing			

* optional

Carbon dioxide emissions embodied in international trade

Last updated: **April 2019**

The OECD Inter-Country Input-Output (ICIO) database, when combined with statistics on CO_2 emissions from fuel combustion and other industry statistics, can be used to estimate demand-based CO_2 emissions. That is, the distribution across economies of final *demand* (*household consumption and industry investment*) for embodied carbon that has been emitted anywhere in the world along global production chains.

The Trade in embodied CO_2 (TECO$_2$) database presents a set of indicators to reveal patterns of CO_2 demand compared to CO_2 production (via resident industry or household emissions). The aim is to provide policy makers with new insights into the environmental impacts of global production systems. Indicators presented in TECO$_2$ database include:

> CO_2 emissions based on production (i.e. emitted by countries)

> CO_2 emissions embodied in domestic final demand (i.e. consumed by countries)

> Net exports of CO_2 emissions

> Per capita emissions; production and demand-based

> Country origin of emissions in final demand

Data downloads (country level): OECD.Stat

The six largest producers and consumers of CO_2 emissions in 2015 were China, United States, European Union (EU28), India, Japan and the Russia Federation. While both production and consumption of emissions have fallen in the United States and the European Union since 2005, there has been a significant increase in China and India. China has the highest absolute emissions from both a demand and a production perspective. However, even though China's per capita demand for CO_2 emissions has increased by over 75% since 2005, US per capita demand is over three times higher.

Top 6 carbon dioxide emitters, 2005 and 2015

TiVA indicators at https://stats.oecd.org

DEVELOPMENT OF ICIO

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Features of OECD ICIO

- Long term project (2011 -)
- National account benchmarked
  - trade balances (goods and services)
  - International comparability (VA at basic prices)
- Direct purchases by non-residents
- International trade and transport margins
- Heterogeneity within manufacturing industry
- National I-O (domestic & import tables)
- Balancing with 198cou & 75 products system

Mexico: exports, import penetration and value-added/output ratio
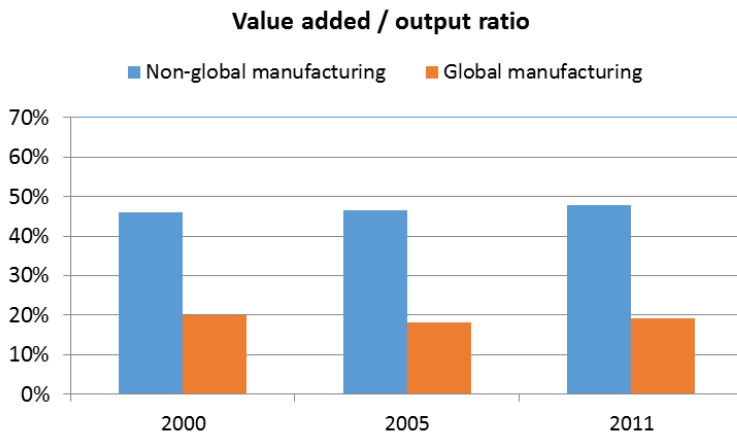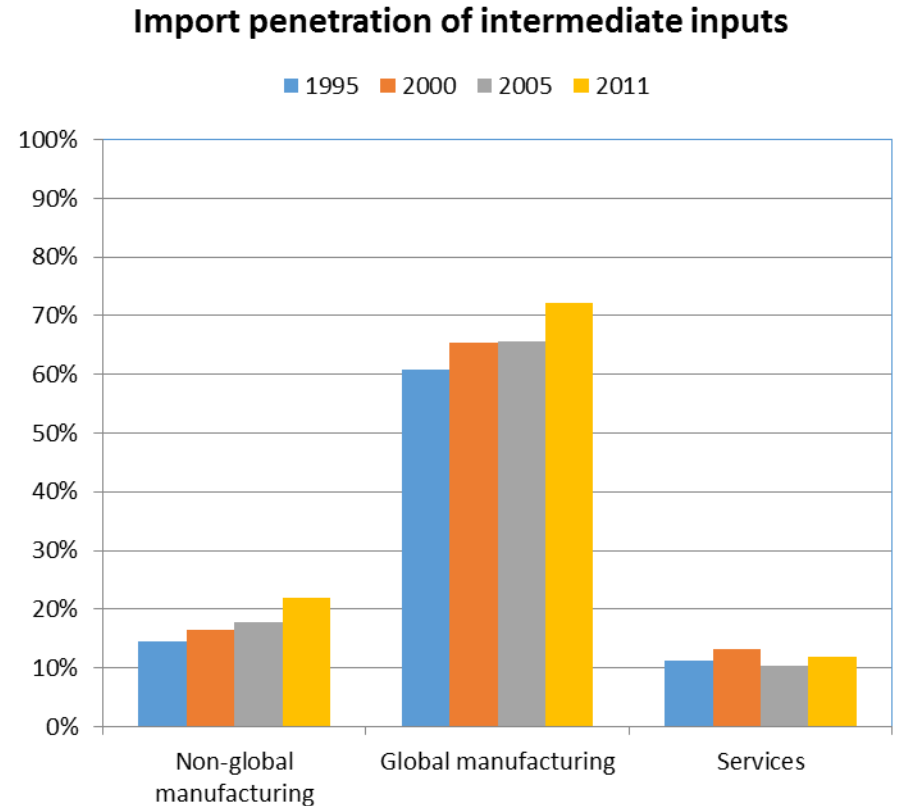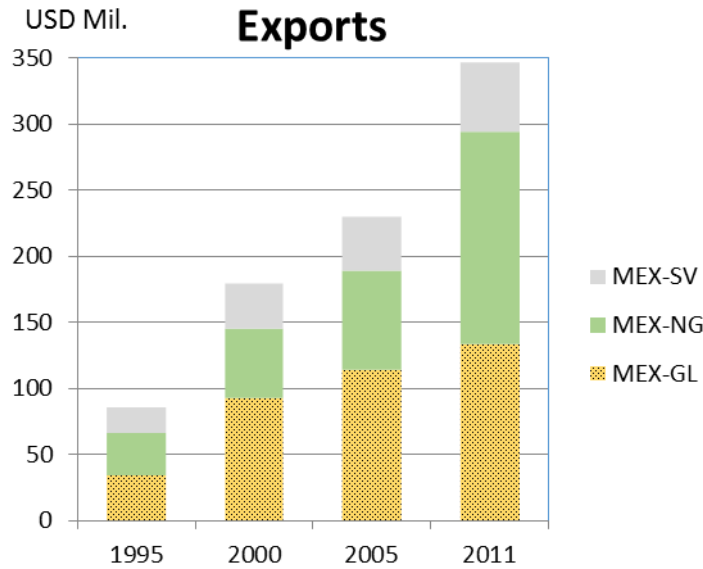
OECD ICIO 2018 compilation overview

1. Data collection and filling gaps
   - SNA/BOP/IO/SUT/SBS/Comtrade/TiS
2. Sectoral constraints
   - Value added and Output
   - Sectoral initial values
   - Expenditure items (includes trade)
3. Balance partner world trade
4. Balance SUTs at purchasers' prices
5. Domestic Symmetric IOT
6. International Use and national Supply
7. Inter-country Input-Output (ICIO)

Data sources for OECD Inter-country inter-industry model

Data sources (national and international)

National Accounts: official country data, main aggregates and satellite accounts

Balance of Payments

Supply-use and Input-Output tables (imports, margins)

Bilateral trade statistics for goods and services

Employment

Tourism satellite account

Energy statistics

Intermediate analytical data products at OECD

Harmonised SUT / symmetric Input-Output tables (OECD I-O)

Bilateral Trade Database by Industry and by End-use for goods (OECD BTDIxE)

Bilateral Trade in Services (OECD-WTO)

Sectoral Value-Added, Output, Employment(OECD STAN)

Adjusted National Accounts (currency, non-resident expenditures and re-exports)

What can countries do to improve analytical framework

- Data
  - Detailed Sectoral VA and Output
  - Capital formation matrix (asset x industry)
  - Energy products trade (pipeline & electricity)
  - Tourism satellite account
  - Annual tables (SUT, IOT, Import)
  - Re-exports in IO/SUT framework
- Analysis
  - Firm heterogeneity within manufacturing industry
  - Subnational regional impact analysis

CO$_2$ EMISSIONS EMBODIED IN PRODUCTION, CONSUMPTION AND TRADE

Features of OECD's CO2 in trade

- Long term project (2003 -)
- Direct purchases by non-resident
  - Household (tourism): road
  - Transportation services industry (marine and aviation international bunkers)
- Using detailed product and country use tables to convert energy/emissions data to ICIO framework

CO$_2$ Emissions factor

- ## OECD's ICUT
  - 198 economies, 75 products, 75 industries
- ## IEA CO$_2$ emissions from fuel combustion
  - 138 economies & world total
  - 46 unique fuel products
  - 34 unique flows (combustion sectors)
- ## OECD's ICUT & IEA CO$_2$
  - 138 economies match + rest of the world
  - 23 flows : one-to-one match
  - 11 flows, one-to-many, allocation based on:
    - Type of fuel use
    - Structure of production and consumption

Definitions of emissions

- Territorial-based emission accounting (e.g. UNFCCC_GHG; IEA_CO2)
  - Fuel sales countries
- Production (e.g. SEEA-AEA; OECD)
  = fuel combustion by domestic industry in territory
    + direct purchases abroad by domestic transp. svc
    - Direct purchases by non-residents transp. svc
- Final demand-based emission accounting
  - The emissions are all embodied in the final demand
    - Foreign CO_2 emissions in domestic demand
    - Domestic CO_2 emissions in foreign demand
- Emissions intensity
  - CO_2 emissions embodied in gross exports
  - CO_2 emissions embodied in gross import

CO2 emissions from fuel combustion

Territorial-based (fuel product)
Other
Oil(37%)
Gas(24%)
Coal(38%)

Territorial-based (flow)
Residential etc(11%)
Transport(26%)
Manuf.& const.(18%)
Electricity and energy(45%)

Resident production-based
Exports
Residential etc
Transport(domestic)
Manufacturing & const.
Electricity and energy
Imports

Production-based by industry/product
AG+MN+CON
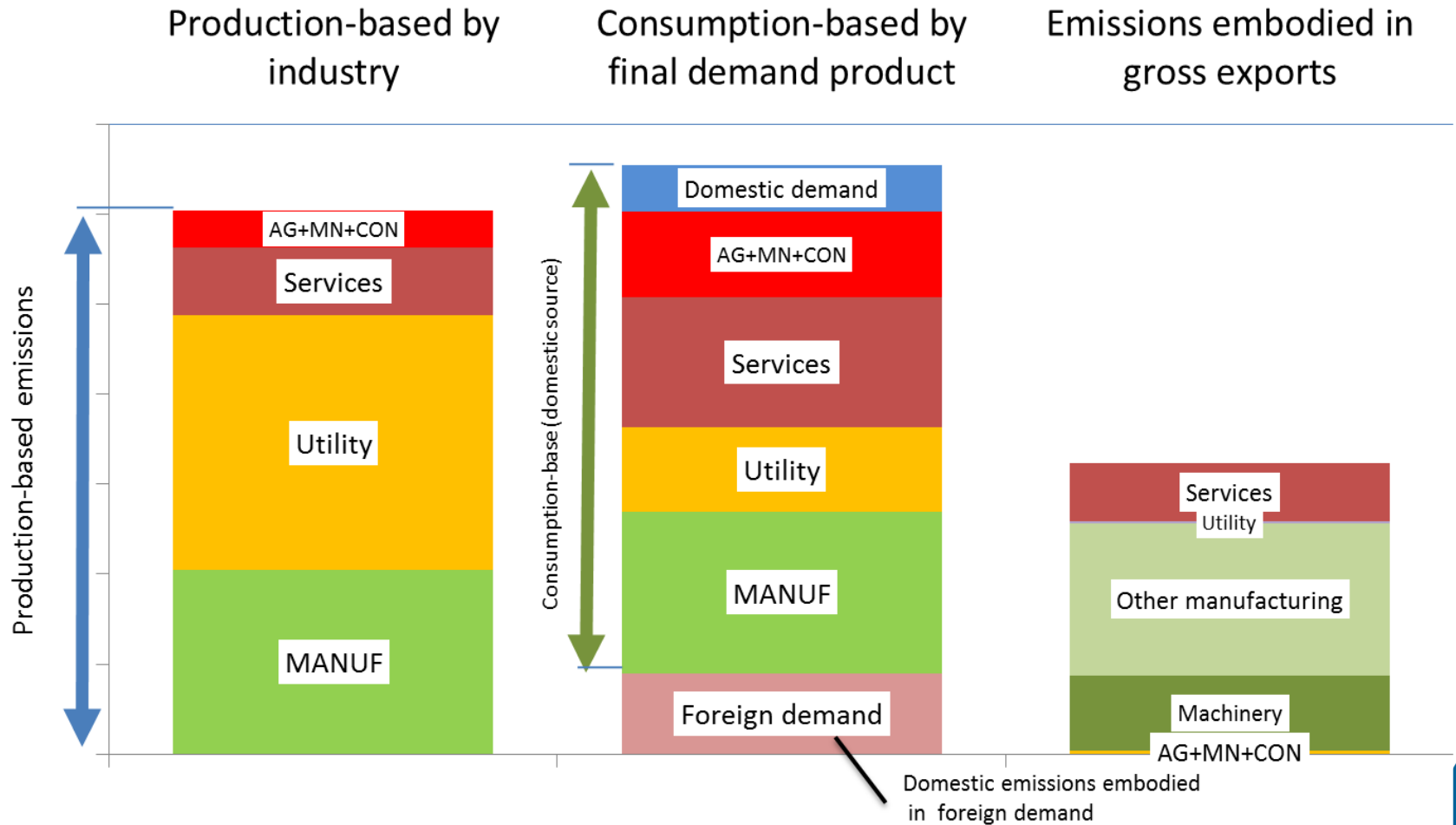Services
Manufacturing
Electricity and energy
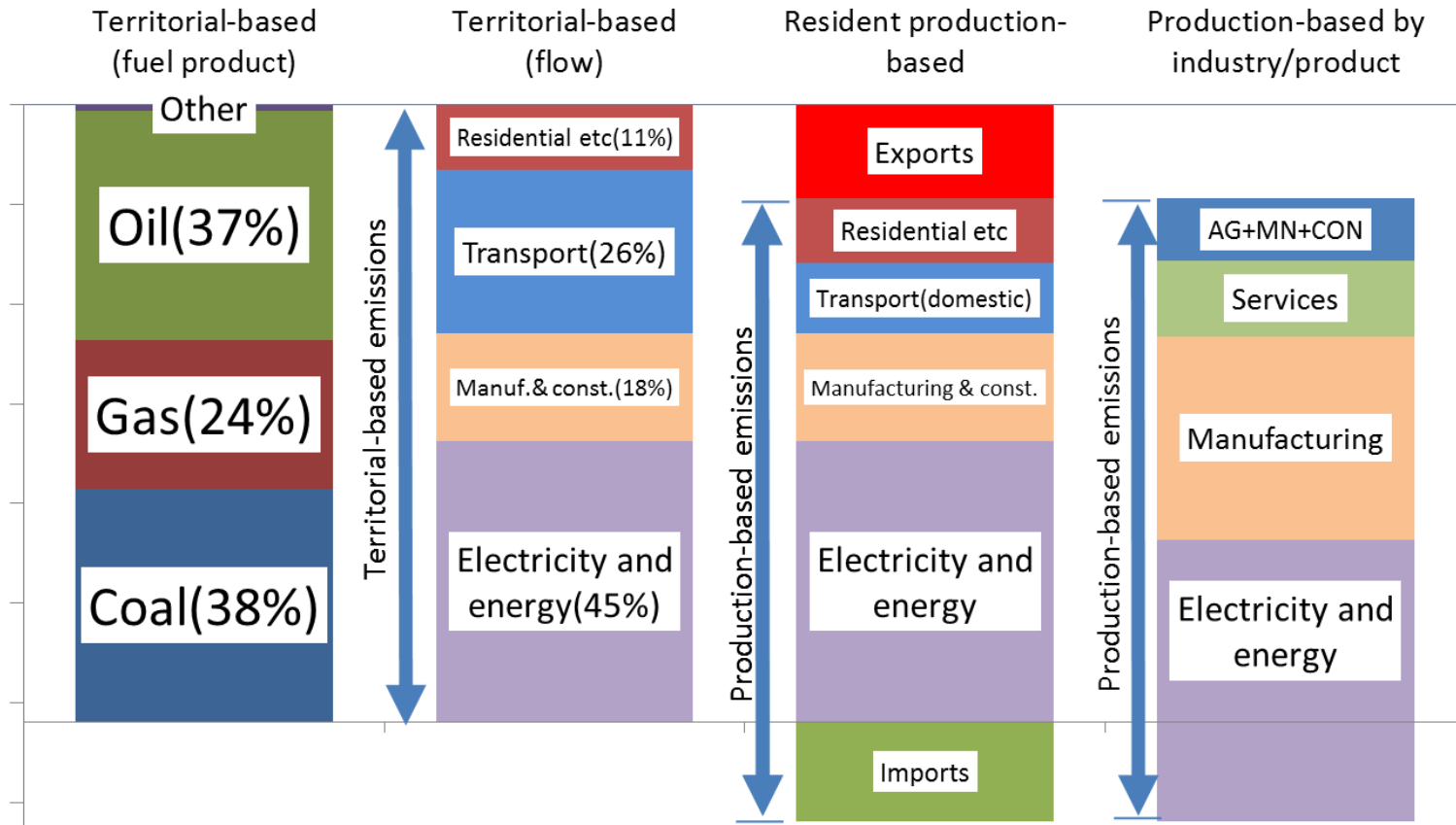
(%) : world average for 2010
Exports = Direct fuel purchases by non-residents (industry and household) in domestic territory
Imports = Direct fuel purchases abroad by residents (industry and household)

Territorial, production, consumption and gross export-based emissions

Production-based by industry

Consumption-based by final demand product

Emissions embodied in gross exports

Production-based emissions

Consumption-base (domestic source)

Production-based by industry: AG+MN+CON, Services, Utility, MANUF

Consumption-based by final demand product: Domestic demand, AG+MN+CON, Services, Utility, MANUF, Foreign demand

Emissions embodied in gross exports: Services, Utility, Other manufacturing, Machinery, AG+MN+CON

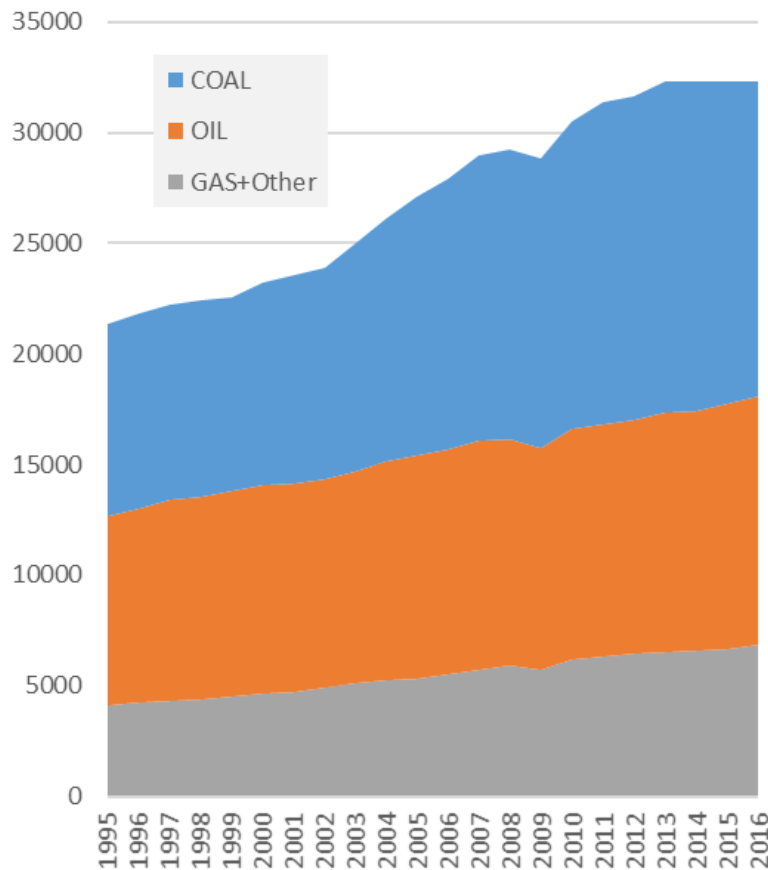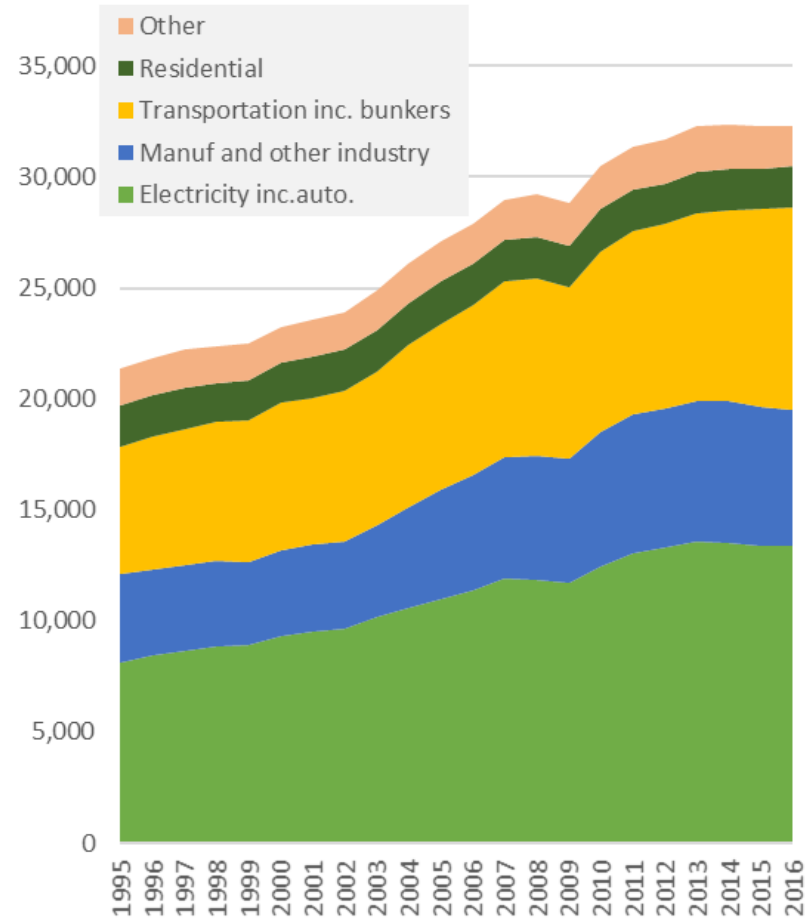Domestic emissions embodied in foreign demand

Territorial-based CO2 emissions from fuel combustion (World, Mton CO2)

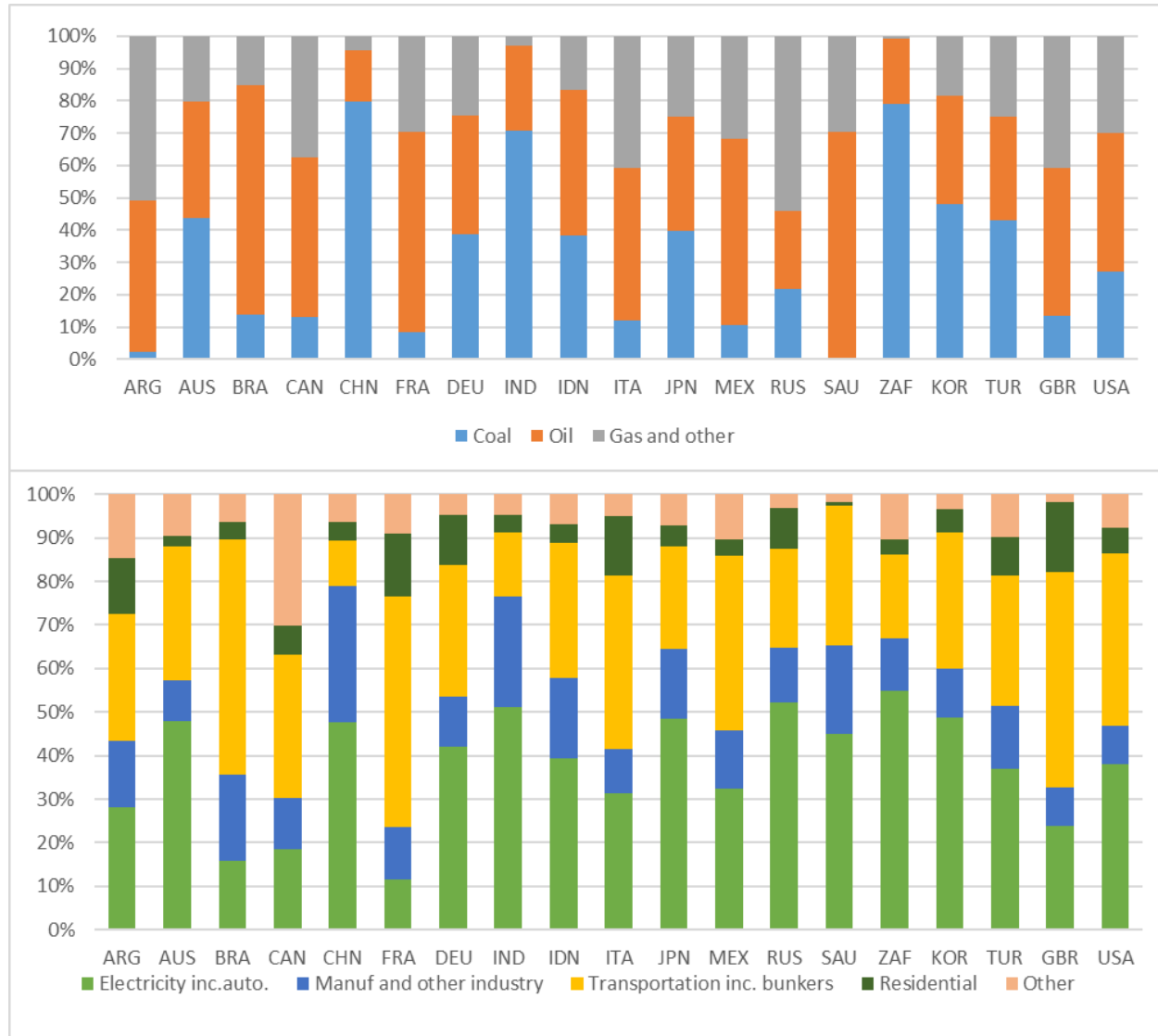by fuel product

2016: coal(44%), oil(35%), gas+other (21%)

by fuel purchaser

2016: Elec.(41%), Manuf. &o ther ind. (19%) Transp(28%),Residential (6%), Other (6%)

Territorial-based CO2 emissions from fuel combustion (selected G20 countries, Mton CO2)

Methodology

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

- Production-based emissions (industry):

$$P^s = TI^s + \sum_s DI^{rs} - \sum_r DI^{rs} \qquad (1)$$

- Emissions factor vector:

$$EF^s = (TI^s + \sum_s DI^{rs} - \sum_r DI^{rs})/X^s \qquad (2)$$

- Resident-based fuel combustion emissions at households:

$$HC^s = TH^s + \sum_s DH^{rs} - \sum_r DH^{rs} \qquad (3)$$

- Emissions embodied in unit production (emissions multiplier):

$$eB = \text{diag (EF) B} \qquad (4)$$

- Production-based emissions:

$$C^{s\cdot} = EF^s * X^s + HC^s \qquad (5)$$
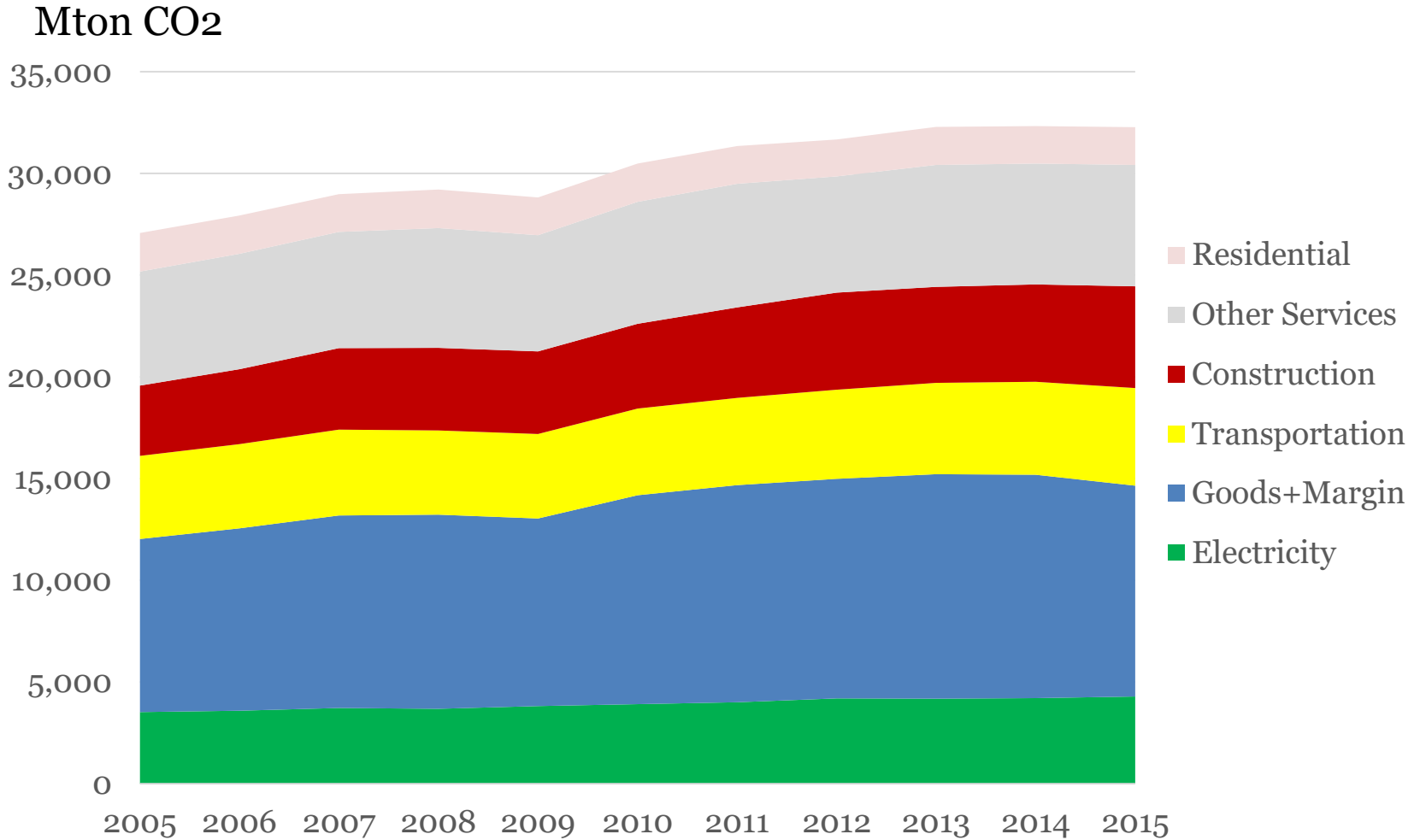
- Demand-based emissions:

$$C^{\cdot s} = eBY^{\cdot s} + HC^s \qquad (6)$$

Demand-based emissions by demand products (World)

Mton CO2

Legend:
- Residential
- Other Services
- Construction
- Transportation
- Goods+Margin
- Electricity

Y-axis: 0, 5,000, 10,000, 15,000, 20,000, 25,000, 30,000, 35,000

X-axis: 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015

Per capita CO$_2$ emissions from fuel combustion demand-based and production-based
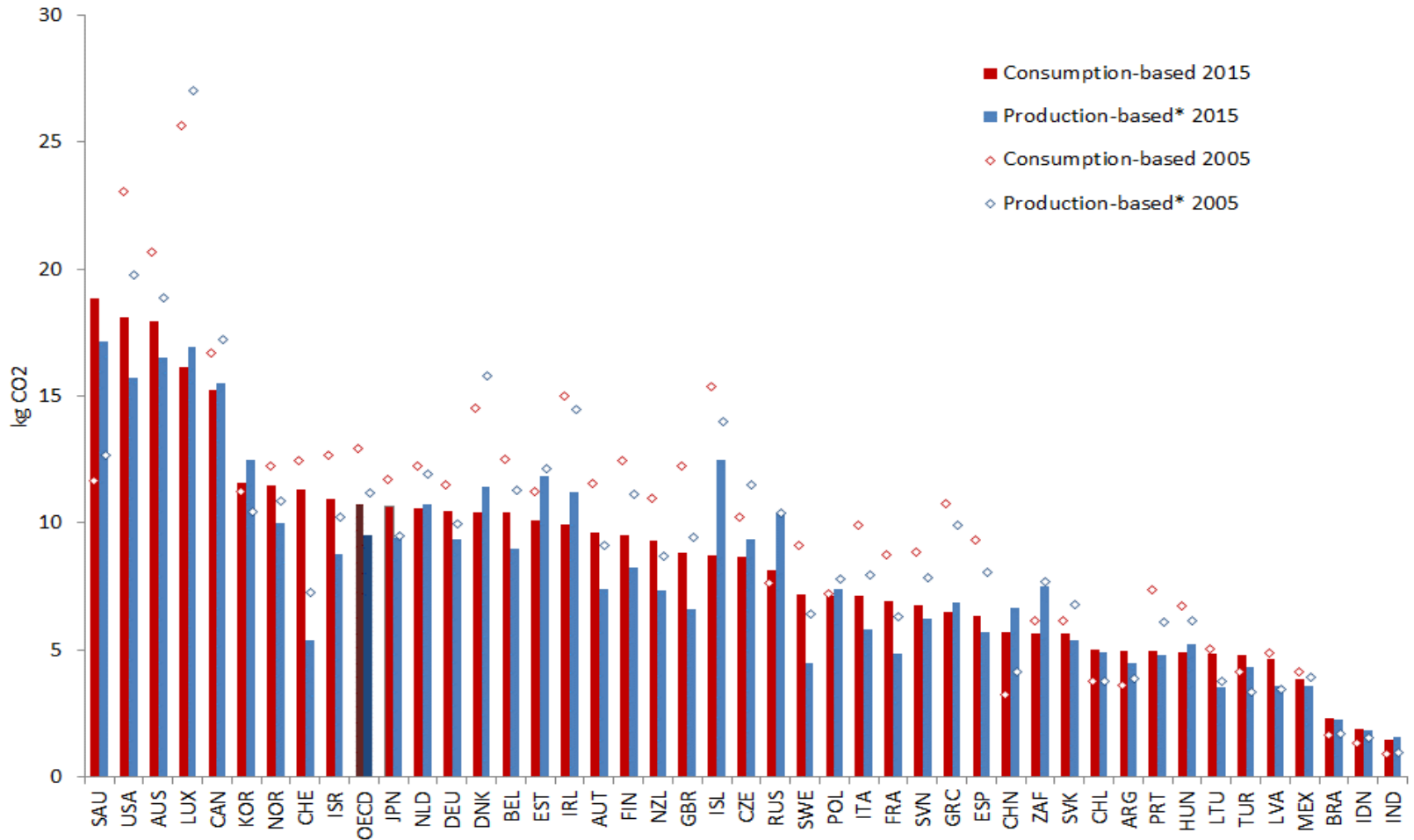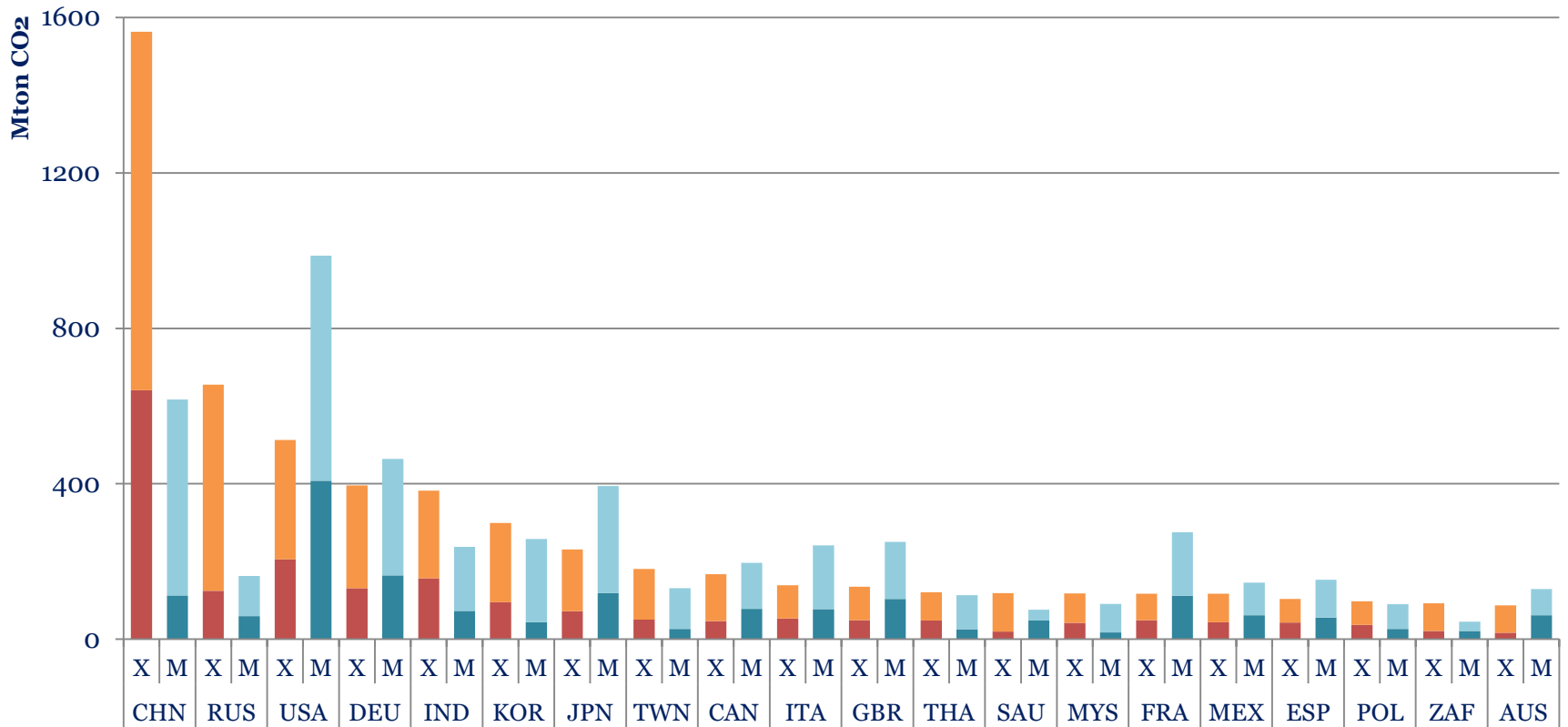

Source: Estimation based on OECD's Inter-Country Input-Output (ICIO) Database (2018), IEA (2018), and UN (2017)

General trends
CO$_2$ embodied in intermediate and final goods trade

Legend:
- ■ Intermediate goods exports X
- ■ Intermediate goods imports M
- ■ Final goods exports X
- ■ Final goods imports M

Production-based and consumption-based CO_2 emissions (OECD and non-OECD)
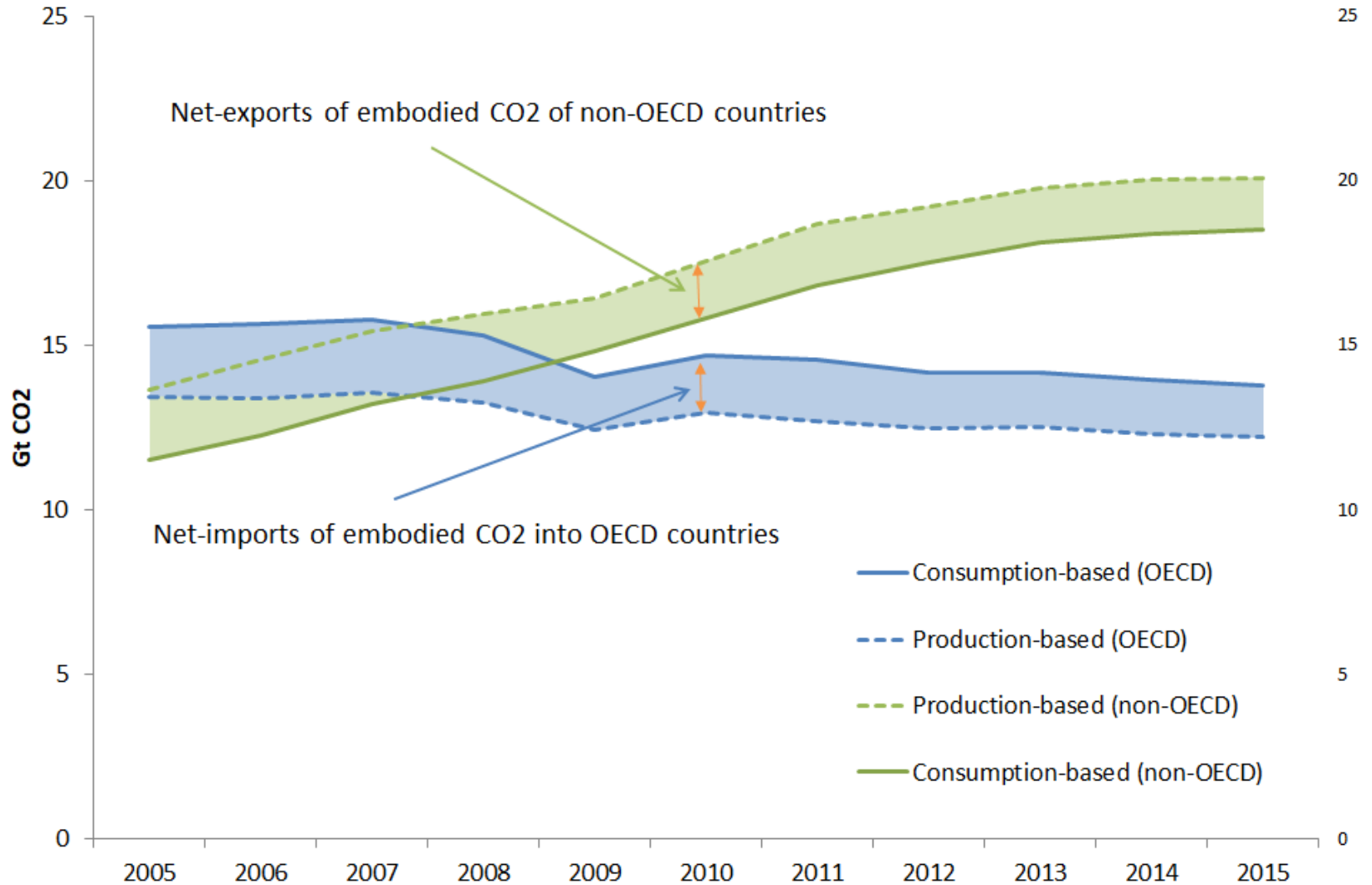
Next steps & challenges

- More integration method with SEEA (e.g. Eurostat and OECD Air Emissions Account)
- Inclusion of other GHGs:
  - Fugitives emissions from fuel
  - Industrial processes (CO2): mineral, chemical, metal, etc
  - Agriculture
- Earlier years (format)
- More recent years (IO/SUT t+4, CO2 t+2)
- More analysis: water, ocean, plastics, circular economics, mineral material
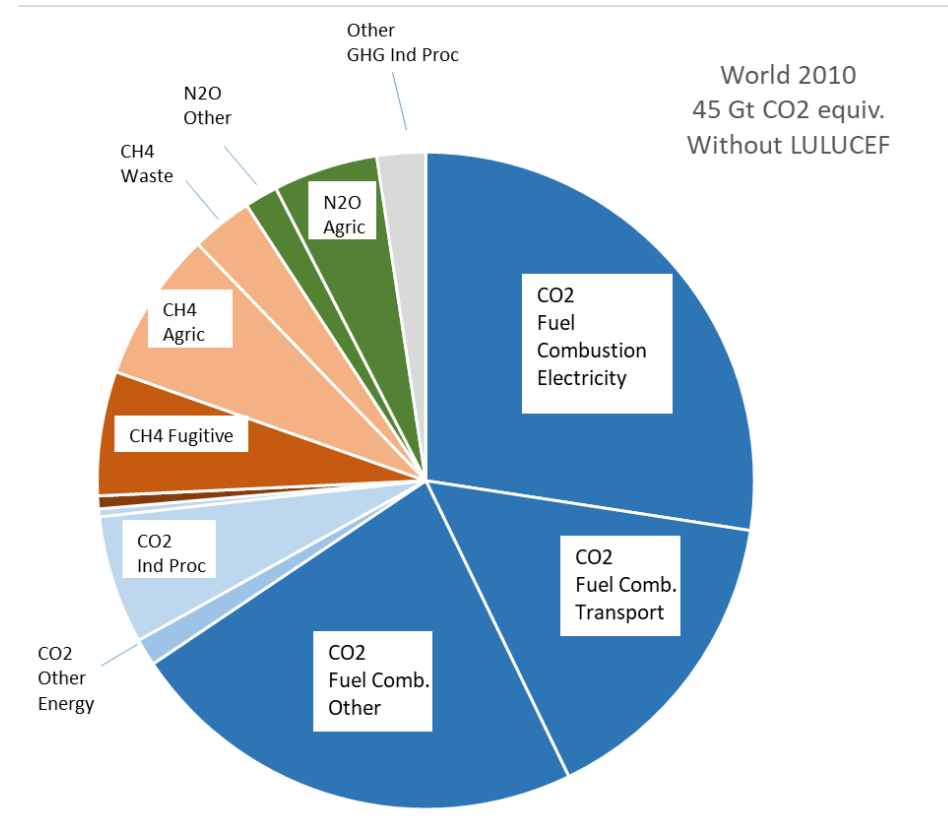
Suggested references & database links

- OECD Analyses using Inter-Country Input-Output model
  - Trade in Value Added http://oe.cd/tiva
  - Trade in employment http://oe.cd/io-empn
  - Trade in CO2 http://oe.cd/io-co2
  - Inter-Country Input-Output Database http://oe.cd/icio

- Other Global IO Databases
  - World Input-Output Database http://www.wiod.org/new_site/home.htm
  - EORA MRIO database http://www.worldmrio.com/
  - EXIOBASE
  - IDE JETRO Asian International IO http://www.ide.go.jp/English/Publish/Books/Io/index.html

THANK YOU

http://oe.cd/icio
http://oe.cd/tiva
http://oe.cd/io-co2
http://oe.cd/io-emp

OECD

TiVA indicators – December 2018 release

- Core indicators on OECD.STAT   http://oe.cd/tiva

  – 64 economies (Kazakhstan added)

  – 36 industries *based on ISIC Rev.4 (incl. Mining breakdown)*

  – Core years: 2005 to 2015 + preliminary estimates for 2016

- Supporting material

  – Country notes (selected countries)

  – Introductory flyer and updated policy briefs

  – Metadata

  – Underlying Inter-Country Input-Output (ICIO) tables *(csv and Rdata formats)*

Inter-Country Input-Output (ICIO) structure

Inter-country I-O *at basic prices*		Intermediate demand						Final consumption and capital formation			Direct purchases by non-residents			Output
		Cou A		Cou B		Cou C		Cou A	Cou B	Cou C	Cou A	Cou B	Cou C	
		Ind 1	Ind 2	Ind 1	Ind 2	Ind 1	Ind 2							
Cou A	Ind 1													X(A1)
	Ind 2													X(A2)
Cou B	Ind 1													X(B1)
	Ind 2													X(B2)
Cou C	Ind 1													X(C1)
	Ind 2													X(C2)
Taxes less subsidies ..		... on intermediate products						... on final products						
		NTZA1	NTZA2	NTZB1	NTZB2	NTZC1	NTZC2	FA	FB	FC	FA	FB	FC	
Value-added		V(A1)	V(A2)	V(B1)	V(B2)	V(C1)	V(C2)							
Output		X(A1)	X(A2)	X(B1)	X(B2)	X(C1)	X(C2)							

Key:

Cross-border flows of **intermediate** goods and services	**Cross-border** flows of **final** goods and services
Domestic flows of **intermediate** goods and services	**Domestic** flows of **final** goods and services

TiVA Country coverage by United Nations Geog. Region

Table 1: Availability of main data sources for OECD ICIO
(Maximum number of countries is 198, as of April 2019)

No. available country	1995-1999*	2000-2009*	2010-2013*	2014	2015	2016	2017	2018	2019	2019-2024	2024-2060	2060-2100
Population (UN)	198	198	198	198	198	0	0	0				
GDP (IMF/OECD/UN)	198	198	198	198	198	198	100	0				
NA main aggregate	198	198	198	198	198	198	198	0				
SNA 2008 detail	53	65.3	85.5	89	86	84	68	33				
Supply and Use tables	22	35.9	43.75	40	32	10	4	0				
Input-Output tables	9.4	13.8	18.25	13	18	1	1	0				
Import table	7.6	12.8	21.5	19	19	2	2	0				
Goods trade (reporter)	129.8	169.5	170.8	164	160	155	142	58				
Population by age (projection)					198	198	198	198	198	198	198	198
GDP (projection)							194	194	194	194	74	50

* average

Sources: National statistics agencies, ADB, Eurostat, IEA, IMF, OECD and United Nations.