Multi-Regional IO Tables: Applications and Construction Challenges

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Presentation Elements

› Multi-regional EE SUT and IOT
  › What is it?
  › What is the policy relevance?
  › What are the main characteristics of ongoing projects?
  › How can research help NSIs and UNCEEA and in reverse?

› My own background
  › Manager at TNO, a large not for profit research institute in NL
  › Professor of Sustainable Innovation, Industrial Ecology Program, NTNU, Trondheim, Norway
  › Leader of EU funded MR EE IO projects of EXIOPOL and CREEA (total 6 Mio Euro, 10-15 partners)
Backgrounds on SUT/IOT

- **EE SUT for a single country**
- **Economic Supply and Use**
- **By industry: emissions and primary resource use**
- **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
- **Advantages**
  - Inherently complete
  - Inherently consistent

<table>
<thead>
<tr>
<th>Products</th>
<th>Industries</th>
<th>Use</th>
<th>Final use</th>
<th>Exports</th>
<th>Use of products</th>
<th>Output of industries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Make / Supply</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Imports cif</td>
<td>Value added</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supply of products</td>
<td>Input of industries</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Extensions:
- Primary Natural Resource input
- Emissions output
- etc.
Relations between SUT and IOT

Supply (basic prices) and Use Tables (purchaser prices)

Valuation matrices: wholesale, retail, taxes/subsidies

Supply table (basic prices)

Use table (basic prices)

Product technology (PTA) or Industry technology (ITA)

Fixed industry sales (FIA) or Fixed product sales assumption (FPA)

Figure courtesy of Jose Rueda Cantuche, EU DG JRC IPTS, Sevilla, Spain
## Backgrounds on MR SUT/IOT

- Country SUT/IOT do not provide insight in ‘pollution embodied in trade’
- **Ideal solution:** MR EE SUT/IOT
  - Country SUT/IOT including value added and final demand (red)
  - Import and export trade matrices for intermediate and final demand (green)
- Exensions: emissions, energy, materials (grey)

![Matrix Diagram](image)

**Industries**

<table>
<thead>
<tr>
<th>Industries</th>
<th>Products</th>
<th>W</th>
<th>C &amp; L</th>
<th>Environ Ext</th>
</tr>
</thead>
<tbody>
<tr>
<td>Z(_{A,A})</td>
<td>Z(_{A,B})</td>
<td>Z(_{A,C})</td>
<td>Z(_{A,D})</td>
<td>Y(_{A,A})</td>
</tr>
<tr>
<td>Z(_{B,A})</td>
<td>Z(_{B,B})</td>
<td>Z(_{B,C})</td>
<td>Z(_{B,D})</td>
<td>Y(_{B,A})</td>
</tr>
<tr>
<td>Z(_{C,A})</td>
<td>Z(_{C,B})</td>
<td>Z(_{C,C})</td>
<td>Z(_{C,D})</td>
<td>Y(_{C,A})</td>
</tr>
<tr>
<td>Z(_{D,A})</td>
<td>Z(_{D,B})</td>
<td>Z(_{D,C})</td>
<td>Z(_{D,D})</td>
<td>Y(_{D,A})</td>
</tr>
</tbody>
</table>

**Resources**

<table>
<thead>
<tr>
<th>Capital(_A)</th>
<th>C(_B)</th>
<th>C(_C)</th>
<th>C(_D)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labor(_A)</td>
<td>L(_B)</td>
<td>L(_C)</td>
<td>L(_D)</td>
</tr>
</tbody>
</table>

**Sectors**

- 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\(_D\)
Relevance of EE SUT and IOT

- EE SUT are very versatile and powerful analytical tools
- 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

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

Tukker et al., 2011, Ecological Economics (in press)
Relevance of imports - MR EE SUT and IOT

- Peters et al., PNAS 2010:
  - Global CO2 emissions (black)
  - Transfer from Annex B to non-Annex B (yellow)
  - Similar work of Ahmad and Wyckoff, 2003, Davis and Caldeira, 2010
- Giljum et al. (in press)
  - Focuses on materials
  - Gives net materials imports and exports in trade
Relevance of MR EE SUT/IOT instead of DTA

- Results of Eurostat EU 27 EE SUT/IOT with ‘Domestic technology assumption’
- EU is seemingly carbon neutral in trade…..
- …where other studies show carbon in imports is a factor 2-3 higher as in exports…..

<table>
<thead>
<tr>
<th>Project name</th>
<th>Funding</th>
<th>Countries</th>
<th>Type</th>
<th>Detail (i.e.)</th>
<th>Time</th>
<th>Extensions</th>
<th>Approach</th>
</tr>
</thead>
<tbody>
<tr>
<td>IDE JETRO (Inomata)</td>
<td>Japan</td>
<td>Asia Pacific (10)</td>
<td>MR IOT</td>
<td>58x58</td>
<td>2000, 2004</td>
<td>-</td>
<td>Harmonize IOT; Link via trade; move discrepancies to RoW</td>
</tr>
<tr>
<td>GTAP (Hertel)</td>
<td>Subscription</td>
<td>World (113)</td>
<td>MR IOT</td>
<td>58x58</td>
<td>2000, 2004</td>
<td>10 (GWP)</td>
<td>Harmonize trade; use IOT to link trade sets; relative crude IOT estimates</td>
</tr>
<tr>
<td>WIOD (Dietzenbacher, RUG)</td>
<td>EU FP7</td>
<td>World (40)</td>
<td>MR SUT</td>
<td>30x60</td>
<td>1995-2000-2006</td>
<td>20+</td>
<td>Harmonize SUT; Link via trade, problems with discrepancies</td>
</tr>
<tr>
<td>EXIOPOL/ CREEA (Tukker, TNO &amp; NTNUJ)</td>
<td>EU FP6/7</td>
<td>World (42)</td>
<td>MR SUT</td>
<td>129x129</td>
<td>2000, 2007</td>
<td>30 emissions, 60 IEA energy carriers; water, land, 80 resources</td>
<td>Create SUT bp; Split Use_dom and Use_imp; Detail and Harmonize SUT; Use trade shares to estimate implicit exports; confront with exports in SUT, RAS out differences, add extensions</td>
</tr>
<tr>
<td>AISHA/ EORA (Lenzen, Un. Sydney)</td>
<td>Australian NSF</td>
<td>World, t.b.d. (200?)</td>
<td>MR SUT</td>
<td>t.b.d (&gt;150?)</td>
<td>1990-2006?</td>
<td>t.b.d.</td>
<td>Create initial estimate; Gather all data available; apply in original format; Formulate constraints; Detect &amp; judge inconsistencies; Let routine calculate Global MR SUT/IOT</td>
</tr>
<tr>
<td>Eurostat (Remond-Tiedrez, Moll)</td>
<td>Eurostat</td>
<td>EU 27 aggregate</td>
<td>SUT</td>
<td>59x59</td>
<td>1995-2007</td>
<td>10 (GWP)</td>
<td>Create SUT bp, Split intra and extra EU trade, aggregate to EU27 totals, remove intra EU imports / export differences to RoW, add extensions</td>
</tr>
</tbody>
</table>

Note: WIOD seems only project that develops current and constant price tables
What did EXIOPOL produce

- WP III.4.b: Database with five ‘big blocks’; flexible set up with regard to sectors, products, countries, etc., import/export and aggregation routines
  - Block 0: ‘Fuzzy front end’ with transformations in WS III.2 and III.3
  - Import routine SUT, EE, trade shares, consistency checks, error reporting
  - Block 1: Harmonized EE SUT by country, trade shares, rRoW initial structure
  - Trade link routine (20 minutes)
  - Block 2: Trade linked MR EE SUT,
  - SUT to IOT transformation routine, pxp and ixi, one technology assumption
  - Block 3: MR EE IOT (pxp, ixi) Inverse, aggregation routines, links to models etc.
  - Output to CMLCLA indicator program (EF, TMR, LCIA, Externalities)
  - A very flexible engine capable of dealing very quick with updates, or even fully new data sets and formats
What EXIOPOL did produce (2)

- 43 harmonized country SUT plus a small RoW
- 130 sectors (detail in agri, energy, minerals, mining, etc.)
- Detailed Value added blocks
- Harmonized data on trade shares by country by sector (products, services)
- Large set of environmental extensions including physical SUT
  - Physical energy SUT (transformed IEA database, 60 carriers by 130 sectors) plus energy related emissions by carrier (30-40 substances)
  - Non-energy emissions (30 substances)
- Primary resource extraction by 130 sectors (80 resources)
- Land use, water use,
- External cost values per emission per sector and country (including some spatial differentiation, e.g. using default stack heights per sector)
- Data set on factor constraints (mainly: 3 classes of labor, land, water) and estimates of resource rents and royalties.
How EXIOPOL did produce its data set - SUT

› Working with SUT as core (GTAP, IDE)
  › Trade and FD is in products
  › Emissions and resource extractions are by Industry

› Production routine
  › Gather and create balanced SUT in bp in original sector format
    › EU: Eurostat SUT with S in bp, U in pp, few give valuation layers
      reverse engineer Ubp from IOT and Sbp
    › Non EU: often IOT, heroic assumption of diagonal S

› Detail
  › Map SUT bp on EXIOPOL classification
  › Use auxiliary information and optimisation routine to create detail
    › AgriSAMS for food and agriculture
    › IEA database, information on material extraction, LCA co-efficients,
      SUT/IOT other countries for estimated co-efficients
How EXIOPOL created its data set - EE

› Resources: allocation SERI (FAO, USGS, etc.) database to extracting sectors
› Emissions
  › Allocation of EIA database to sectors + emission factors (IPCC, CLRTAP, etc.)
  › Other activity variables + emission factors
› Land, Water: mainly FAOSTAT plus allocation
How EXIOPOL created its data set – Trade links

- Use bp is separated in Use dom and Use imp
- Use imp is further allocated to country of origin with trade shares (harmonized UN COMTRADE by Feenstra et al.)
- When we do so for all countries, we get an ‘implicit export’ by country that in theory should match export vector in Use table
- It does not due to
  - Valuation differences (cif versus fob)
  - Statistical differences / error
- We match this by
  - Using Exports in SUT as constraint;
  - Rescaling so that total imports = total exports at global level
  - GRAS is applied to the bilateral Import Use tables to get a balanced system
Plans in CREEA (2011-2014)

› FP7 CREEA (Compiling and Refining Economic Environmental Accounts
  › EXIOPOL team with notable additions – CBS (NL) and SCB (Sweden)
  › Does practical data refining tests and compilation related to SEEA 2012
    › Water*
    › Materials and waste*
    › Kyoto issues – land use change, carbon trading, taxes*
    › Forests
  › Will also use outcomes of * to update EXIOBASE,
    › Additional physical SUT and waste accounts
    › Improved water, land use change and carbon trading accounts
    › Next to creating a more recent base year
  › We have funds reserved for intensive collaboration with formal circles (e.g. OECD, UNCEEA, UNEP ?????)
Longer term roadmap ideas for EE SUT/IOT

- Further harmonization of SUT/IOT in more detail
- Expanding number of countries covered
- Integration with physical data to P-SUT (e.g. with FAO and IEA data)
- Harmonizing trade data sets/shares (both economic as physical)
- Integration of Life cycle inventory data (is SUT/IOT by single process)
- Integration of spatially explicit information for land and water use
- Inclusion of monetary and physical capital stocks
Potential for improvements and collaboration

› Research groups in fact make MR SUT/IOT rather than NSIs or UN
› My main suggestions to official data gatherers like NSIs, UN, FAO, IEA:
  › SUT & IOT
    › Publish valuation layers – particularly EU must have them…..
    › Please use harmonized sector classifications – really!
› Trade
  › Solve ‘mirror statistics puzzle’ in UN COMTRADE
  › Start work on service trade sets…..
› Physical data (energy – IEA; agro-food: FAO)
  › Please use CPC for classifying products
  › IEA: ideally, try to move to an industry classification based on ISIC
  › …and move from territorial to resident principle
Potential for improvements and collaboration

- Improved collaboration between research projects and official institutes can help
- Eurostat experience
- Used EXIOPOL and WIOD staff and methods to create their official EU27 EE SUT
- Quite some countries create their own EE SUT/IOT
- Why not form a (in)formal collaborative working group on this
  - With NSI and research representatives
  - Akin the OECD WG on Material Flow Analysis
  - Various ‘hosts’ thinkable (UNCEEA & London Group, UNEP, OECD, or a combination of these)
- CREEA can offer some funds to support this.
THANKS FOR YOUR ATTENTION!
Some issues about data availability

- Eurostat works with
  - IPTS and Konstantz on gap filling ESA95 SUT
  - TNO, RUG, NTNU, CML on creating an EE SUT
- For 16 out of 27 EU countries (75% GDP) an ‘Excellent data set’
  - 3-4 countries with valuation layers transmitted to Eurostat
  - 12 other countries that give voluntary information, but many do not want to have this published!!!!!
- Even in our Eurostat project we could not work with these tables
- We will publish
  - Aggregated EU27 table constructed by separating Uimp, non EU and Uimp, EU, rebalancing intra EU trade
  - With extensions, and several analyses
- In a way weird – WIOD, EXIOPOL are forced to redo this work with less information…..hope with time this will improve