Multi-Regional Environmental IO Tables: Progress of the CREEA project

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This work and other key projects on Global MR EE IO have been just published in a Special Issue of *Economic Systems Research*, 2013 (25) 1, edited by Arnold Tukker and Erik Dietzenbacher


Background Elements

- CREEA: Compiling and refining environmental and economic accounts
- EU FP7, 2011-2014, 3.5 Mio Euro
- Background
  - Arnold: TNO, NTNU, Leader of EU funded MR EE IO projects of EXIOPOL and CREEA
  - Partners TNO, CML, WI, SERI, EU DG JRC IPTS, NTNU, 2-0 LCA, ETH, TU Twente (Water Footprint), CBS, SCB, EFI
- This and other key projects on MR EE IO just published in a Special Issue of *Economic Systems Research*, 2013 (25) 1


CREEA is part of a broader portfolio of 15 Mio Euro

1. Goal: building the most ambitious macro-database for economic global relations, emissions and resource use, and the most ambitious global economic model
2. Role of each project (3 Mio each, TNO leads)
   - EXIOPOL: first version of the database, TNO government money: first version of a dynamic CGE model
   - CREEA: creates global Monetary, Physical and Energy SUT
   - DESIRE: builds time series that can calibrate our model
   - CARBON CAP: uncertainty assessment for consumption based climate policy
   - EMINIMM: allows adding diffusion of innovation to the model
   - POLFREE: will align our model with an environmental model, and will allow to sophisticate policy scenarios / parameters
   - DG ENV Resource efficiency flagship: very visible application of the model
   - COMPLEX: integrating into an IA model
3. Some other ideas:
   - Composition of 400 products with critical materials (AERTOS project, in part)
   - Improve data on taxes, link with transport databases, GIS databases
   - Deal with price volatilty and price changes of commodities

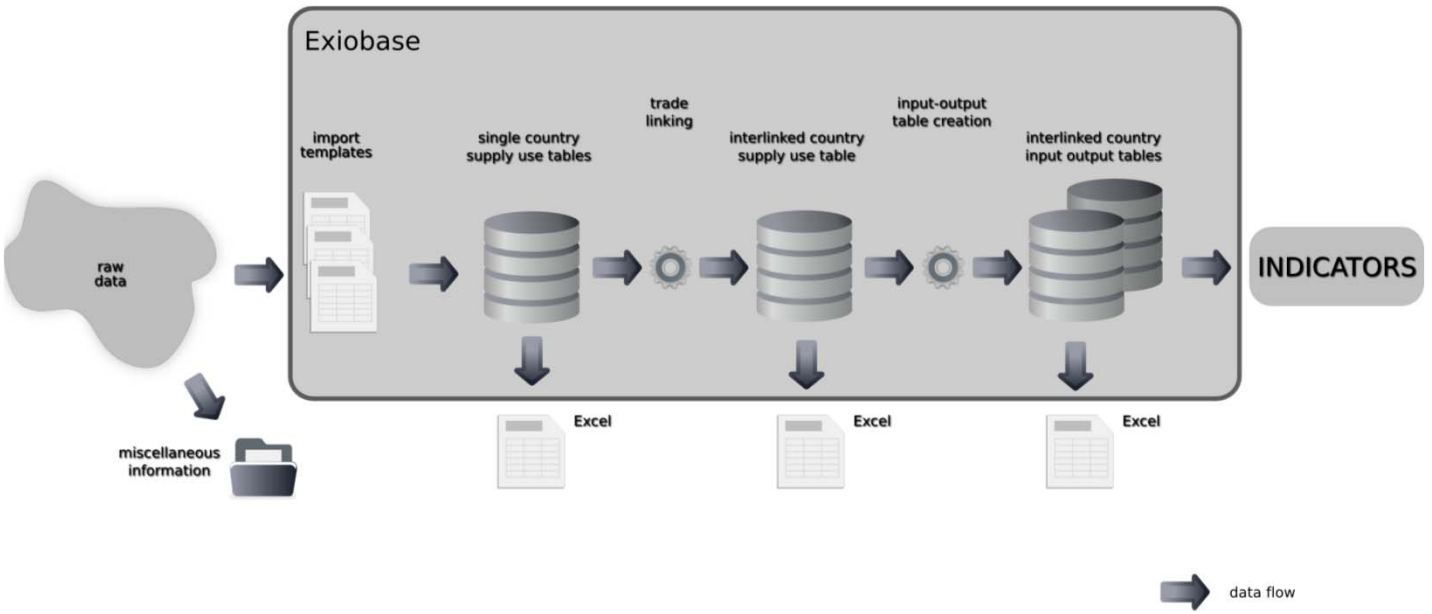

What you need: detailed Multi-Regional EE SUT SUT/IOT

- Ideal solution: a database that links country SUT/IOT via trade
  - Country SUT/IOT including value added and final demand (red)
  - Import and export trade matrices (green)
  - Exensions: emissions, energy, materials (grey)
- Solves ‘pollution embodied in trade’
- Ideally as economic and energy / material MR SUT at high detail
- Some 4-5 MR EE IO available now, see ESR review

		Industries				$Y_{*,A}$	$Y_{*,B}$	$Y_{*,C}$	$Y_{*,D}$	q
Products		$Z_{A,A}$	$Z_{A,B}$	$Z_{A,C}$	$Z_{A,D}$	$Y_{A,A}$	$Y_{A,B}$	$Y_{A,C}$	$Y_{A,D}$	q_A
		$Z_{B,A}$	$Z_{B,B}$	$Z_{B,C}$	$Z_{B,D}$	$Y_{B,A}$	$Y_{B,B}$	$Y_{B,C}$	$Y_{B,D}$	q_D
		$Z_{C,A}$	$Z_{C,B}$	$Z_{C,C}$	$Z_{C,D}$	$Y_{C,A}$	$Y_{C,B}$	$Y_{C,C}$	$Y_{C,D}$	q_C
		$Z_{D,A}$	$Z_{D,B}$	$Z_{D,C}$	$Z_{D,D}$	$Y_{D,A}$	$Y_{D,B}$	$Y_{D,C}$	$Y_{D,D}$	q_D
W		W_A	W_B	W_C	W_D					
g		g_A	g_B	g_C	g_D					
C & L		$Capital_A$	C_B	C_C	C_D					
		$Labor_A$	L_B	L_C	L_D					
Environ Ext		$NAMEA_A$	$NAMEA_B$	$NAMEA_C$	$NAMEA_D$					
		$Agric_A$	$Agric_B$	$Agric_C$	$Agric_D$					
		$Energy_A$	$Energy_B$	$Energy_C$	$Energy_D$					
		$Metal_A$	$Metal_B$	$Metal_C$	$Metal_D$					
		$Mineral_A$	$Mineral_B$	$Mineral_C$	$Mineral_D$					
		$Land_A$	$Land_B$	$Land_C$	$Land_D$					

Main steps

- 1: Make harmonized EE SUT (EU27+16 others, RoW)
  - 130 sectors & products
  - 30 emissions, 80 resources, 60 IEA energy carriers, land, water
  - Create physical and energy SUT via prices, physical databases
- 2: Link via trade to global MR EE SUT
- 3: Make global pxp and ixi MR EE IOT by collapsing MR EE SUT

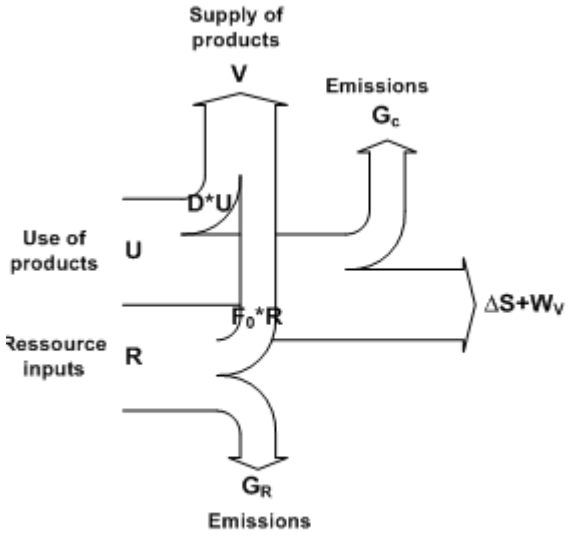



CREEA WP3, water accounts

- Physical Water SUT for a test country (Netherlands)
- Valuation methods with regard to water extraction
- Water quality accounts with regard to chemical and thermal pollution
- Dataset for EXIOBASE: water use by 160 sectors for 43 countries

CREEA WP4: Global P-SUT = MFA/Waste accounts

- For each ‘cell’ in the SUT, we create a physical input-output balance
  - U = material inputs, next to primary resource
  - S, emissions = material outputs
  - Remainder is “waste”..with properties related to U!
- We then add all wastes by type to +/- 20 categories….and distribute them over re-use, landfill, incineration and compare to waste statistics
- Problematic issue is waste from stocks/durable goods; no stock data
- We estimate physical flows using physical data where available and prices



		Industries				$Y_{*,A}$	$Y_{*,B}$	$Y_{*,C}$	$Y_{*,D}$	q
Products		$Z_{A,A}$	$Z_{A,B}$	$Z_{A,C}$	$Z_{A,D}$	$Y_{A,A}$	$Y_{A,B}$	$Y_{A,C}$	$Y_{A,D}$	q_A
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W		W_A	W_B	W_C	W_D					
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CREEA WP5: Forest accounts

- TASK 5.1: Revising the proposed SEEA 2012 methodology for forests
- TASK 5.2: Developing procedures for integrating national forest data into the proposed SEEA 2012 framework
- TASK 5.3: testing the methodology by data gathering for selected countries
- Each task corresponds to a deliverable in the project
- Rather stand alone deliverable


CREEA WP6: Kyoto accounts

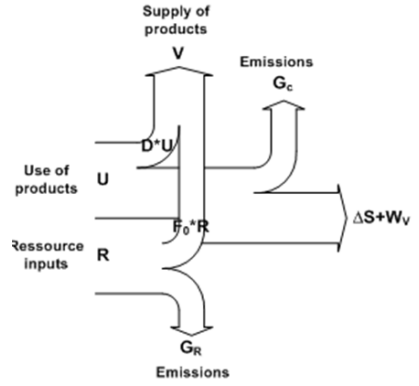
- Mapping IEA energy database on MR SUT and emission calculation
  - IEA format -> SUT
  - Territorial to residence
  - IEA product classification now harmonized with EXIOBASE 2.0; IEA industries need correspondence with more detailed EXIOBASE
  - Allocation: mix of physical and economic coefficients (latter assuming price homogeneity of Use)
  - UNFCCC emission factors give emissions
  - Other emissions similar approach
- Land use cover change: tested for Annex 1, not certain for others
- Experimental inclusion of Emission trading schemes
- Experimental analysis of response measures (e.g. taxation)


CREEA WP7, Integration in EXIOBASE

- Detailing country SUT
  - Use more detailed sector and product statistics to detail row and column totals
  - Use additional information to estimate per sector supply and use co-efficiency (e.g. similar country, LCI, IEA, Agrisams); Use detailed trade data to split trade
  - …then harmonize with a RAS alike procedure…or iron out incompatibilities (e.g. there is sure Use, but no domestic Supply nor imports -> imports may be wrong)
- Add extentions, ‘peg’ energy & physical accounts (part integrated in detailing using price assumptions and using physical supply/use totals)
- Link via trade
  - Distribute imports via trade shares to countries of origin, estimate freight & insurance margins with global transport databases
  - Then usually the implicit exports do not match exports in SUT (mismatch at differen levels: total global export // global import; export // import by product globally; exports in country SUT not equal to implicit exports -> there are differences that must be removed!
  - Give slack to trade shares and optimize differences
  - Store inevitable differences in inventories or ‘difference’ column

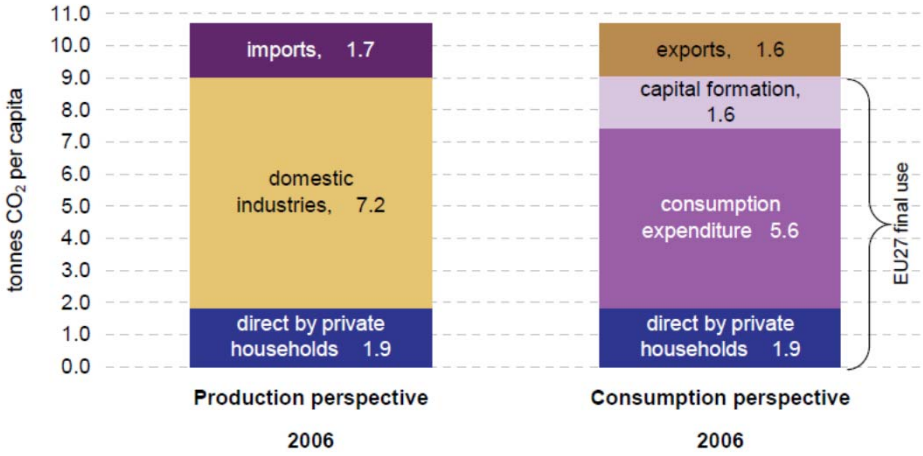
What CREEA has created: EXIOBASE 2.0

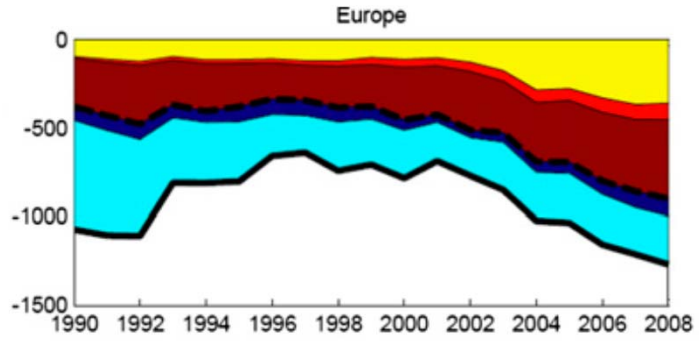
- A global MR SUT with extensions for 2007
  - 160 sector and 180 products by country
  - Trade linked
  - Not only monetary MR SUT, but also energy MR SUT (probably good, IEA based) and material MR SUT (somewhat problematic)
  - 43 countries and 5 ‘rest of continents’
  - 80 resources, 40 emissions
  - Nice tool to analyse resource-efficiency at sector, country and global scale including geographical trade offs



CREEA cases – just started. Some EXIOPOL results

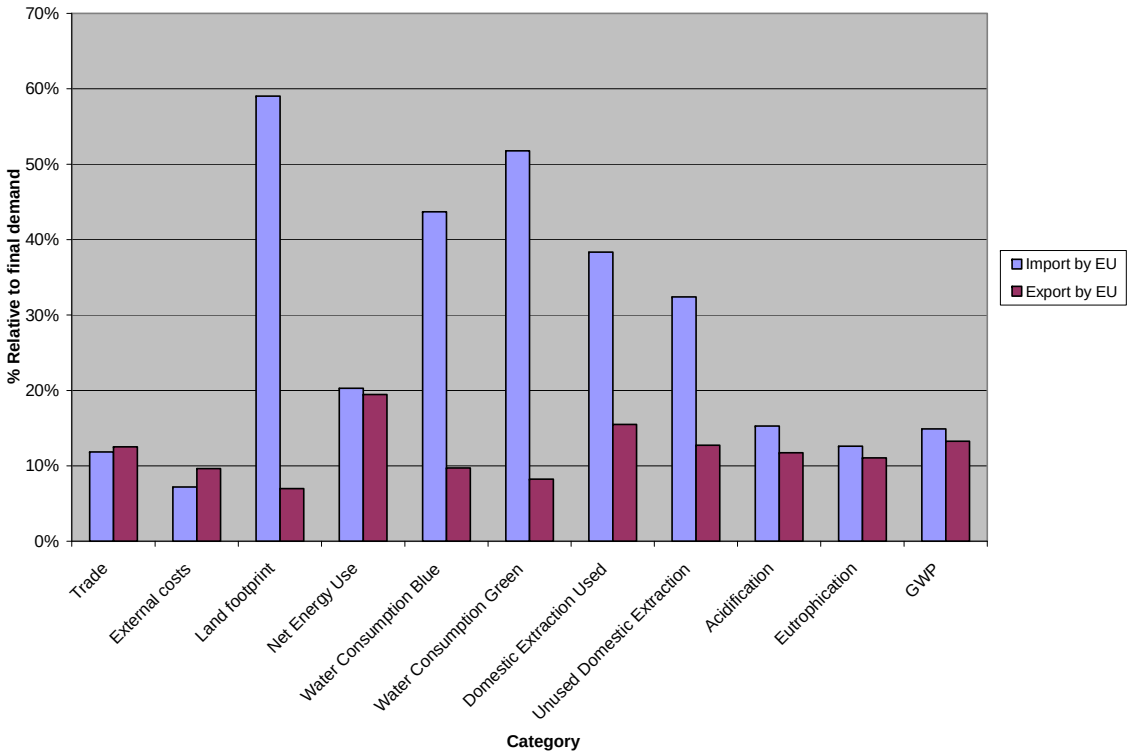
- Eurostat EU 27 EE SUT/IOT on carbon footprint
- One caveat
  - 'Domestic Technology Assumption" -> EU seems carbon-neutral in trade….
- …where other studies show carbon in imports is a factor 2-3 higher as in exports…..
- EXIOPOL can make such calculations for all 110 extensions





Net carbon trade EU. Peters et al, PNAS, 2010

EXIOPOL results



- Pollution embodied in EU27 imports and exports relative to pollution driven by final demand, 2000
- Europe relies heavily on land, water, and material use abroad where product policy focuses mainly on energy issues


Conclusion

- UN SEEA 2013 suggests SUT/IOT as the way to organise economic and environmental data in a consistent framework
- EXIOPOL, CREEA show the power of having such a consistent dataset
- Main problem is harmonization across data suppliers
  - SUT (NSIs): please provide valuation layers
  - Energy & Physical data (e.g. IEA, FAO): use standard product & industry classifications
  - Emission data (e.g. UNFCCC, CLRTAP): idem
  - Trade (UN COMTRADE): solve mirror statistics puzzle
- EXIOBASE available for a not for profit fee at www.exiobase.eu
- Allows us to update; we further envisage ‘flagging’ harmonization problems to primary data suppliers so that they can improve


THANKS FOR YOUR ATTENTION!


What is needed for more formal MR EE IO tables?

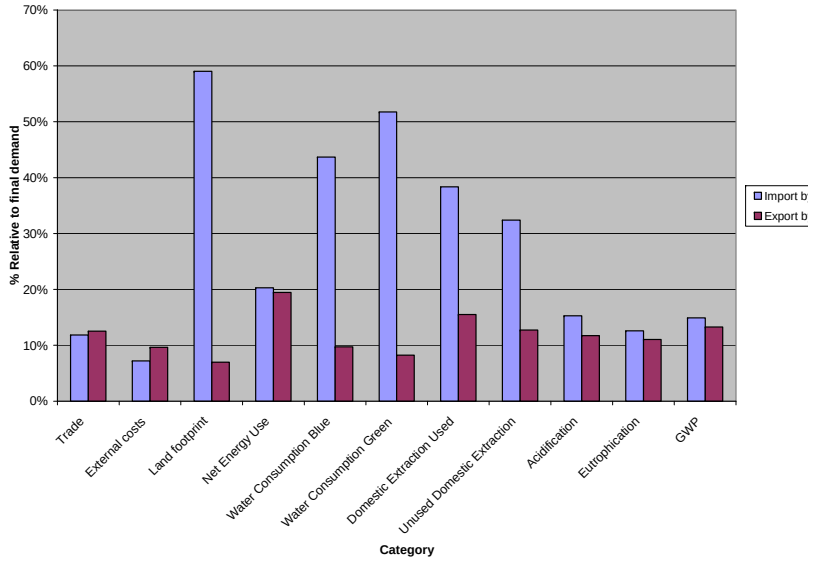
- Linking country tables to a global MR SUT/IOT is not the problem
  - EXIOBASE creates this in 20 minutes from country tables and trade data
  - Has a flexible set up with regard to sector classifications
- The problem is (harmonized) data:
  - SUT & IOT (NSIs)
    - Make valuation layers available – particularly EU must have them….
    - Use harmonized sector classifications where possible – really!
  - Trade (UN, WB, OECD, NSIs)
    - Put effort in harmonization (‘mirror statistics puzzle’ in UN COMTRADE)
    - Start work on service trade sets…..
  - Physical data (energy – IEA; agro-food: FAO)
    - It helps to use CPC as product classification in FAOSTAT and IEA
    - IEA: ideally, try to move to an industry classification based on ISIC
    - …and move from territorial to resident principle

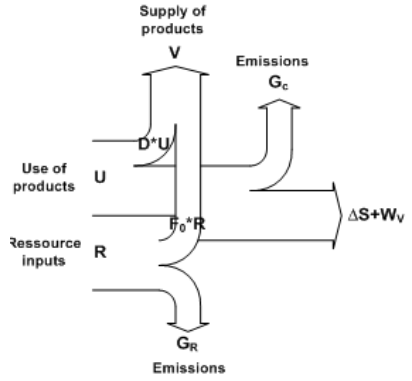

Potential collaboration with the statistical world

1. There seems interest from UN SD, WB, others to work on MR IO
   - Project partners from EXIOPOL, EORA, WIOD could help
     - Sharing e.g. EXIOBASE trade linking routine
     - Sharing experiences with data harmonization
     - Cf Eurostat's official EU27 EE SUT build by EXIOPOL&WIOD staff
2. Countries build own EE SUT/IOT but face pollution embodied in trade
   - A joint WG of NSIs and researchers could link and harmonize such initiatives, compare OECD WG on Material Flow Analysis
   - CREEA can offer some funds to support this,,,,
   - ,,,would there be interest? What would be a good host ? (e.g. UNCEAA, London Group, UNEP SETAC LCI, OECD….)
3. Support to countries with less data seems feasible too
   - EXIOPOL, EORA had to develop many gap filling routines
   - Crude but usable EE SUT probably can be estimated with FAOSTAT, IEA and macro-economic data


What kind of results can you get ?

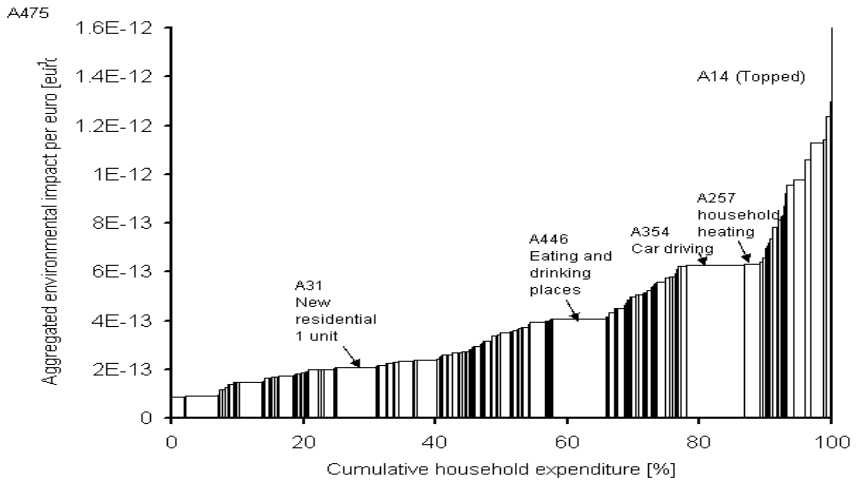
- Calculating most pressures:
  - Carbon, water, land & ecological footprint
  - MFA indicators
  - Etc.
- With one consistent data set:
  - Production perspective: by sector / country
  - Consumption perspective: by product, pollution in trade
- Resource and energy efficiency at sector level
  - Cross-sector comparison
  - Cross-country comparison by sector





What you can calculate with EE SUT and IOT

- EU EIPRO (480 sector EE IOT)
  - Priority setting of products
  - Proved that food, mobility and housing were prio's
- EU Diet change
  - Change to healthy diets by changing demand vector
  - Showed rebounds by linking EE IOT to the CAPRI model
- Limitations of official data in EU
  - Sector detail (60+)
  - Emissions (few or absent)
  - Imports estimated by 'domestic technology ass'



Tukker (ed., 2006), Journal Industrial Ecology 10: 3

	Aggregated environmental impacts (%)			
	Scenario 0: Status quo	Scenario 1: Recommendations	Scenario 2: Recommendations including red meat reduction	Scenario 3: Mediterranean
Sub-scenario 'All'				
Food	27	27	25	25
Non-food	73	73	73	73
Total	100	100	98	98
Sub-scenario 'All + first order'				
Food	27	27	25	25
Non-food	73	73	74	73
Total	100	100	99	98
Sub-scenario 'All + first and second orders'	100	100	99	99

Tukker et al., 2011, Ecological Economics (in press)

Relations between SUT and IOT

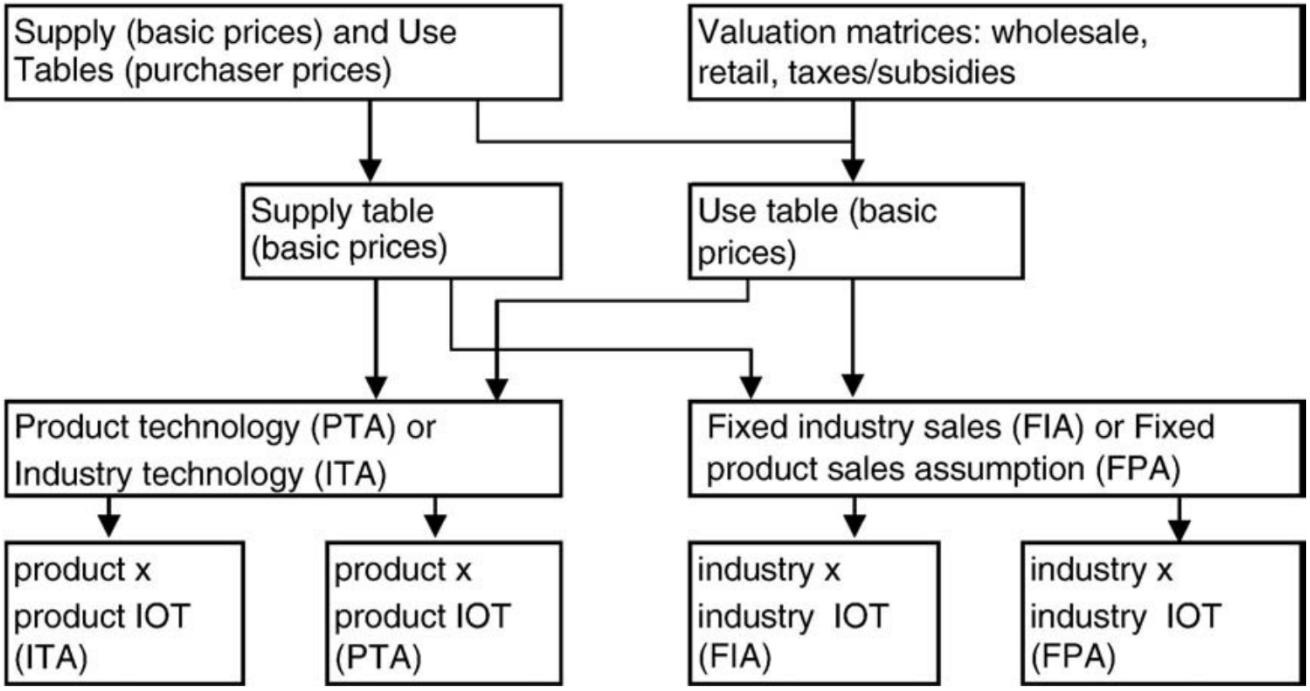


Figure courtesy of Jose Rueda Cantuche, EU DG JRC IPTS, Sevilla, Spain


TNO innovation for life

Major (research) initiatives in creating (Global) MR EE SUT/IOT

TABLE 1. Review of the main GMRIO databases.

Database name	Countries	Type	Detail ($i \times p$)*	Time	Extensions	Approach
EORA	World (around 150)	MR SUT/IOT	Variable (20–500)	1990–2009	Various	Create initial estimate; gather all data in original formats; formulate constraints; detect and judge inconsistencies; let routine calculate global MR SUT/IOT
EXIOPOL	World (43 + RoW)	MR SUT	129 × 129	2000**	30 emissions, 60 IEA energy carriers, water, land, 80 resources	Create SUTs; split use into domestic and imported use; detail and harmonize SUTs; use trade shares to estimate implicit exports; confront with exports in SUT; RAS out differences; add extensions
WIOD	World (40 + RoW)	MR SUT	35 × 59	1995–2009, annually	Detailed socio-economic and environmental satellite accounts	Harmonize SUTs; create bilateral trade database for goods and services; adopt import shares to split use into domestic and imported use; trade information for RoW is used to reconcile bilateral trade shares; add extensions
GTAP-MRIO	World (129)	MR IOT	57 × 57	1990, 1992, 1995, 1997, 2001, 2004, 2007	5 (GWP), Land use (18 AEZ), energy volumes, migration	Harmonize trade; use IOTs to link trade sets; IOT balanced with trade and macro-economic data
GRAM	World (40)	MR IOT	48 × 48	2000, 2004	Various	Use harmonized OECD IOTs; neglect differences like ixi and pxp; use OECD bilateral trade database to trade link
IDE-JETRO	Asia-Pacific (8: 1975) (10: 1985–2005)	MR IOT	56 × 56 (1975) 78 × 78 (1985–1995), 76 × 76 (2000, 2005)	1975–2005	Employment matrices (2000, 2005)	Harmonize IOTs based on cross-country survey information; link via trade, manual balancing to reduce discrepancies within a certain bounds

*i = number of industries, p = number of products, **The follow-up project CREEA constructs the EE GMRIO for 2007.

SUT/IOT: official UN ‘SEEA 2013’approach to organise environmental and economic data

	Products	Industries			
Products		Use	Final use	Exports	*Use of products*
Industries	Make / Supply				*Output of industries*
	Imports cif	Value added			
	Supply of products	*Input of industries*			
		Extensions: - Primary Natural Resource input - Emissions output - etc.			

- EE SUT for a single country
  - Economic Supply and Use
  - By industry: emissions, primary resource use
  - Imports, exports
- Can provide you
  - Per final use category: value added by industry
  - With impact per Euro per industry known: life cycle impacts per final use category
- Relation with MFA, LCA
  - ‘Disaggregated MFA’: splits material flows of one country into sectors & products (& stocks)
  - ‘Aggregated LCA’: is an LCA at sector rather than unit process level