ESA/STAT/AC.238
UNCEEA/6/16

DEPARTMENT OF ECONOMIC AND SOCIAL AFFAIRS
STATISTICS DIVISION
UNITED NATIONS

Sixth Meeting of the UN Committee of Experts on Environmental-Economic Accounting
New York, 15-17 June 2011
North Lawn Building – Conference Room C

EXIOPOL and CREEA: Towards a global Multi-Regional Economic and Physical Supply and Use tables with Environmental Extensions

Paper prepared by Arnold Tukker

(for discussion)

EXIOPOL and CREEA: Towards a global Multi-Regional Economic and Physical Supply and Use tables with Environmental Extensions

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Background material to a presentation at UNCEEA, New York, 16 June 2011

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Abstract

The project EXIOPOL (A New Environmental Accounting Framework Using Externality Data and Input-Output Tools for Policy Analysis) had as a key goal to produce a Multi-Regional Environmentally Extended Supply and Use Table (MR EE SUT) for the whole world. The EXIOPOL database (EXIOBASE) has a unique detail and covers 30 emissions, around 80 resource extractions, given specifically for 130 sectors and products by 43 countries making up 95% of global GDP, plus a Rest of World. A follow-up project of 3.5 Mio Euro under the EU's FP7 program, called Compiling and Refining Environmental and Economic Accounts (CREEA), will expand this database with improved extensions for water, land use and other resources, but above all to create an additional layer with physical information in the (economic) SUT in the EXIOPOL database (in short: EXIOBASE). For the first time this will produce a global, integrated Multi Regional Environmentally Extended Economic and Physical Supply and Use Table (MR EE E&PSUT). This paper discusses methods used in EXIOPOL to produce the MR EE SUT. It will further explain the approach chosen in CREEA to add a physical layer to the MR EE SUT. It will further highlight some analytical results that can be obtained with that database, such as assessing the amount of carbon emissions and resources embodied in trade, how consumption in the West creates resource extraction in the South, etc.

Keywords: Resources, emissions, supply and use tables, input output tables.

1 Introduction

The Integrated Project (IP) EXIOPOL (A New Environmental Accounting Framework Using Externality Data and Input-Output Tools for Policy Analysis) has been set up by FEEM and TNO (being co-ordinator and scientific director) under the EU's 6th Framework Program. It has a budget of 5 Mio Euro and runs between Spring 2007 and 2011. A key goal of that project was to produce a Multi-Regional Environmentally Extended Supply and Use Table (MR EE SUT) for the whole world. EXIOBASE has a unique detail and covers 30 emissions, around 80 resource extractions, given specifically for 130 sectors and products by 43 countries making up 95% of global GDP, plus a Rest of World. A follow-up project of 3.5 Mio Euro under the EU's FP7 program, called Compiling and Refining Environmental and Economic Accounts (CREEA), will expand this database with improved extensions for water, land use and other resources, but above all to create an additional layer with physical

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[1] The EXIOPOL and CREEA project teams, in total over 20 people, contributed highly to the insights presented in this paper. Without being complete, I would like to mention particularly José M. Rueda Cantuche (IPTS), Richard Wood (NTNU), José Acosta (Wuppertal Institute), Stephan Lutter (SERI), Arjan de Koning and Reinout Heijungs (CML), Jannick Schmidt (2.-0 LCA), and Olga Ivanova (TNO)

information in the (economic) SUT in the EXIOPOL database (in short: EXIOBASE). For the first time this will produce a global, integrated Multi Regional Environmentally Extended Economic and Physical Supply and Use Table (MR EE E&PSUT).

Creating a harmonized database like this from multiple, unaligned datasources forms a considerable challenge. Section 2 summarizes the approaches applied and presents the structure of EXIOBASE. In section 3 we briefly present the plans of how this database will be expanded with physical supply and use information. Section 4 gives an example of the analyses that can be done with this database and ends with conclusions.

2 EXIOBASE: creating a harmonized, MR EE SUT

2.1 Introduction

The input-output framework as exemplified by the European System of Accounts (ESA95) consists of three types of table: supply and use tables (SUT) and symmetric input-output tables (IOT). The supply table shows the supply of goods and services, both domestic and imported, by product and type of supplier in basic prices, while the use table shows the use of goods and services by product and type of use in purchase prices, i.e. as intermediate consumption by industries, final use (consumption, gross capital formation) and exports. The use table can be converted to basic prices with the help of valuation matrices reflecting retail, wholesale and taxes/subsidies per product used per industry. Most analytical applications and models used (e.g. CGE) are based on IOTs rather than SUT. Using various assumptions about technology, IOTs can be derived from the SUT in basic prices (e.g. Leontief and Ford (1970), Miller and Blair (1985)). SUT and IOT can be expanded with satellite accounts to indicate an industry's resource inputs from and emission outputs to the environment (see figure 2.1.). EE SUT and EE IOT are one of the most versatile forms of presenting environmental and economic information in one coherent and inherently complete framework. They show all economic transactions in society, as well as primary resource extractions and emissions by industry. This allows, for instance, analysing how consumption of final products causes impacts by industry along the value chain. Usually EE SUT and EE IOT are made for single countries. By making a global database that connects countries via trade, it becomes possible to analyse how consumption in e.g. the West creates resource extraction and related impacts in the South.

2.2 Creating EXIOBASE: harmonizing SUT, gathering extensions, and trade linking

A coherent global database, however, requires that the following major problems have to be solved

1. Many countries publish SUT or IOT, but usually not in the same industry and product sector classification, or not at a detail relevant for environmental assessments
2. Quite some countries publish emission inventories, but these are usually limited to greenhouse gases and not broken down by industry sectors used in SUT or IOT.
3. Combining national SUT or IOT to a global, trade linked database, is very complicated and has been done only a few times before by other groups (most notably in the GTAP project).

Figure 2.1: Schematic SUT with environmental extensions

	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.			

In Tukker et al. (2009) we give an extensive review about the methodological approach followed. In short, the following steps were taken

1. Harmonizing and detailing SUT
    a. Gathering SUT from the EU27 via Eurostat, and other SUT and IOT from 16 other countries (covering in total 95% of the global GDP). Gap filling of missing European SUT via ‘same country assumption’. Converting IOT into SUT by assuming a diagonal Supply table.
    b. Constructing Use tables in basic prices via reversed engineering
    c. Harmonizing and detailing SUT with auxiliary data from FAO and a European AgriSAMS for agriculture, the EIA database for energy carriers and electricity, various resource databases for resources, etc.
2. Harmonizing and estimating extensions
    a. Allocating available resource extraction data (e.g. FAOSTAT, Aquastat) to industry sectors
    b. Allocating the International Energy Agency database for 60 energy carriers to sectors of use. Estimating emissions on the basis of energy and other activity data and TNOs TEAM model
3. Linking the country SUT via trade

a. Splitting of Import Use tables and allocating imports to countries of exports using UN COMTRADE trade shares

b. Confronting the resulting implicit exports with exports in the SUT, adjusting differences and rebalancing via RUGs GRAS procedure

4. Importing all data in EXIOBASE developed by CML, a specially constructed database system with extensive reporting on errors and inconsistencies allowing for iterative improvement of the database.

2.3 The result: EXIOBASE

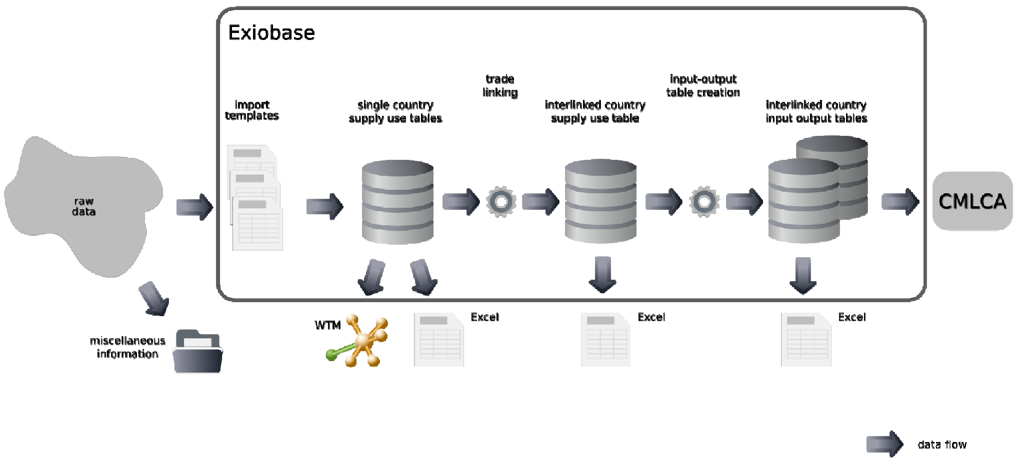
The result of the former steps is visualized in Figure 2.2: the EXIOBASE database. In essence it consists of three blocks:

1. Block 1: a storage facility for the single country environmentally extended supply-use data. Into this block all data from the harmonization steps are imported and EE SUT for countries are created
2. Block 2: the storage of the international supply-use table (interlinked supply-use table or MR EE SUT) and
3. Block 3: the storage of the international input-output table (interlinked country input-output table or MR EE IOT).

Between block 1 and 2 a script is installed that performs the trade linking procedure as described in section 2.2. Since most analytical applications use IOT rather than SUT, another script creates in Block 3 the MR EE IOT. The MR EE SUT and MR EE IOTs that are available have the following characteristics:

- Covering 43 countries (95% of the global economy) and a Rest of World (the other 150+ countries in the world combined)
- Distinguishing 130 industry sectors and products
- Covering 30 emitted substances and 80 resources as extensions by industry.
- Full trade matrices: insight is given into which product from which country is exported to which industry sector in another country.

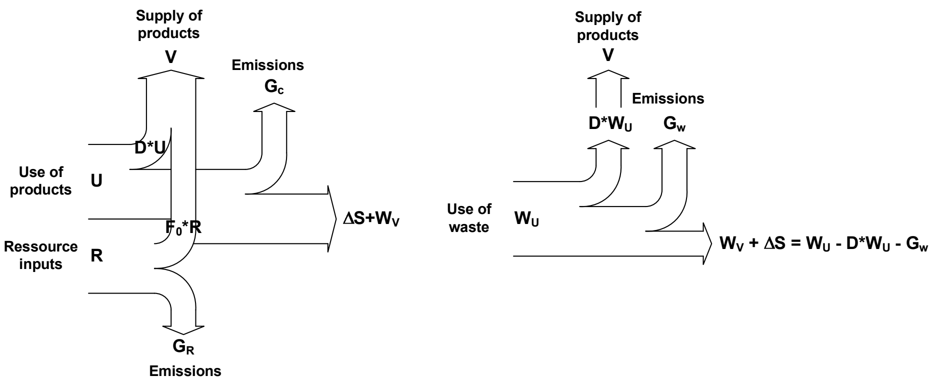
Figure 2.2: The EXIOBASE system



3 CREEA: adding physical information

In EXIOPOL's follow-up project, CREEA, two important additions will take place. First, the database will be updated to a more recent base year. But more importantly, physical information will be added to the SUT. This approach was pioneered in the FORWAST project, linking waste accounts to material flow accounts (MFA), making use of the mass balance principle (see figure 3.1 below). Any industry uses primary resources (R) and products (U) as input. It further produces products (V). Such data can be made available by making physical supply and use tables, and resource input table (part of the Environmental Extensions), all simply expressed in kg dry matter. A part of the resource inputs and product inputs will be lost as emissions (Gc and Gr). Such emissions are also available in EE SUT/IOT as emission tables, part of Environmental Extensions. Transfer coefficients (D and Fo) indicate with fraction of product (U) and resource (R) are transformed into products (V) and emissions (Gc and Gr). Transfer coefficients can be calculated based on information within the accounting system; the ratio between use of feedstock products and the supply, or they can be based on other information. From the mass balance principle follows that the amount of waste (Wv) is the difference between Inputs of products (U) and resources (R) and Output of products (V) and Emissions (Gc and Gr), with a correction for stock changes (ΔS, i.e. use of products with a life time > 1 year). This correction is needed since durable products produced long time ago, such as houses, may result in waste in the year for which the accounts are constructed. The use of waste (i.e. management of waste via recycling or treatment) can be analysed in a similar fashion (see Figure WP4.2). Waste (Wu) enters a waste management process, in part is converted into a useful product (V) and emissions (G), with as output residual waste (Wv).

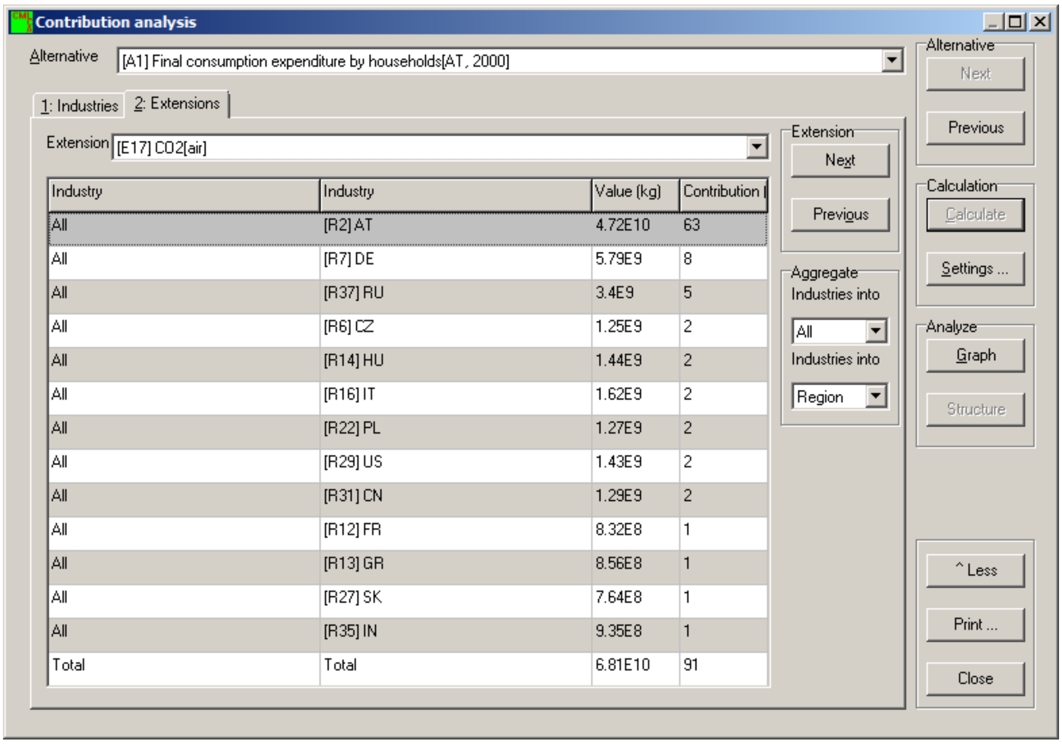
Figure 3.1: Mass balance principle (Schmidt et al., 2009)



4 An illustrative analysis, conclusions and outlook

The database has just been finalised and case study work is currently under way. Figure 4.1 gives an illustration of the analyses that can be done almost instantly with the database produced. A key question in the climate change debate if countries should be primarily held responsible for the greenhouse gas emissions on their territory, or the greenhouse gas emission driven by their consumption. For instance, countries like China produce a lot of products used in Europe and the US, so one could debate if related emissions (but also resource uses) are caused by China rather than the Europe or the US. Figure 4.1 gives a screenshot of a contribution analysis of CO2 emissions induced by final consumption of households in Austria (here split up by country of origin without detailing sectors of origin).

Figure 4.1: Contribution analysis of CO_2 emissions induced by final household consumption in Austria



Such analyses have been done before, but mainly for individual substances or aggregated resource categories. EXIOBASE is capable of doing this in an integrated manner for 30 emissions, 80 resources, water, and land use and hence capable of making detailed trade offs visible between different environmental pressures. One of methodological issues is that economic MR SUT calculates emissions and resources embodied in trade on the basis of economic allocation. Adding physical information via the CREEA project opens the potential to add trade balances in physical terms, and hence use different allocation methods. This creates again its own complexities – in essence a combined harmonization and trade linking of economic and physical data now should be strived for, something hardly tried yet in the past. Adding physical information to the economic database, and also adding further spatial detail (e.g. using GIS with regard to e.g. land use and water use) are however clearly key elements in the roadmap of further development of global MR EE E&P SUT.

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