PROJECT N. 037033

EXIOPOL

A NEW ENVIRONMENTAL ACCOUNTING FRAMEWORK USING EXTERNALITY DATA AND INPUT-OUTPUT TOOLS FOR POLICY ANALYSIS

TECHNICAL REPORT:
Definition study for the EE IO database

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Report of the EXIOPOL project

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Authors	Arnold Tukker (TNO) and Reinout Heijungs (CML), eds., with contributions of Maaike Bouwmeester (RUG), Arjan de Koning (CML), Walter Manshanden (TNO), Stephan Moll (Wuppertal Institute) José Rueda-Cantuche (IPTS) and Glen Peters (NTNU)
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Summary

This draft definition document describes the key choices in setting up the EXIOPOL environmentally extended input-output database.

1. Countries to be included: based on criteria like GDP, trade with Europe, and embodied impacts in products the following countries have been selected to be included next to the EU27: United States, Japan, China, Canada, South Korea, Brazil, India, Mexico, Russia, Australia, Switzerland, Turkey, Taiwan, Norway, Indonesia and South Africa. While covering over 90% of the global GDP, this selection may miss impact intensive sectors related to resource extraction; with the imports of such resources known, these processes can be modelled specifically.
2. Basic architecture: the database will be set up on the basis of Supply and Use tables (SUT). Extensions will be added, and the country SUT will be trade linked. This Multi-regional SUT can be transformed via different technology assumptions into product by product and industry by industry MR IOTs. While this approach forces us to construct various valuation matrices, advantages are that SUT are closest to the statistical sources, allow for extensions linked to industries (and products), and to link trade and final consumption to products, and that an MR SUT has the flexibility to be transformed in various types MR IOTs, depending on user needs.
3. Industry and product classification will follow NACE 1.1. and CPA 1.1. Additionally to the 60 products and sectors discerned in ESA95, over 60 sectors and products will be added, mainly in the field of agriculture and food, resource extraction and –processing, and some other sectors.
4. The base year for the primary data will be 2000, since for later years not sufficient SUT or IOT are available and staying as close as possible to primary sources is a point of departure on the project. If resources permit this, a data set for 2005 or later will be constructed via simple extrapolation of SUT, and using trade data for this year.
5. Traditional value added categories labor, net taxes and gross operating profit will be used, in which additionally rents on land and royalties on resource extraction will be specified. Labor will be discerned in 3 categories, and per category hours worked, wages paid, etc. will be included. The database can be expanded to include full capital accounts, but these will not be constructed in this project.
6. About 100 environmental extensions will be discerned, allowing calculating the Ecological footprint, LCIA indicators, external costs, and MFA indicators. Sources will be various material flow databases, FAOSTAT, IEA energy databases, etc., combined with emission factors.
7. A non survey method developed by RU Groningen will be applied to trade link the SUT.

Annex III to this report lists the most important elements of the database i.e. the harmonized data categories to be used. The report discusses further technicalities such as how the transformation from primary data to the harmonized EXIOPOL format is envisaged, etc.

1 EXIOPOL: The Environmentally Extended Input-output (EE I-O) database

1.1 Exiopol in brief

FEEM and TNO have set up the Integrated Project (IP) EXIOPOL (A New Environmental Accounting Framework Using Externality Data and Input-Output Tools for Policy Analysis). It has over 35 other partners and runs between March 2007 and 2011. It has a budget of almost 8 Mio Euro of which 5 Mio Euro is funded by the EU's 6th Framework Program. It comprises of 'Clusters' of Work packages that must achieve the following goals:

(a) to synthesise and develop further estimate of the external costs of key environmental impacts for Europe (Cluster II, about 2 Mio Euro);

(b) to set up an environmentally extended (EE) Input-Output (I-O) framework in which as many of these estimates as possible are included, allowing the estimation of environmental impacts and external costs of different economic sector activities, final consumption activities and resource consumption for countries in the EU (Cluster III; about 2 Mio Euro);

(c) to apply the results of the external cost estimates and EE I-O analysis for the analysis of policy questions of importance, as well as for the evaluation of the value and impact of past research on external costs on policy-making in the EU (Cluster IV, about 0.3 Mio Euro).

These three most important Clusters in the project are completed with three smaller Clusters covering Project management, Strategy, and Education and Dissemination.

This Technical report forms the definition study for the EE I-O database (point b). It is written by the 9 partners of the full EXIOPOL consortium that are responsible for Cluster III (see Table 1.1).

1.2 Structure of the work on EE I-O

The Supply and Use Tables (SUT) and Input-Output Tables (IOT) form a key component in national economic accounting systems (e.g. System of National Accounts (SNA) United Nations 1993:) and European System of Accounts ESA; European Communities 1996). In layman terms, a Supply table shows the output value of the product groups that each industry sector produces. The Use table shows the purchases of products by industries (that use them in production) and by final consumers (households and governments). An Input-Output table (IOT) combines the information in SUTs. For instance, an industry by industry IOT describes the monetary value of purchases by an industry from each other industry (and hence the sales from an industry sector to each other industry sector).

Table 1.1: Participants in the IP EXIOPOL (status: August 2006. Partners primarily involved in EE I-O marked with *)[1]

Participant. Number	Participant name	Participant short name	Country
1	Fondazione Eni Enrico Mattei	FEEM	IT
2	The Netherlands Organisation For Applied Scientific Research*	TNO	NL
3	University of Bath	UBATH	UK
4	Leiden University, Institute of Environmental Sciences*	UL-CML	NL
5	Joint Research Centre, Institute for Prospective Technological Studies*	JRC-IPTS	ES
6	Wuppertal Institute for Climate, Environment and Energy*	WI	DE
7	National Environmental Research Institute	NERI	DK
8	Forest Technology Centre of Catalonia	CTFC	ES
9	Univerzita Karlova v Praze, Charles University Environment Center	CUEC	CZ
10	Queen's University Belfast	QUB	UK
11	Universitaet Stuttgart, Institute of Energy Economics and the Rational Use of Energy	USTUTT-IER	DE
12	Norwegian University of Science and Technology (including RPI)*	NTNU	NO
13	Nachhaltigkeitsforschungs und -Kommunikations Gmbh*	SERI	AT
14	University of Parma	UNIPR	IT
15	Ecologic Institut für Internationale und Europäische Umweltpolitik	ECOLOGIC	DE
16	University College of London	UCL	UK
17	Association pour la Recherche et le Développement des Méthodes et Processus Industriel, Ecole Nationale Supérieure de Mines	ARMINES	FR
18	Institute of Occupational Medicine	IOM	UK
19	Sweco Grøner As	SWECO	NO
20	Wageningen University	WU	NL
21	Finnish Environment Institute	SYKE	FI
22	Vrije Universiteit Amsterdam, Institute For Environmental Studies	VUA-IVM	NL
23	Chinese Academy of Social Sciences	CASS	CHN
24	European Forest Institute	EFI	FI
25	University of Padova	UNIPD	IT
27	University of Delhi, Institute of Economic Growth	UDELHI-IEG	IN
28	Institute for European Environmental Policy	IEEP	UK
29	Norvegian Institute for Water Research	NIVA	NO
30	Centre for European Economic Research	ZEW	DE
31	Warsaw University, Warsaw Ecological Economics Center	UW-WEEC	PL
32	Clean Air Action Group	CAAG	HU
33	Gesellschaft fuer Wirtschaftliche Strukturforschung	GWS	DE
34	Société pour la Promotion Internationale des Industries Aromatiques	IAP-SENTIC	FR
35	Swedish University of Agricultural Sciences	SLU	SE
36	Flemish Institute for Technological Research	VITO	BE
37	Rijksuniversiteit Groningen*	RUG	NL

[1] The project is being expanded with various national statistical bureaus. Furthermore, an advisory board is set up with other relevant actors, most notably EEA, EUROSTAT, and other bodies like OECD and the World Bank

Most industries of course cause emissions to the environment, and use primary resources. The magnitude of such 'environmental extensions', usually expressed in kg emission or resource use, can be listed in a 'satellite account' as attribute of an industry sector. In this way, an 'Environmentally Extended Input-Output Table' or EE IOT is created Such a table can have all kind of analytical applications. For instance, it can be calculated what value individual industries contributed to purchases by final consumers, and by allocating the emissions and resource use of each industry proportionally, the environmental impact of such purchases can be calculated.

A further sophistication is to take into account trade. EE IOTs usually are produced for individual countries. However, many intermediate and final products are imported, often from countries with a different economic structure and environmental impact per unit of added value. It is hence relevant to discern EE IOTs from different countries and link them via trade (Peters et al., 2006; Nijdam and Wilting, 2003).

The EE I-O work in EXIOPOL wants to cover the EU-27 and its most important trade partners. Since this will result in a country list that covers most of the global economy, *de facto* EXIOPOL aims to develop a global, multi-regional input output table with environmental extensions (MR EE IOT). This database will be connected to external costs of emissions as calculated in other parts of EXIOPOL as well.

Developing the indicated EE I-O table is an ambitious task. There are six major issues at stake that need attention (see Figure 1.1 for the relation between WPs):[2]

(a) First, for the countries included in the table individual SUT/IO tables have to be gathered, uniformed, and adjusted to a meaningful detail in sectors and products. This is done in two Work Packages focusing on the EU27 and the Rest of World.

(b) Second, for the countries included in the table various dozens of environmental extensions per sector have to be gathered. This is again done in two WPs focusing on the EU27 and Rest of World.

(c) Third, the country tables have to be linked via trade data. A separate WP is devoted to this task.

(d) Fourth, for specific analytical applications it should be possible to use the database in conjunction with econometric forecasting models. It concerns e.g. various models in use at project partner IPTS, and the World Trade Model of project partner RPI. A WP focuses on these links with other models.

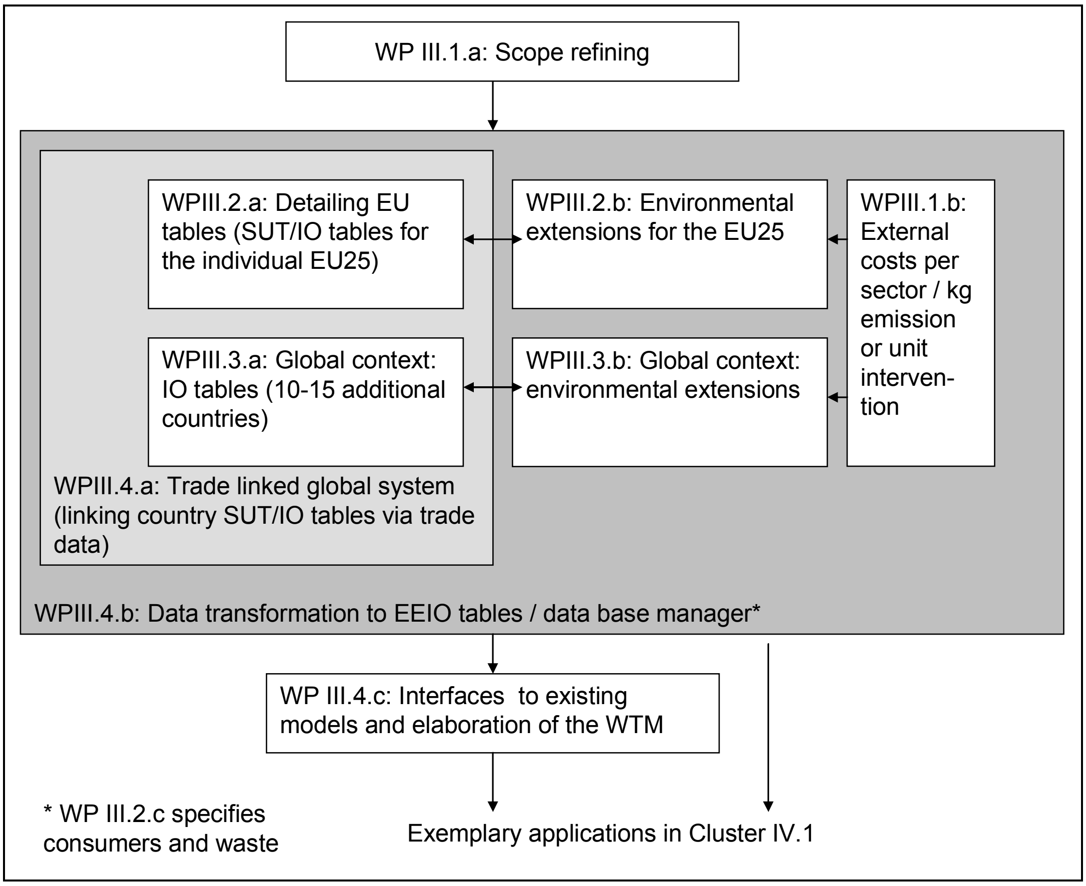
(e) Fifth, the role of consumers and post-consumer waste treatment must be added to the SUT/IO tables that traditionally focus on the production side. Consumer and waste are addressed in one WP.

[2] Smaller WPs not discussed in detail are a) the transformation of external cost data into a format that can be used in combination with EE I-O, and how to include waste management and consumer activities in the EE I-O table.

(f) Finally, all data have to be embedded in a user-friendly and updatable general purpose database system. This is also a separate WP.

For how to approach point a-d dedicated scoping reports have been written (see box 1). The first four issues are covered in the scoping reports listed in Box 1, published end July 2007. This report synthesises and elaborates on these 4 scoping reports, making integrated decisions on how to set up the database (point e). It basically forms the definition study for how to build the EE I-O database that should be the result of Cluster III. Note that this report reflects the outcome of deliberations and analyses made *after* the underlying reports mentioned in Box 1.1 were published; choices made in the present report may not be consistent with and will in that case prevail over the suggestions made in the older report.

Figure 1.1: Structure of the work in Cluster III of EXIOPOL on EE I-O



Box 1.1: Underlying Scoping reports

Peters. G., W. Manshanden et al. (2007). Technical report focusing on checks on economic data sources for SUT/IO tables for EU25 and RoW (DIII.1.a-1)

Moll. S. and S. Giljum (2007) Technical report on sources for environmental extensions for EU25 and RoW. DIII.1.a-2

Bouwmeester, M. and J. Oosterhaven (2007). Technical Report: Inventory Of Trade Data And Options For Creating Linkages. DIII.1.a-3

Neuwahl, F., J. Rueda-Cantuche, and F. Duchin (2007). Technical Report On Specifications Of The Database In View Of The Desire To Link It With Existing Models. DIII.1.a-4

1.3 Structure of this definition report

To conclude this report needs to define, based on the other deliverables of the Scoping phase of Cluster III, the database design. To this end, we will

- Introduce the concept of SUT, IOTs and environmental extensions in more detail (chapter 2);
- List operational criteria that the database ideally has to match (chapter 3);
- List key questions with regard to database design arising from the other scoping documents, discuss per element the pro's and con's, and indicate our preferred approach (chapter 4)
- Elaborate and operationalise the resulting strategic design (chapter 5 in relation to Annex III, that reviews the structure of lists used in the database).

2 EE I-O: An introduction

2.1 SUT and IOT: an overview

Supply and Use Tables (SUT) and Input-Output Tables (IOT) are a component of the System of National Accounts (SNA; United Nations 1993) and European System of Accounts (ESA95; European Communities 1996).

The supply table shows the supply of goods and services by product and industry, distinguishing between domestic industries and imports (hence it is a product-by-industry table). The use table shows the use of goods, services and value-added by product and by type of use, such as, intermediate consumption (industry) and final consumption (hence it is a product-by-industry table). The SUT are a central component of the ESA95 as they show the flows of money through an economy and are used for both statistical and analytical purposes.

An input-output table gives a detailed description of the domestic production processes and transactions within an economy. The IOT is constructed by merging the supply table and the use table into one single table and is expressed as either a product-by-product or industry-by-industry table. The central part of an IOT is thus square (it contains the same number of rows and columns) and symmetric (the items indicated by the rows and columns are the same: both are products or both are industries). The abbreviation SIOT is sometimes used to refer to a square and/or symmetric IOT.

The merging of the SUT into a single table requires assumptions – hence loss of information – but the IOT is the standard framework for a detailed structural analysis of economic activity (input-output analysis, IOA). The SUT itself requires no (or fewer) assumptions, therefore it is the preferred accounting framework for SNA and ESA95.

In terms of EXIOPOL both the SUT and IOT may play a central role. Generally, analysis is performed using IOT, but the SUT provides the foundation for constructing the IOT. The SUT is closer to the statistical source, while the IOT is estimated. Since the IOT requires additional work to construct, some National Statistical Institutes (NSI) only construct the SUT and not the IOT. On the other hand, since IOT is more relevant for analysis, some NSI construct the IOT directly and by-pass the SUT. Thus it is necessary to present a more detailed description of the SUT and IOT and the relations between them to facilitate decision making in EXIOPOL.

2.2 Supply and Use tables

Table 2.1 gives a stylised supply table, and Table 2.2 a stylised use table, roughly following the format of ESA95 (Eurostat, 2002).

Table 2.1: Supply table (after Eurostat, 2002)

	Industries	Imports (c.i.f)	Total	Valuation	Total
Products	**Production matrix:** Output by products and industries	**Imports** broken down by products	Supply of products at basic prices	**Valuation adjustment items by product**: + Taxes less subsidies on products +Trade and transport margins	Supply at purchasers' prices
Total	**Output by industry at basic prices**	Total Imports	Total supply at basic prices		**Total supply**

Table 2.2: Use table (after Eurostat, 2002)

	Industries	Sub-total	Final use			Total
			Final consum-ption	Gross capital formation	Exports, f.o.b.	
Products	**Intermediate consumption at purchaser's prices by product and industry**		**By house-holds, NPISH, govern-ment**	**Gross fixed capital forma-tion and changes in invent-tories**	**Intra- and extra EU**	Use at purcha-sers' prices
Subtotal (1)	Total intermediate consumption by industry		Total final use by type			**Total use**
Compensation of employees Other net taxes on production Consumption of fixed capital Operating surplus, net	**Components of value added by industry**					
Subtotal (3)	Value added					
Total (1)+(3)	**Output by industry at basic prices**					

The tables reflect the following identities:

- the output of an industry in the supply table is equal to the its intermediate consumption plus value added in the use table (all expressed in basic prices);
- total supply of a product is equal to the use of a product (all expressed in purchaser prices)

The supply table is given in so-called basic prices, where the use table is given in so called purchasers' prices. An intermediate level is producer's prices, where for imports and exports a distinction between cost, insurance, freight and free on board prices is at stake (see Box 2.1) Purchaser's and basic prices can be related in two ways:

- Via a transformation in the supply table. Columns are added, that give per product the valuation adjustments (taxes less subsidies on products, trade margins, and transport margins)
- Via valuation matrices that allow to transform the use table from purchasers' to basic prices. In principle 3 valuation matrices are needed, that specifies for each cell in the intermediate and final consumption blocks in Table 2.2 the[3]
    - Net product taxes less subsidies;
    - Trade margins
    - Transport margins

These valuation matrices in fact distribute the column totals for each valuation adjustment given in the supply table over using industries. This is relevant, since generally margins and net taxes/subsidies differ for each using industry.

Box 2.1: Types of prices in SUT and IOTs (Eurostat, 2002)

.The relationship between basic and purchasters'prices can be shown as follows:

Purchasers' price (excluding any deductible VAT)
- Non-deductible VAT
- Trade and transport margins
= Producers' price
- Taxes on products (excl. VAT)
+ Subsidies on products
= Basic price

The basic data which are used to compile the supply and use tables have different valuations:

- Production/output data are usually valued at basic prices or at producers' prices;
- Data on intermediate consumption and final use are usually valued at purchasers' prices;
- Imports are valued at cif-prices (= price of a good delivered at the frontier of the importing country, or the price of a service delivered to a resident, before the payment of any import duties or other taxes on imports or trade and transport margins within the country);
- Exports are valued fob (= price of a good at the frontier of the exporting country, or the price of a service delivered to a non-resident, including transport charges and trade margins up to the point of the border, and including any taxes less subsidies on the goods exported).

[3] Note that for EE IO analysis it is important to deal properly with transport margins and the 'freight' component in c.i.f. They basically represent transport services, which is an impact intensive activity. This needs specific attention in the transformation of SUTs and IOTs to standard classifications in EXIOPOL (see chapter 4)

In similar vein, the import vector given in the supply table can be distributed over intermediate and final consumption, giving an import matrix. This allows distinguishing a use table for domestic output and a use table for imports that in total again give the use table without differentiation as given in figure 2.2. Such a differentiation may be relevant if the ratio imported products / domestic products differs highly between different industries (intermediate consumption/use) and different categories of final use.

Supply and use tables (that is to say, the production table and the intermediate consumption table) are not necessarily square and/or symmetric, as the number and classification of products and industries may be different.

2.3 Input-output tables

The crucial difference between SUT and IOT is that the symmetric structure of the inter-industry part: no product-by-industry, but industry-by-industry or product by product. The supply aspect of the IOT is left implicit: the inter-industry part shows what an industry uses, its supply is not accounted for, but can be deduced from the fact that the output of an industry is used for intermediate consumption as well as for final use. As a consequence, products are not part of the IO-scheme, and final demand is not related to products, but to industries. The difference is subtle: the final demand for a product like "agricultural products" is now changed into a final demand for a "agricultural sector's outputs".

In contrast to SUT, IOT are square and symmetric[4]: they have the same number and classification of industries or products in the horizontal and the vertical direction.

Apart from the industry-by-industry IOT presented above, an alternative IOT format is product-by-product.

Both types of IOT have certain conceptual problems. For instance, adding value takes place within in an industry, not within a product.[5] But final demand is for products, not for industries.

[4] The term symmetric refers here to the fact that a certain row and a column with the same index refer to the same industry. In mathematics, a symmetric matrix denotes a quite different thing: a square matrix in which $A_{ij} = A_{ji}$ for all i and j.

[5] Likewise, and extremely relevant in the context of EE IO, emission should be connected to industries, not to products.

2.4 Relationship between SUT and IOT: from SUT to IOT and back

2.4.1 Introduction

It is possible for EXIOPOL to construct its database using either SUT or IOT as building blocks. The decision what to use will be based on both theoretical, empirical, modelling, and data availability issues. Further, for some countries we may just be able to obtain SUT, and for others IOT, so conversions between the two are inevitable. We hence discuss here some background theory explaining the relation of SUT with IOT. The intention here is not to give a detailed analysis, but rather outline the key issues to facilitate decision making. More detailed discussions can be found elsewhere (Miller and Blair 1985; United Nations 1999; ten Raa and Rueda-Cantuche 2003; ten Raa and Rueda-Cantuche 2007).

2.4.2 Notation and conventions

First, we introduce a mathematical representation[6] of the important elements of SUT and IOT.

The core parts of the supply table can be written as follows:

V	m	q
x^{T}		

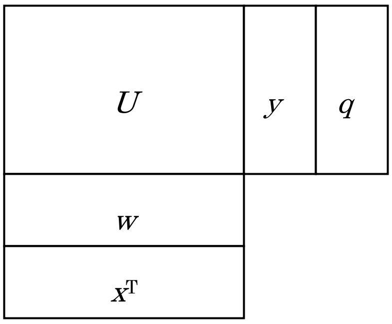
Here, V is the production matrix[7], an element V_{ij} indicates the supply of product i by industry j. [8] The vector m is a vector of product imports, and q is the vector of product total supplies (either by industries or through import). Finally, x is the vector of industry outputs.

Likewise, the core part of the use table can be written as

[6] Appendix II summarizes notation.

[7] This most central element of the supply table or supply matrix is also sometimes referred to as the supply table or supply matrix.

[8] Notice that the V-part of the supply table thus indicates a product-by-industry table. Some authors use the letter S to refer to it. The transpose of V, denoted as V^{T}, is an industry-by-product table that can be referred to as the make table. Some authors use V for it, not V^{T}.



Here, U is the intermediate consumption matrix, an element U_{ij} indicates the use of product i by industry j. The vector y is the vector of final demand for products (distinguishing several columns of final uses, e.g., consumption of households and government, gross fixed capital formation and exports), and the vector q is the vector of total use of products, by industry and by final users. The matrix w furthermore represents the various types of value added per industry, and the vector x is the vector of total industrial inputs.

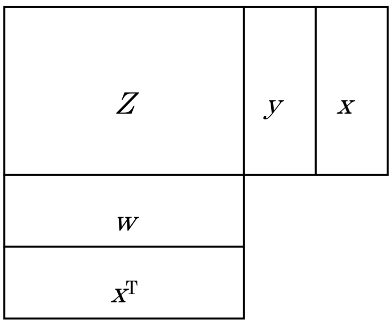
A supply table and a use table can be combined into one table; see Table 2.3.

Table 2.3: The general structure of the combined SUT.

	Products	**Industries**	**Final demand**	**Totals**
Products	0	U	y	q
Industries	V^T	0	0	x
Imports/Value added	m^T	w		
Totals	q^T	x^T		

Notice that this table contains the vector q at two places, and the vector g at two places.

IOTs come in two sorts: industry-by-industry and product-by-product tables. For now, we restrict the discussion to industry-by-industry IOTs. A general template is as below:



Here, the matrix Z is the input-output matrix, where Z_{ij} indicates the use of use industry i's output by industry j. The matrix w is as before: value added per industry. The matrix y is again a matrix of final demand, but now not for products, but for industrial output. Finally, x represents the total demand on each industry, as well as the total input to each industry.

2.4.3 Totals and balances of SUT and IOT

Table 2.3 contains column and row totals for products and industries.

First we introduce the conventions for adding rows and columns. The vector e is the summation vector, a column of 1s of appropriate size. Thus, for an arbitrary matrix A, a vector of sums over columns is written as

$$Ae = \sum_j A_{ij} \tag{1}$$

and a row vector[9] of sums over rows

$$e^{\mathrm{T}} A = \sum_i A_{ij} \tag{2}$$

Application of the summation conventions to the row and column sums in Table 2.3 yields four equations: for the use of products

$$q = Ue + ye \tag{3}$$

and for the supply of products

$$q = Ve + m \tag{4}$$

For the inputs to industries we have

$$x = e^{\mathrm{T}} U + e^{\mathrm{T}} w \tag{5}$$

and for the outputs of industries

$$x = e^{\mathrm{T}} V \tag{6}$$

Obviously, the total use of products must be equal to the total supply of products. Therefore, the two entries with q (one for use and one for supply) have received the same symbol. Thus

$$q = Ue + ye = Ve + m \tag{7}$$

A second balance equation holds for the inputs to and the outputs to industries:

$$x = e^{\mathrm{T}} U + e^{\mathrm{T}} w = e^{\mathrm{T}} V \tag{8}$$

The two balance equations are summarized in Table 2.4 below.

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[9] If we consistently use the convention that vectors are always column vectors, and that row vectors are to be denoted as the transpose of a (column) vector, we should write here $(e^{\mathrm{T}}A)^{\mathrm{T}} = A^{\mathrm{T}}e$ instead of $e^{\mathrm{T}}A$. For reasons of simplicity, however, row vectors and column vectors will not always be distinguished by notation.

Table 2.4: The balance equations in SUT.

	Total	Use	Supply
Products	q	$= Ue + ye$	$= Ve + m$
Industries	x	$= e^{T}U + e^{T}v$	$= e^{T}V$

In IOT (at least of the industry-by-industry type) balancing is easier, as the table does not specify products, but is restricted to industries. The use of industry outputs is given by

$$g = Ze + y_z e \tag{9}$$

and the supply of industry outputs is

$$x = Z^{T}e + w^{T}e \tag{10}$$

Because demand and supply balance one another, we write

$$x = Ze + y = Z^{T}e + w^{T}e \tag{11}$$

This is summarized in Table 2.5.

Table 2.5: The balance equations in IOT.

	Total	Use	Supply
Industries	x	$= Ze + ye$	$= Z^{T}e + w^{T}e$

2.4.4 Technical coefficients and the normalization of SUT

In EXIOPOL, we are ultimately interested in determining the industry outputs x and the product outputs q for an arbitrary final demand vector y. Thus we use supply and use tables and the input-output table not as an accounting tool, but as a modelling tool. The numbers in the tables refer to an observed situation, in a certain base year, with an observed final demand, and the situation in a scenario with a different final demand is predicted.

SUT and IOT contain data on transactions in the actual volumes, e.g. 12 million euros. In the modelling context, these tables are normalized, i.e. expressed as technical coefficients that show the transactions per euro of product input or output, or per euro of industrial input or output.

For the IOT, the transactions matrix is transformed into a normalized, coefficient matrix by dividing sectors' inputs by their outputs:

$$A = Z\hat{x}^{-1} \tag{12}$$

For the SUT, things are more complicated, as we can choose to normalize by the industry's output or by the product's supply. But as a matter of fact, supply and use tables are not so often normalized, and we do not expect that we will need it in EXIOPOL.

2.4.5 The use of SUT for calculations

In SUT, for an arbitrary demand *y'*, the use of products *q'* by industry will depend on the industry output *x'*, which implies normalizing the system with respect to industry output[10],

$$q' = \left(U\hat{x}^{-1}\right)x' + y' \tag{13}$$

To keep the notation simple, the distinction between primed and unprimed symbols will be dropped, the context will suffice to make clear whet we mean. Thus, we have

$$q = \left(U\hat{x}^{-1}\right)x + y \tag{14}$$

This is the standard balance equation for the use of products and is a single equation in two unknowns. To solve this system requires knowledge of how products are produced. In its un-normalized form, the supply balance, does not provide enough information to solve the system of equations. There is one equation in two unknowns, related to the fact that industries usually have next to their main product outputs also secondary outputs. We consider two common assumptions for secondary production: The industry-technology assumption and the commodity-technology assumption.[11] Note that for the transformations discussed Supply and Use tables must be expressed in the same prices (basic), transformations between these prices as discussed in section 2.2 hence may be required.

2.4.6 From SUT to IOT via the Industry-technology assumption (ITA) and Commodity-technology assumption (CTA)

<u>Introduction</u>

Statistical agencies usually collect data in a SUT framework. Further analysis, however, often takes place on the basis of IOT. Thus, IOTs have to be constructed from SUTs. This is not a trivial step. Supply tables can accommodate industries that produce more than one product, and products that are produced by more than one industry. IOTs do not mention the products, but only contain information on aggregated outputs of an industry.

This section introduces the assumptions and choices that need to be made in converting a SUT into an IOT. A central element here is the treatment of secondary products by means of technology assumptions or sales assumptions. Significant debate relates to the choice of technology assumption. There are numerous technology assumptions (ten Raa and Rueda-Cantuche 2003), but in all likelihood EXIOPOL will apply either the ITA or CTA (see ten Raa and Rueda-Cantuche 2007 for an interesting comparison of ITA and CTA).

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[10] From this point on, we will simplify the matrix of final demand, where columns represent different type of final use (households, government, etc.) to a single column vector of aggregate final demand.

[11] One could argue that the word “technology” should be dropped here, because it would be inappropriate to use it for industry-by-industry IOTs, and that for these table the term “industry-sales assumption” would be better. However, for the sake of recognisability, this term has been preserved here.

Industry-technology assumption (ITA)

The ITA assumes that all industries have the same input structure (technology) regardless of the product they produce. This assumption leads to the market share matrix,

$$x = \left(V^{\mathrm{T}}\hat{q}^{-1}\right)q \tag{15}$$

The SUT leads to two equations in two unknowns and the system can be uniquely solved for either unknown. The system of equations, (14) and(15), can easily be represented in a supply-use block

$$\begin{pmatrix} q \\ x \end{pmatrix} = \begin{pmatrix} 0 & U\hat{x}^{-1} \\ V^{\mathrm{T}}\hat{q}^{-1} & 0 \end{pmatrix}\begin{pmatrix} q \\ x \end{pmatrix} + \begin{pmatrix} y \\ 0 \end{pmatrix} \tag{16}$$

Solving this system for industry output gives the industry-by-industry requirements matrix (the central block in an industry by industry IOT),

$$x = A^{\mathrm{x}}x + y^{\mathrm{x}} \tag{17}$$

where[12]

$$A^{\mathrm{x}} = V^{\mathrm{T}}\hat{q}^{-1}U\hat{x}^{-1} \tag{18}$$

and

$$y^{\mathrm{x}} = V^{\mathrm{T}}\hat{q}^{-1}y \tag{19}$$

Solving the system for product output gives the product-by-product requirements matrix (the central block in a product by product IOT),

$$q = A^{\mathrm{q}}q + y \tag{20}$$

where[13]

$$A^{\mathrm{q}} = U\hat{x}^{-1}V^{\mathrm{T}}\hat{q}^{-1} \tag{21}$$

In addition, various manipulations can be used to construct different systems. For instance, a system that takes the final demand in products and returns the industry output is

$$x = \left(I - A^{\mathrm{x}}\right)^{-1}V^{\mathrm{T}}\hat{q}^{-1}y \tag{22}$$

Alternatively, this same equation can be solved as

$$x = V^{\mathrm{T}}\hat{q}^{-1}\left(I - A^{\mathrm{q}}\right)^{-1}y \tag{23}$$

with the same solution resulting. This shows that if the final demand is in a product classification then the SUT can be used to convert the resulting output to an industry classification.

Commodity-technology assumption (CTA)

An alternative assumption is to assume that all products have the same input structure (technology) regardless of the industry that produces it. This amounts to normalizing with respect to industries,

[12] This is the fixed product sales structure model.

[13] This is the industry technology assumption.

$$x = \left(\hat{x}V^{-1}\right)q \qquad (24)$$

Again, we have a system of two equations in two unknowns,

$$\begin{pmatrix} q \\ x \end{pmatrix} = \begin{pmatrix} 0 & U\hat{x}^{-1} \\ \hat{x}V^{-1} & 0 \end{pmatrix}\begin{pmatrix} q \\ x \end{pmatrix} + \begin{pmatrix} y \\ 0 \end{pmatrix} \qquad (25)$$

As for the ITA, the CTA leads to either a product or industry system. Solving the system for industry output gives the industry-by-industry requirements matrix (the central block in an industry by industry IOT),

$$x = A^{x}x + y^{x} \qquad (26)$$

where[14]

$$A^{x} = \hat{x}V^{-1}U\hat{x}^{-1} \qquad (27)$$

and

$$y^{x} = \hat{x}V^{-1}y \qquad (28)$$

Solving (14) and (24) for product output gives the product-by-product requirements matrix (the central block in an industry by industry IOT),

$$q = A^{q}q + y \qquad (29)$$

where[15]

$$A^{q} = UV^{-1} \qquad (30)$$

In addition, various manipulations can be used to construct different systems. For instance, a system that takes the final demand in products and returns the industry output is

$$x = \left(I - A^{x}\right)^{-1}\hat{x}V^{-1}y \qquad (31)$$

ITA versus CTA

In essence the choice of ITA or CTA relates to how the supply table is normalized; equations (15) and (24). The pro's and con's of each assumption can be summarized as follows. The CTA is preferable theoretically, but it has the disadvantage of producing negative numbers. Due to this problem, many users apply the ITA despite the various theoretical issues[16]. Given that different users may demand the EXIOPOL database, it is advisable for EXIOPOL to allow flexibility for the user to take their preferred option. Once a complete set of SUT is available, it is straight-forward to apply either the ITA or CTA to produce either industry or product tables.

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[14] This is the fixed industry sales structure model. Notice that the symbols A^{x}, y^{x}, etc. have a meaning only within the CTA text; in the ITA text such quantities are defined differently.

[15] This is the product technology model.

[16] An additional note relevant for EXIOPOL is that the CTA works in physical units while the ITA does not.

2.4.7 IOT

The result of the transformations described before is a square Input Output Table. The industry by industry IOT describes the monetary value of purchases and sales by an industry from and to each other industry. A product by product IOT describes how much input of other products is needed to produce the total volume of a specific product, and for what this volume of product is used. Table 2.4 gives an example of an industry by industry IOT.

If EXIOPOL uses IOTs as basic building blocks for its database, common sense will guide the choice of industry or product tables. If the final demand and emission intensities are all in products, then it would make sense to use product tables. If they are both in industries, then it would make sense to use industry tables. If the final demand is in products and emissions intensities in industry then the choice is arbitrary. At some stage the supply table will be required to convert either the final demand to industries or the emission intensities to products. While not obvious, this implicitly happens when one selects a product or industry table – recall that the difference between an industry IOT and product IOT is simply the order of multiplication of the normalized SUT. Also here it may be advisable that EXIOPOL allows flexibility for the user to take their preferred option.

2.4.8 From IOT to SUT

As noted earlier, the usual way to proceed is from accounting framework (SUT) to analysis framework (IOT). There is one important complication. There are countries that publish no SUT but only IOT. In order to create harmonized SUT for EU-27 and the rest of the world, such IOT may have to be transformed to SUT. As noted earlier, industry-by-industry IOT contain no information on products, so the step from IOT to SUT requires assumptions on the products involved. The typical default assumption to be made is that every industry produces one and only one product, that directly corresponds with its sector. Thus an industry that is called "processing of meat cattle" produces only "products of meat cattle", not milk. Obviously, this trick will only work for SUT frameworks in which there is a on-to-one correspondence between products and industries.

2.5 Environmental extensions

2.5.1 Introduction

The System of Integrated Environmental and Economic Accounts – SEEA 2003 (United Nations et al. 2003) provides the conceptual foundation for environmental extensions to SNA-based IO and SU. Broadly two main types of extensions can be distinguished (see SEEA 2003, p. 30):

1. <u>*Natural Resources*</u> cover mineral and energy resources, water and biological resources (in addition land is considered in the context of EXIOPOL). Natural resources flow mainly from the national environment into the national economy.

2. *Residuals* are the incidental and undesired outputs from the economy without economic value and are discharged into the environment. Usually, it concerns emissions to air, water and soil[17].

Such extensions can be attached to both frameworks, SUT and IOT. Both ways of attaching environmental extensions are discussed below.

2.5.2 EE-SUT

Environmental extensions can be attached to a Supply-Use framework – an EE-SUT. The 'use' of natural resources, products and residuals is recorded row-wise in the upper-right part of the scheme. Natural resources are extracted ('used') by production activities (industries) and consumption activities (households, government and non-profit organisations). The 'supply' of natural resources, products and residuals are recorded column-wise in the lower-left part of the EE-SUT scheme

Residuals (emissions) are mainly discharged to nature ('used' by nature).

The EE-SUT scheme also offers the flexibility to record the supply and use of residuals not by industries but by products. This may become helpful in cases where statistics on environmental extensions are not reported by industries but by production technologies, i.e. associated with certain products This would require to include a set of columns and rows for physical products (between the items 'imported products' and 'residuals').

2.5.3 EE SIOT

For attaching environmental extensions to an IOT several options exist. The scheme in Table 2.4 shows an EE IOT via so-called satellite approach. The monetary SIOT remains as it is and the non-monetary environmental extensions are attached in form of separate accounts underneath the monetary accounts. It is also thinkable to merge monetary and physical flows into one symmetric system arriving at so-called hybrid tables.

The satellite accounts of environmental extensions are rather simple. There is an input-matrix of environmental extensions and an output-matrix. Inputs are primary natural resources ('gifts from nature'). The output matrix of environmental extensions comprises the various emissions. The simplified EE-SIOT scheme in Figure 2.4 does not consider controlled landfill sites and the natural environment since they are usually not part of the monetary SIOT. As a consequence the total of residual inputs in the EE-satellite does not equal the total of residual outputs.

[17] Note that by-products used in the economic system, waste that is recycled, or waste that is treated, all form still flows in the economy and hence have a place in the SUT or IOT. Only a final emission or the final land use occupation of a landfill can be included as an extension.

Table 2.4: Environmental extensions in a Symmetric Input-Output framework (EE-SIOT)

	Industries	Sub-total	**Final use**			**Total use (basic prices)**
			Final consum-ption	Gross capital formation	Exports, f.o.b.	
Industries	**Industry by industry transactions in basic prices**		**By house-holds, NPISH, govern-ment**	**Gross fixed capital forma-tion and changes in inven-tories**	**Intra- and extra EU**	
Subtotal (1)	Total intermediate consumption by industry		Total final use by type			**Total use**
Tax less subsidies (2)	Net tax on production [??]					
Total (1)+(2)	Total intermediate consumption in purchasers's prices [where are transport margins?]					
Compensation of employees Other net taxes on production Consumption of fixed capital Operating surplus, net	**Components of value added by industry**					
Subtotal (3)	Value added					
Total (1)(2)(3)	**Output by industry at basic prices**					
Imports	Imports cif					
Total supply	**Supply in basic prices**					

Input (natural resources: land, fossil fuels, minerals, etc.)	Resource use per type and industry		Idem, per consumption activity			Total
Output (emissions)	Emission per type and industry		Idem, per consumption activity			Total

2.5.4 Stocks

The natural resource flows entering the economy are linkable to natural stocks as well. The environment can be thought of in natural capital terms as a collection of various types. The SEEA 2003 distinguishes broadly three categories of natural capital: natural resources, land and ecosystem inputs. Chapter 7 of the SEEA 2003 presents methods to compile physical and monetary asset accounts and how to link stock and flow information.

2.6 Inter-country linked SUTs and IOTs

Until now, we have discussed SUTs and IOTs for individual countries only. If sufficient insight in trade is available, SUTs for individual countries can be combined to a Multi-regional SUT, and IOTs for individual countries to a Multi-regional IOT. To this end, the national IOT or SUT must be split according to both spatial origin and destination, and data inconsistencies must be dealt with. This is part of the project, and discussed in more detail in chapter 4. Examples of the overall structure of such inter-country tables is given in Figure 2.5 and Figure 2.6[18].

Figure 2.5: Intercountry input-output table

$Z^{11}y^{11}$	......	$Z^{1r}y^{1r}$	......	$Z^{1n}y^{1n}$	$z^{1w}y^{1w}$	x^{1}
⋮	⋱	⋮		⋮	⋮	⋮
$Z^{r1}y^{r1}$	......	$Z^{rr}y^{rr}$	......	$Z^{rn}y^{rn}$	$z^{rw}y^{rw}$	x^{r}
⋮		⋮	⋱	⋮	⋮	⋮
$Z^{n1}y^{n1}$	......	$Z^{nr}y^{nr}$	......	$Z^{nn}y^{nn}$	$z^{nw}y^{nw}$	x^{n}
$Z^{w1}y^{w1}$	......	$Z^{wr}y^{wr}$	......	$Z^{wn}y^{wn}$		
$(W^{1}W_f^{1})'$	......	$(W^{r}W_f^{r})'$	......	$(W^{n}W_f^{n})'$		
$(x^{1}y^{1})'$	......	$(x^{r}y^{r})'$	......	$(x^{n}y^{n})'$		

- r,s = 1 … n countries
- w = rest of the world
- Z^{rs} = intermediate goods matrix
- z^{rw} = intermediate goods vector
- y^{rs} = final demand vector
- x^{r} = output vector
- W^{r} = value added matrix, intermediate goods
- W_f^{r} = value added matrix, final demand

[18] Taken from Bouwmeester and Oosterhaven. (2007). In the first scoping reports notatations were not yet fully harmonized in the project, so it may be that notations in figure 2.5 and 2.6 differ somewhat from the rest of this chapter

Table 2.6: Intercountry supply and use table

0	U^{11}	………	0	U^{1r}	………	0	U^{1n}	0	u^{1w}	q^{1}
V^{11}	0	………	V^{1r}	0	………	V^{1n}	0	V^{1w}	0	x^{1}
⋮	⋮	⋱	⋮	⋮		⋮	⋮	⋮	⋮	⋮
0	U^{r1}	………	0	U^{rr}	………	0	U^{rn}	0	u^{rw}	q^{r}
V^{r1}	0	………	V^{rr}	0	………	V^{rn}	0	V^{rw}	0	x^{r}
⋮	⋮		⋮	⋮	⋱	⋮	⋮	⋮	⋮	⋮
0	U^{n1}	………	0	U^{nr}	………	0	U^{nn}	0	u^{nw}	x^{n}
V^{n1}	0	………	V^{nr}	0	………	V^{nn}	0	V^{nw}	0	q^{n}
0	U^{w1}	………	0	U^{wr}	………	0	U^{wn}			
$(v^{w1})'$	0	………	$(v^{wr})'$	0	………	$(v^{wn})'$	0			
0	$(W_*^{1})'$	………	0	$(W_*^{r})'$	………	0	$(W_*^{n})'$			
$(z^{1})'$	$(x^{1})'$	………	$(z^{r})'$	$(x^{r})'$	………	$(z^{n})'$	$(x^{n})'$			

r,s = 1 … n countries
w = rest of the world
V^{rs} = supply matrix, intermediate goods and final demand (industry by product)
U^{rs} = use matrix, intermediate goods and final demand (product by industry)
v^{wr} = supply vector, intermediate goods and final demand
u^{rw} = use vector, intermediate goods and final demand
q^{r} = output by commodity vector
x^{r} = output by industry vector
W_*^{r} = value added matrix, intermediate goods and final demand

3 State of the art and design specifications

3.1 The EE I-O data situation today

The European System of Accounts 1995 (ESA95) requires that individual EU member states transmit on a yearly basis SUT and on a 5 yearly basis SIOTs to Eurostat (EC, 1996). On a voluntary basis, individual member states report National Account Matrices including Environmental Accounts (NAMEAs). These include some 10-15 emissions to air (Eurostat, 2005) All this material is available in a harmonized format at a resolution of 60 sectors and products. Various studies including EIPRO showed that this is not sufficient for environmental applications. Agriculture, mining, energy production and transport are areas with high environmental impact intensities, which however differ considerably per sub-sector. Hence a much higher resolution of at least 100-150 sectors or more is essential for allocating sustainability impacts in a meaningful way to sectors, products, etc. (Tukker et al., 2006, Weidema et al., 2005) Furthermore, the ESA95 country SUT and IOT are not linked via trade to a full table for the EU27. In sum, an integrated IOT table for the EU is not available, let alone the one that integrates a significant number of environmental extensions.

For many other countries in the world SUT and IOT are available. For some countries like Japan and the US they have a very high detail (500 sectors or products). The OECD has used this material to produce industry by industry IOTs with a harmonized sector classification. The most recent OECD data have as base year 2000 and cover about 90% of the global GDP (Yamano and Ahmad, 2006). Still, all these tables are for single countries only and usually have no official links to environmental extensions[19].

The Global Trade Analysis Project (GTAP) gives a multi-regional I-O table for the world economy that discerns an impressive amount of sectors (58) and regions (87). It links such data also to energy use (Dimaranan, 2006). This effort probably comes closest to the goals EXIOPOL pursues. Various drawbacks include however data transparency, a sector classification which diverges quite a lot from ESA95, lack of environmental extensions, sometimes dated original data [20].

Finally, DG JRC IPTS is working on a set of harmonized SUT and IOT for the EU27 countries for the year 2000 and aims to transform them to an integrated EU27 table (Rueda Cantuche et al., 2007). This data set is further being detailed

[19] Individual research groups sometimes combine I-O data with environmental data sources, such as in the US. Japan has developed with a number of other countries bilateral I-O tables that include trade.

[20] The GTAP project has a track record of about 15 years, and build up an impressive user and support network. GTAP updates its database roughly every three four years. It relies on voluntary submissions of tables in GTAP format from research institutes rather than official statistical bureaux. For some countries the original IOT is quite dated, and just scaled up to the new base year.

considerably for the agriculture and food sector. This IPTS data set can probably be made available for EXIOPOL by end 2007 or early 2008. It will also be submitted to GTAP for inclusion in the next GTAP release[21].

The EE I-O work in EXIOPOL seeks to solve the problem that no integrated EE IOT exists for Europe or the world. The project aims hence at filling an essential gap in the current toolbox of environmental (and economic) accounting at the Commission's services. The project's aim is really to leapfrog: it would give the EU a full-fledged, detailed, transparent, public, official global EE IOT with externalities, allowing for numerous types of analyses for policy support. In relation, it is an explicit goal of the project that the database should not stay in ownership of the developers, but is handed over for structural maintenance and use to one of the relevant Commission's services (DG JRC IPTS, the European Environment Agency, and EUROSTAT). How to organize the heritage of EXIOPOL is part of the project, but this ambition is realistic: DG JRC/IPTS has expressed it willingness to do so in due time.

3.2 Design specifications related to potential analytical applications

The potential applications of an EE I-O database have been discussed at length in the IPTS report 'Environmentally Extended Input Output Tables and Models in Europe (Tukker et al., 2006). That report discerns as three main functions of such an EE I-O database (see box 3.1). An EEA report roughly came to the same types of applications (Femia and Moll, 2005)

1. Problem analysis (typical questions: pollution embodied in final consumption, pollution embodied in trade, etc.). For this, a static table for a specific year is sufficient.
2. Monitoring. For this, time series of data are needed, and via techniques such as decomposition analysis the factors driving changes in environmental pressure can be identified.
3. Foresight and scenario analysis. For this, a policy scenario can be 'imposed' on the table, which for such purposes than usually is used with a dynamic model.

The database has to be designed in such a way that such applications are possible. Yet, it has to be stressed that the project primarily develops a database, since that is the true added value of our work. The effort to create linkages to existing models, or building new models, hence has been limited. Further, a database like this probably can be used to answer dozens, if not hundreds of questions. Building a user-friendly interface to accommodate so many queries goes too far as well. EXIOPOL foresees doing some illustrative policy analysis in Cluster IV, and the development of the interface and related queries will be focused on this need.

[21] Frederik Neuwahl, IPTS, personal communication, August 2007

Box 3.1: Applications of an EE I-O database (from: Tukker et al., 2006)

1) Environmental problem analysis. This involves the analysis of the nature and causes of environmental problems, as related to resource use and emissions relevant for policy. The most important application of EEIO models for this purpose include analyses of:
   a) Life cycle environmental impacts per consumer group (e.g. inhabitants of a city versus the rest of a country; car owners versus non-car owners, etc.)
   b) Life cycle environmental impacts of consumption expenditure categories, per consumption category (e.g. the impact of food consumption at home and the impact of food consumption in restaurants)
   c) Life cycle environmental impacts of product groups (e.g. cars, meat, houses, etc.)
   d) Life cycle environmental impacts of products (in combination with LCA via so-called hybrid LCA-EEIO. In such hybrid LCA-EEIO, the impact of a specific product is analysed with LCA, and the impacts of process chains not included or 'cut off' in the LCA are estimated with the help of EEIO)
   e) Life cycle impacts related to primary resources used (e.g. oil, copper, wood, etc)
   f) Factors that are responsible for the main contributions to life cycle impacts mentioned under point 1 to 5. Examples include the relative importance of impacts in the resource extraction, production, use and waste management stages; the relative importance of domestic impacts and impacts embodied in imports; and the sector mainly contributing to impacts of a consumer group, expenditure category, or product (group)
2) Prospective effect analysis of policies. This involves the ex ante prediction of effects of policy measures and may include trend and scenario analysis. The most important application of EEIO models for this purpose include:
   a) Economy-wide environmental and other implications of changes in life styles and consumption expenditure patterns, like a shift from travelling to educational and cultural services;
   b) Economy-wide environmental and other implications incremental or radical technical change of products or processes, like a shift to coal based hydrogen production for large scale fuel cell introduction, combined with carbon sequestration;
   c) Economy-wide environmental and other implications of emission reduction measures, like fine dust reduction in all combustion processes, including shifts to prevention;
   d) Economy-wide environmental and other implications of price effects, such as environmental taxation and other ways to internalise of external effects (or other price effects in the aforementioned scenarios
3) Monitoring and ex post effect analysis of policies. This involves the ex post analysis of impacts and effectiveness of policy measures, including time series analysis.
   a) Analysis of the relation between environmental impact, be it emissions, total material requirement, or a specific impact, and economic output, via a variety of cross sections of the economy (for instance for a specific industry sector, a specific product group, a specific consumption expenditure category).
   b) In relation to the former point: monitoring of eco-efficiency ratio's (impact per unit of value created).
   c) Decomposition analysis of observed changes in the aforementioned ratio's (for instance if decoupling between CO2 emissions and economic growth is caused by a change in consumption patterns, change in technology structure, or a change in emission factors).

Note further that the applications above are possible for environmental and economic questions. This will have implications for data needs. An extreme example: almost all economic analysis need data on the factor inputs labor and capital inputs, where most environmental analysis can do very well without. Economic analyses may ask detail in sectors with a high labor and capital intensity and – input; environmental analyses will ask detail in sectors where impact intensity is high. Etc. Where choices have to be made, EXIOPOL probably will prioritize from an environmental perspective.

3.3 Other design specifications

The Description of Work (DoW) of EXIOPOL already formulated a number of key points of departure in developing the EE I-O database. Elaborating on this, the project team formulated in the inception phase the following design criteria:

1. Transparency. The philosophy behind EXIOPOL is that its database should be in principle fully transparent and traceable.
2. Orientation to a future ideal with regard to primary data gathering by National Statistical Offices, e.g. in terms of sector and product resolution, classifications, and data architecture[22].
3. Theoretical superiority. This includes e.g. the ability to link environmental extension in a physical meaningful way to sectors
4. Empirical superiority – also given data limitations (timeliness, availability, number of transformations needed). This implies for instance that the database itself should stay as close as possible to official statistics, particularly of Eurostat.
5. Easy updatability and flexibility towards (new) future opportunities and changes (such as potential future improvements of sector and product detail, inclusion of physical flows, and creating time series)
6. Suitability to express environmental impacts in the indicators Ecological footprint, External costs, Total Material Requirement (TMR), and the Life cycle impact assessment (LCIA) themes GWP, ODP, POCP, acidification and eutrophication.
7. Linkeability to a selected number of dynamic models, the World Trade Model, and to Life Cycle Assessment (via hybrid LCA or 'IOA-LCA'); this implies amongst others that a minimum number of factor inputs (in price and volume) and factor stocks must be inventoried.
8. Relevance: focus of data gathering efforts on what matters (see box 3.2). This implies in any case realizing a sector detail that is meaningful for most environmental applications, which requires detailing the ESA95 classification in the areas of agriculture, mining and mineral extraction, energy production, and waste management.

[22] The idea is that our project should set a reasonable benchmark in terms of structure, and that will form a guidepost for data generators in the future. See however section 2.1. that different uses will pose different demands to the EE I-O table.

9. Fit with workload and time path of EXIOPOL (e.g. related to the number and complexity of transformations between 'raw' data and the harmonized EXIOPOL structure; the extent to which sectors must be further disaggregated, etc.)
10. Openness: the database must be protected (to avoid commercial hijacking) but open source and accessible for a large number of users
11. High degree of automatization and user friendliness. For instance, ideally basic data should be automatically converted for updates.
12. Computability. It must be possible to handle the database and do the calculations on a PC, which poses potential limits to the amount of data that maximally can be handled.
13. Added value over what exists

Box 3.2: Data relevance

A Multi-regional EE I-O database consists of an enormous amount of data, and priorities have to be set both in the gathering of data in a base year, and in the potential production of updates. The project must obviously cover the EU27, but for the rest of the world countries with a high GDP, large trade volumes with the EU27 or impact-intensive processes are a priority. Detail in sectors and products from an environmental perspective is only relevant when impact intensities differ, and total impact (given impact intensities and sector volumes) is high.

Furthermore, the project probably must pay more attention to data types that are inherently volatile than data that can be assumed to be rather stable. For instance, for stable data types it may be acceptable to use or extrapolate from easy accessible older data sources (e.g. technical co-efficients, valuation matrices, factor and resource inputs and emissions per unit added value in most countries). But rather volatile data (such as production and consumption volumes per product or sector, exchange rates, and trade volumes) and countries and sectors that have a fast development (e.g. China) probably need a relatively high attention.

4 Key choices

4.1 Introduction

In its kick off meeting, the team identified about 14 key questions with regard to the design of the database. These questions have been refined in the various individual scoping documents for the WPs in Cluster III. On this basis and further discussion in the project team, the following key choices were identified:

1. Countries to be included next to the EU27 and how to handle the remaining 'true' Rest of world
2. Basis and route for building the global multi-regional trade-linked database (based on SUT or SIOT)
3. Definition of sector and product classification and detail
4. Structure of consumer activities
5. Choice of base year
6. Value added elements c.q. factor inputs/flows and constraints/stocks to be included
7. Primary IOT/SUT data sets to be used, and transformation principles for mapping such data on the harmonized EXIOPOL structure[23].
8. Environmental extensions (classification, detail, and attribution problems including carbon accounting issue)
9. Procedure for linking the individual SUT/IOT country tables via trade
10. Terminology and notation conventions

In the sections below we now will discuss in detail the options, the pro's and the con's in view of the criteria in chapter 2, and the team's decision. Where we try to be as specific as possible, it is inevitable that quite some specific decisions can only be made once in depth insight in data and problems is available, i.e. while working with the data in the main project phase.

All the choices will be reflected in the database outline, discussed in chapter 5.

[23] Note this point covers a host of issues, ranging from how to include different price layers c.q. to transform a Use table in purchaser prices to basic prices, transit of goods, enhancing sector detail, etc.

4.2 Countries to be included in relation to data availability, and handling the 'true' Rest of world

4.2.1 Introduction

The NTNU/TNO background document lists four main criteria to guide the choice of additional countries that can be included in the database next to the EU27:

1. share of global GDP
2. share of trade with the EU27
3. environmental impact related to goods imported by the EU27
4. percentage of GDP traded with the EU27 in a specific country

The last criterion would allow analysing the impact of EU policies on countries highly depending on trade with the EU. Yet, this would imply that a lot of small countries, mainly in Africa, would have to be included. Since from our perspective there is a need to limit the complexity and the desire to focus on global environmental and economic impacts, the use of the first three criteria is preferred. Criterion 1, 2 and 3 lead to roughly the same country sets, and allows for covering over 90% of the global GDP and over 80% of the imports to the EU27 with just 16 additional countries. Most of these countries also have reasonable data available for 2000 or later.

From the perspective of workload and complexity this has advantages over choosing a much larger country set. It also has the strategic advantage that we concentrate on a limited number of countries with good data, and hence are most likely to come up with a trustworthy data set for the vast majority of the global GDP. In terms of quality, including primary data for dozens of other countries will have probably no added value over e.g. including them by extrapolation, given the generally poor primary data available, the limited time per country that would be available to harmonize and improve them, etc.

4.2.2 Proposed country set and available data

Table 4.1 below gives the ranking of countries on the basis of the three criteria. We propose to select next to the EU27 16 countries: the top-17 countries based on GDP, excluding Saudi Arabia since that economy is probably dominated by one sector, i.e. oil and gas production (see below). The set includes small countries closely related to the EU27 like Norway and Sweden, with the exception of non EU countries formerly part of Yugoslavia.

This set covers about 80% of the trade with the EU27 and over 90% of the global GDP. As reviewed by Table 4.2, all these countries have SUT or IOTs for around 2000 (Japan, Korea, Mexico, China, Taiwan and Brazil seemingly no SUT). It could be considered to add further Hong Kong, Singapore and Argentina due to GDP and/ortrade volume with the EU27.

The only real danger of our approach is that particularly impact-intensive industries like mining in the other countries are left out. For instance, the list above misses important resource producing countries, such as Saudi Arabia, Libya, Algeria, UAR, Chile. However, many of those economies are dominated by just a few sectors (e.g. the oil producing countries by oil and gas production).

This can be solved by looking at the trade data in combination with knowledge about what products and commodities usually cause high impacts in the production stage. It will be relatively easy to model such impact-intensive processes in this 'true RoW' or even construct this 'true RoW' along the following lines. Total exports from the RoW and imports to the RoW are known. Together with environmental data, this gives insight in the most important sectors. Total GDP is known as well. Using this information as constraints and applying technology transfer assumptions, it is probably possible to 'construct' a stylised SUT/SIOT for the RoW. An alternative is to use the RoW just as 'sink' and 'source' for the unallocated imports and exports to/from the 43 countries covered, and to attribute information on environmental impacts in the RoW directly to these import and export flows. Missing information on environmental impacts can be completed using life cycle assessment databases.

Table 4.1: Top 17 non EU countries concerning GDP, Trade with EU25, and embodied CO2 in trade with the EU25 (Peters et al. 2007)

Country	GDP	Trade with EU25	Embodied CO_2 in imports (Peters et al. 2007; GTAP classification)
United States*	1	1	1
Japan*	2	4	2
China*	3	2	3
Canada*	4	16	9
South Korea*	5	8	8
Brazil*	6	10	16
India*	7	14	--
Mexico*	8	--	--
Russia*	9	3	5
Australia*	10	--	--
Switzerland*	11	6	4
Turkey*	12	7	11
Taiwan*	13	9	14
Saudi Arabia	14	11	6 [Rest of Middle East]
Norway*	15	5	7 [EFTA other]
Indonesia*	16	--	--
South Africa*	17	--	--
Argentina**	-- [20]	--	--
Hong Kong**	-- [21]	--	10
Singapore**	-- [26]	15	13
Malaysia	-- [24]	--	12
Algeria	-- [29]	12	15 [Rest of North Africa]
Libya	-- [35]	13	15 [Rest of North Africa]

* To be included next to the EU27 in the EXIOPOL database

** Second priority for the EXIOPOL database

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Table 4.2: Availability of primary SUT and IOT for priority non EU-countries

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	Name	USA	Japan	China	Canada	Republic of Korea	Brazil	India	Mexico	Russian Federation	Australia	Switzerland	Turkey	Taiwan	Norway	Indonesia	South Africa
Supply and Use Table	Most recent	2002	2000			2000	1996	1998/9		2000	2001/2	2001	1998	2004	2003		
	Update frequency	5				?	1-5				1-3			2-3	1		
	Years					60-20	85-96				58-02			81-04	01-03		
SUT details	# products					?	80				96(106)	42		?	59		
	# industries					?	43				96(106)	42		?	59		
	Currency					Kwon	Reais	Rupies		Rouble	AUS	Sfr	TL	P	NAC		
	Valutation	Pr				?	B				?	B			B-R		
Symmetric IO table	Most recent	2002	2000	2002	2002	2000	1996	98/99	2002	1997	2001/2	2001		2004	2002	2000	
	Update frequency	5	5	5			1-5	5			1-3			2-3	5		
	Years						85-96	93-99			58-02			81-04	01; 02		
Symmetric Details	Product\Industry		Pp	pp	Pp	pp		pp	pp	pp		ii	Pp	?	pp	pp	
	# sectors	500	500	124		404		115	57	22	96(106)	42		160?	59		
	Currency	$	Yen		C$	Kwon		Lakh	Peso	NAC	AUS		TL	Yuan	NAC		
	Valutation			PR	B	P	B			B		B		P	B		
	Technology							ITC							?		
	Import table			N		Y	Y			Y	Y	N	Y	Y	Y	Y	

4.3 Basic architecture: SUT or SIOT based

4.3.1 Introduction

EXIOPOL has the following basic options to construct a global, multi-regional SUT or IOT with environmental extensions (further abbreviated MR EE SUT or MR EE IOT). We remind the reader to chapter 2, that introduced two types of IOT (product by product and industry by industry), which can be derived from SUTs via two basic ways of dealing with secondary products (the product technology and industry technology assumption)

The first 2 routes base themselves directly on national IOTs. These are extended with environmental information and then linked via trade:

1. Route 1p: pxp MR EE IOT produced from national pxp SIOTs
    a. Use or create national product x product SIOTs,
    b. Add Environmental Extensions and Link via Trade
2. Route 1 i: as above, but now starting with national ixi SIOT, leading to a ixi MR EE IOT.

The following 4 routes use national SUTs as a basis. These are extended with environmental information and then transformed to national SIOTs with environmental extensions that in turn are linked via trade. This route has four variations, since there are four basic ways of transforming SUTs to SIOTs (i.e. via the aforementioned two technology assumptions into a product by product or industry by industry SIOT). In sum:

3. Route 2p-ita: product by product MR EE IOT produced from national SUTs with the industry technology assumption
4. Route 2i-ita: industry by industry MR EE IOT produced from national SUTs with the industry technology assumption
5. Route 2p-pta: product by product MR EE IOT produced from national SUTs with the product technology assumption
6. Route 2i-ita: industry by industry MR EE IOT produced from national SUTs with the product technology assumption

The last route foregoes building a traditional MRIOT, but creates a Multi-regional SUT. To national SUTs environmental extensions are added, and these are directly linked via trade. The result is a MR EE SUT.

7. Route 3: MR EE SUT by using national SUTs, adding environmental extensions and liking them via trade.

4.3.2 Considerations

Quite some studies in the field of EE IO seem to make the choices listed above unconsciously, or don't distinguish between different types of IOTs produced via different assumptions. Where the practical consequences of this may be limited[24], we feel that in EXIOPOL a well-founded choice is needed.

The approaches presented above have some overlap. Route 1-2 can in principle be combined with route 3-6. Depending on what is available, national EE IOTs are produced directly from IOTs or via SUTs. The resulting set of EE IOTs is then trade linked, leading to the MR EE IOT (in products or industries). Also the MR EE SUT resulting from route 7 can be transformed in 4 ways to the same end results as in route 3-6 (i.e. product by product or industry by industry MR EE IOT via the industry technology assumption or product technology assumption).

As for advantages and disadvantages in terms of the design criteria mentioned in Chapter 3, the following can be remarked).

a) most analytical applications (problem and attribution analysis, monitoring, scenario analysis) are usually done with SIOT.

b) Specifically, most dynamic models are built around an SIOT- rather than SUT core. Different models may need different types of SIOT.

c) From a theoretical viewpoint, environmental extensions usually need to be linked to industry sectors, where final demand and trade needs to be linked to products. SIOTs are either in products or sectors, and only the routes starting with SUT create the flexibility to accommodate both. Further, it is now generally acknowledged that since SUTs are closer to the statistical sources, they form the best basis for building up an input-output framework.

d) From an empirical and practical viewpoint, no clear preference seems available. For the EU27 SUTs are published yearly where SIOTs are published only 5 yearly. For other countries the situation is mixed. Some countries produce SUTs and SIOTs, But since IOT is more relevant for analysis, some NSI construct the SIOT (some in products, some in industries) directly and by-pass the SUT. NSIs usually can produce higher quality SIOTs from SUTs than 'outsiders' since they can use additional background information and hence apply more sophisticated technology assumptions.

e) In terms of workload, for SUT based approaches have the problem is that usually the supply table is published in basic, and the use table in purchaser prices where they need to be in the same valuation to produce SIOTs. As explained eloquently by Rueda Cantuche et al. (2007), an input-output framework based on SUT needs next to the supply and use table also 3-4 valuation matrices (giving retail-, wholesale- and transport

[24] For instance, in many SUT and IO schemes the industry and product classifications are similar and SUTs are hence square. Furthermore, supply tables often show that by production is relatively unimportant and that hence the output of a sector falls mainly in one product category. Such supply tables (square, only non zero's on the diagonal) will always result in the same SIOT (independent of the technology assumption and if it concerns product by product or industry by industry tables

margins and taxes less subsidies). This implies more work on aligning prices than if directly SIOTs would have been used. On the other hand, since SIOTs are not similar but sometimes in products and sometimes in industries, also here transformations are needed. Once SUTs are in the right prices, transformation to SIOTs via one of the technology assumption is straightforward.

f) An uncertainty may be the issue of computability. As will be explained later, the database will cover about 43 countries with over 100 sectors and products each, or 4300 rows and columns in a country linked IOT, but double that number in a country linked SUT. With EXIOPOL probably reaching the limits of what PCs can handle, this point needs further consideration.

g) Concerning added value over what exists, the approach differs from the work of GTAP and OECD, who directly base themselves on IOTS.

4.3.3 Proposed approach

The EXIOPOL database will be most flexible if national SUTs are used as the basic building blocks for the database. Environmental extensions can be added in various ways to the SUT (related to products and industries). SUTs can be linked via trade of products. This results into a MR EE SUT that in turn can be transformed to various types of MR EE IOT, depending on what a specific model needs as input, preferences of the analyst, etc. It is this flexibility with regard to output and procedural/theoretical superiority that prompts us to choose for route 3: building a MR EE SUT by using national SUTs, adding environmental extensions and liking them via trade.

There are several caveats, though;

a) Some countries do not produce SUT. Here, with some crude assumptions the SIOT can be split into a Supply and Use table (see section 4.8)

b) With Supply tables usually in basic, and Use tables usually in producer prices, a set of valuation matrices has to be made available to transform the Use table in basic prices.

c) Some countries produce SUT ánd SIOT. Since often SUT and SIOT are not fully compatible,it is inevitable that two of the three tables are declared dominant (either Supply and Use, or Supply and SIOT). The third then must be derived from the others. In this case, full consistency with data from NSIs is impossible since the NSI data are not consistent in themselves.

4.4 Sector and product classification

4.4.1 Introduction

Sectors

At this moment, a development of a new international harmonized sector and product classification is in its final stages. The classification is *de facto* finalised and will probably formally adopted in 2008. It concerns ISIC rev. 4 (sectors) which in Europe will be implemented in the form of NACE rev. 2. and CPA rev. 2. Communication with Eurostat learned that NSIs most probably will start to use NACE rev. 2 in compiling data for 2008. NSIs then have 3 years to transfer data to Eurostat, implying that the first NACE 2 based SUT will be available early 2012, and the first NACE2 based IOTs (produced over 2010) will be available 2014.

For EXIOPOL, it could be pro-active to use directly this future standard. Yet, the data EXIOPOL will use are from the past and hence all based on the older classifications. Further, many NACE rev. 1 sectors do not map one on one to NACE rev. 2 sectors. Using NACE rev. 2 would ask a considerable effort on transformations from the EXIOPOL team, with dubious advantages given the time it still will take before NSIs will publish SUT and IOTs in that classification. It is obvious that there are more relevant priorities in the project, and hence will base our sector classification on NACE 1.

Products

For products, a variety of classification exists. Trade statistics use e.g the 'Combined Nomenclature' (CN; about 10.000 products), two versions of the Harmonized Commodity Description System (HS, over 5000 products), the SITC classification (3118 products) or the BEC classification (19 types of products). For use in national and regional accounts the UN developed the Central Product Classification (CPC) of which the Statistical Classification of Products by Activity in the European Economic Community (CPA) is its EU counterpart. ESA95 discerns 60 product groups based on CPA for use in SUTs and SIOTs. In this, products are described in exactly the same terms as industries (e.g. 'Agriculture, hunting and related service activities' and 'Products of Agriculture, hunting and related service activities'). This reflects the strong relation between the sector classifications that exist in ISIC / NACE and the product classifications in CPC / CPA. Like NACE and ISIC, CPC and CPA are currently revised, but the same rationale discussed under 'sectors' prompts us to base our product classification on the current CPA1.1 classification.

Detail in products and sectors

From previous applications of EE I-O tables, it is clear that given the magnitude of impacts and the difference of impact intensity of underlying sectors for a good allocation of environmental impacts to sectors and products the following areas need a reasonable detail (e.g. Tukker et al., 2006b; Weidema et al., 2005)l[25]:

1. agriculture, forestry and fishing and further food processing (separating various activities with very different environmental profiles, such as animal production, growing of crops, and fishing)
2. energy and electricity generation (separating various forms of extraction of energy carriers and electricity generation)

[25] Food, mobility, housing and the use of electrical appliances cause 70-80% of the life cycle impact of final consumption. Energy production and production of base materials cause most impacts from a natural resource input perspective.

3. minerals and mining and the further processing (separating various metals, who usually have very different environmental profiles when it comes down to mining and further processing)
4. transport (separating modalities, and if it concerns freight and person transport)
5. waste management (separating a few waste management options with totally different environmental profiles, such as incineration and landfill)

4.4.2 Proposed sector and product classification

For EXIOPOL it has advantages to work in square SUTs, and to use a product classification that is close to the one used in ESA95 since most of the original country tables will follow that classification. This prompts us to use NACE rev 1 for sectors and CPA 1.1 for products. Though for products we also will use trade data in different classifications, the high level of detail of that data should make it relatively easy to map them on our final CPA 1.1 based product classification (official transformation tables are available). In adjusting sector and product detail the hierarchy followed in NACE rev. 1 and CPA 1.1 should be followed: it is allowed to combine sectors or products in a specific sub-category, but it should not be allowed that products or sectors from different sub-categories are combined. The latter would, in fact, lead to a new classification at this sub-level.

By adjusting the level used of NACE rev. 1 and CPA 1.1 for different product and sector categories, the vast majority of products and sectors that EXIOPOL wants to discern can be identified. There are a few problem areas

1. NACE rev 1.1 sector 01 is Agriculture, hunting and related service activities. The classification does not make much distinction between different farm crops, and since many models are geared towards the GTAP classifications when it comes down to agriculture, a better option may be to use that classification here. A key consideration is that the IPTS work on detailing the agriculture sector will also use this kind of sector classification and EXIOPOL hence can take over such results.
2. NACE rev 1. sector 13.20 is Mining of other non-ferrous metal ores. There is no deeper level in the official classification. Here, we had no option but to create an own deeper level to discern individual metal ores.
3. NACE rev 1. sector 90.02: Waste treatment and disposal is not further subdivided. EXIOPOL needs a sub-division of treatment options, most notably landfill and incineration. We had no option but to make our own subdivision of this sector.

Annex III shows the product and sector classification to be used in EXIOPOL. We will discern about 125 sectors and products, about 65 more than currently in ESA95. The higher level in detail mainly is related to the following sectors and products:

- About 25 Food related, due to detailing agriculture and food processing. For the EU27 this data most likely will become available via current IPTS efforts (see chapter 3).
- About 15 Energy related, due separating oil and gas extraction, and separating power generation, refinery products, production of gas, and

production of heat. The IEA energy data inventoried for calculating environmental extensions (see section 4.9) probably will provide a lot of information that can help to create this additional detail.

- About 15 Metals related, due to detailing of mining and subsequent processing of individual metals. The material flow data that will be inventoried as a part of the work on environmental extensions (see section 4.9) will provide a lot of information that can help to create this additional detail.
- About 4 Transport related, due to separating modalities and freight/person transport
- About 2 Waste related, due to separating waste treatment sectors

How to create this additional level of detail is discussed in section 4.8. Apart from the data sources mentioned above, simple technology transfer assumptions may be used from countries that have IOT or SUT at a high level of detail.

4.5 Final demand

4.5.1 Introduction

Next to exports, EXIOPOL will at least discern as final demand the traditional consumer- and government expenditure columns part of the traditional final demand block in use tables and IOTs.:

- Final consumption expenditure
    - Final consumption expenditure by households
    - Final consumption expenditure by non-profit organisations serving households (NPISH)
    - Final consumption expenditure by government
- Gross capital formation
    - Gross fixed capital formation
    - Changes in inventories

Final consumer expenditure, NPISH and government expenditures may include activities that generate their own environmental impacts that cannot be allocated to the production of products and services. Such 'use phase' impacts can best be illustrated with the example of car driving that causes a significant amount of emissions due to fuel use. Consumer and government expenditure on specific products hence somehow should be linked to such environmental extensions in the use phase in a transparent way.

4.5.2 Proposed way of including consumer activities

The easiest way to create a structure in which extensions related to use phase impact can easily be included, is by splitting up final consumption by households, NPISH and governments in a number of meaningful activity categories. The vector of consumption by product by household is in fact replaced by a matrix of activity by products, combining the use of different products for different activities. Environmental extensions can be added to these activities. Government consumption and NPISH can be included in the same way.

4.6 Base year

4.6.1 Introduction

For most of the EU27 SUTs are available for 2003 and SIOTs are available for 2005. The 2004 SUTS will in most cases only be available by early 2008, and the 2005 SUTs and IOTs even later. That makes them a too risky basis for the EXIOPOL database: some countries already asked for derogations, etc. For the 16 non EU countries availability may give us no option but to work with tables from around 2000-2002. In sum, the choice of the base year is probably reduced to one of the years between 2000 and 2003. A factor further to consider is that IPTS currently works on its own data set, and will by the end of 2007 be able to produce a set of SUTs and SIOTs in basic prices for the year 2000 at the 60x60 sector and product level, ready for use in EXIOPOL. IPTS also works on creating additional sector detail in agriculture, a result available by early 2008.

Trade data and environmental data form less a constraint. Trade data are available up to around 2005, just as most of the environmental data. The exception is the resource database for non EU-countries we envisage to use, which has data for up to 2002.

Going for 2000 as a base year may have as important drawback that our dataset may seem outdated once it is completed in 2008/2009. This may make the EXIOPOL database not attractive for modellers, who in most cases still have to do some effort to link the dataset to their model. Yet, modellers in fact now work often with much older data. The 2006 OECD IOT set is based on 1998-2000 vintage tables. The latest GTAP release is for some countries based on original tables dating back as far as the early 1990s. The bare truth is, that at this stage there *is* no primary data more recent than, say, 2002. Apparently more recent SUT and SIOT data can only have been produced by extrapolating (sometimes much) older work.

4.6.2 Proposed base year

The proposal is to go for a 2000 base year. The advantages are:

1. EXIOPOL will build further on the work of IPTS. This avoids that different but similar datasets are generated, and allows EXIOPOL to concentrate on harmonization of non EU data and enlarging sector detail.
2. Data for non EU countries will be probably more abundant and stable.

This choice fits with the principle that we put the production of trustworthy data first. Once such a sound basic dataset exists, extrapolations in time and place will give us probably a more reliable result than aiming directly to cover many countries and trying to model recent data where they do not exist.

The drawbacks related to this not so recent base year can be overcome in two ways:

1. Once the complete harmonized database is produced, an extrapolation to a more recent base year is performed.
2. EXIOPOL will be rigorously prepared for time series, by automating procedures for data transformation as far as possible.

Our intention is to apply solution 1), performing an extrapolation to e.g. 2005 or 2006. This intention will be dropped though, if the other activities will use all time available.

4.7 Added value elements, factor inputs and constraints/stocks

4.7.1 Introduction

Value added elements

SUT and IOT traditionally contain a value added block, in which the following elements of value added are discerned:

- Compensation of employees: wages and salaries + employers' social contributions
- Net taxes on production (production taxes paid by industry excluding non-deductible VAT and those ad valorem taxes used to derive the total supply of products in the supply matrix at basic prices; MINUS production subsidies received by industry exclusing those ad valorem subsidies used to derive the supply matrix at basic prices).
- Gross operating profit (often divided into costs of capital and net operating profit)

Such data will obviously be part of the database; the only discussion is if a further level of detail is required. For instance, for the envisaged application in EXIOPOL the World Trade Model requires specific estimates of land rents and royalties on the extraction of specific resources (most notably oil and gas), now part of Gross operating profits.

Capital and labor: data needed in productivity analyses

In economic models, production is realized by the use capital and labour. Capital is measured by investment and labour is measured by full-time equivalents. Both variables are rather fixed and don't change that much year by year. Capital and labour are used by economists to compare countries (and regions). It is generally known how much value added is produced in a country; what is key is how much capital and labour was required to produce that amount of value added. In general, the key variable here is productivity. The proportion between value added/labour (measured in hours worked annualized in FTE) is labour productivity and the proportion between capital/value added is the capital/output ratio.

The use of labour productivity in common impact analysis is to estimate the impact on the amount of labour affected by a policy measure. Capital productivity is less used in common regional IO analysis. In economic analysis it is used to assess return on capital and to assess the impact of regional policies by means of investment in infrastructure (for example) on output in the long term. In general, this is done by time series models with lags and are complicated from an econometric point of view as well as from an analytical point of view.

Capital

Moreover, data are complicated in the case of capital. Gross investment is the annual positive change of the capital stock, depreciation is the annual loss of value of the capital stock. In general, only investment (the positive change) is empirically known. The others variables are assumptions or based on scarce empirics. To assess the capital stock, apart from price inflation three important variables are needed over a considerable number of years:

- Investment (gross capital formation)
- Depreciation (costs of use of capital)
- Starting value of capital stock in base year – generally a compilation of estimation, construction and assumption

Capital stock is generated by investment, depreciation and depreciation over a significant number of years (time series). In sum, the assessment of capital stock has a huge data requirement. Furthermore, in the national accounts investment is a three dimensional concept:

- First, investment is produced by some sector (commonly construction, car/train/aeroplane industry, ICT). This is according to the sector classification;
- Second, it is owned by someone (government, sectors, households);
- Third, it is discerned by type (10 categories).

The IOT gives only the first one (who has produced the good or service that is used as investment). The supply table gives investment by type.

Labour

Labour is a less complicated issue. It is a relative simple concept compared to capital, and has in general two dimensions. Labour is generally measured at the supply side – consistent with population and the labour force – and at the demand side – consistent with production. What we will need in EXIOPOL is labour measured at the demand side. Then, one has a direct relationship with productivity by sector, a key parameter in economic analysis. Skill level is also an important characteristic of labour, but this is generally measured at the supply side. At the national level, this in not considered as a problem. Shares by sector (low-middle-high) is the most used one, but one has to be aware that NSI has the same definition of skill level.

On the other hand, labour productivity by sector is relatively simple to assess. The stock of labour is generally known; sectoral breakdown could be a problem than could be overcome, but in general the amount of hours worked by sector is a issue. The International Labour Organization (ILO), but also OECD and Eurostat do have enough data on labour to assess productivity by country and sector for a certain year. From a political point of view, it is recommendable to do so, because politicians want to know the employment impact of their measures. Moreover, labour productivity could easily be added in the IO analytical framework.

The proposal is to focus on labour productivity by sector and if possible skill level by sector. But, to assess FTE in the proper way and determine the impact of labour market constraints one also needs data on skill level, the number of persons, the number of hours worked, hourly wages and Full Time Equivalent.

4.7.2 Proposed classification of value added and factor inputs and constraints/stocks

In EXIOPOL, we will refrain from analysing capital stocks and changes therein. The matter is simply too data-intensive to take on this (non budgeted) task in the current project in the right way. It would imply setting up full capital accounts that includes an initial capital stock per type per sector, the investments, and use of capital per type per sector.

For labor, the situation is less complicated. We will discern 3 categories of labor (high,medium and low skilled), and include the compensation paid, the demand in hours, fte and persons, and also include the available labor force in persons (see table 4.2).

Since we further will specify land rents and royalties as component of value, this leads to the following structure of the value added block:

- Compensation of employees: wages and salaries + employers' social contributions
    - Low skilled
    - Medium skilled
    - High skilled
- Net taxes on production (production taxes paid by industry excluding non-deductible VAT and those ad valorem taxes used to derive the total supply of products in the supply matrix at basic prices; MINUS production subsidies received by industry exclusing those ad valorem subsidies used to derive the supply matrix at basic prices).
- Gross operating profit, divided into
    - 3a) Consumption of fixed capital: amount of fixed assets used up during a certain year (excluding any rents on land)
    - 3b) Rents on land
    - 3c) Royalties on resources: 'profit transferred to the owner of the resource extracted' (inventoried for oil, gas, coal, iron, aluminium and copper)
    - 3d) Remaining Net operating profit

Table 4.3: Labour (note: hourly wages x hours demand equals labor compensation in SUT)

Labour	1	Supply	Low
	2	(persons)	Medium
	3		High
	4		Total
	5	Demand	Low
	6	Persons	Medium
	7		High
	8		Total
	9	Demand	Low
	10	Hours	Medium
	11		High
	12		Total
	13	Demand	Low
	14	FTE	Medium
	15		High
	16		Total
	17	Demand	Low
	18	Hourly wages	Medium
	19		High
	20		Total

4.8 Transformation principles primary SUT/IOT data to EXIOPOL data

4.8.1 Introduction

The aforementioned choices (basing ourselves on SUT, sector and product classifications, countries to be included and base year) now make clear what kind of transformation steps are needed given the available primary data. Such transformation steps have been described by various authors who did previous work on harmonizing SUT and/or IO tables (e.g. Rueda Cantuche et al., 2007; Yamano and Ahmad, 2006; Dimaranan, 2006). In principle, for each country a data set consisting of SUT, valuation matrices and import/export matrices is needed for the base year chosen and in the classification relevant for EXIOPOL. It is clear that this set can only be completed via a variety of transformation and estimation procedures. Transformations and estimations may be needed in the following areas

1. Completing the basic data set per country (SUT, valuation matrices and import matrices). This may imply estimating valuation matrices or import matrices, or working backwards from SIOT to SUT if a country does not publish SUT. It may also imply estimating missing and confidential data.

2. Harmonizing the SUT across countries. This includes transforming data to a common sector and product classification[26], adjusting to a common base year, and using a common unit.
3. Detailing sector and product classifications in specific areas (agriculture, food processing, mining, metals production, etc.). Though a special case of b), it is a major challenge in SUT transformation and therefore discussed separately.
4. Other necessary re-adjustments (e.g. adjusting for re-exports that may not be treated properly in the original collected data, or other valuation issues)

4.8.2 Proposed transformation steps

Where the main approach to performing the different transformation steps can be identified, it goes too far for this document to indicate in detail which steps in which sequence will be performed for what country table. This can only be done once in-depth insight in the structure and backgrounds of basic country tables has been gained, which is a job for the main phase of the project. We hence here list shortly the method or methods that we consider for using in the transformations

Completing the basic data set

a) Using SIOT to construct a fully absent SUT: assume a Supply table without by-products, or construct an 'average' Supply table with secondary products on the basis of information from other countries. Use this constructed Supply table to calculate a Use table in basic prices.
b) Estimating valuation matrices that can convert a Use table in purchaser's prices into basic prices. One approach is to use valuation matrices from another available 'representative' country (Rueda Cantuche et al., 2007). Another approach uses available Supply tables and SIOTs to calculate a Use table in basic prices (cf. Chapter 2)[27].
c) Estimating import matrices. The simplest approach is to assume proportional use of domestic and imported products in all sectors. Alternatively, known import matrices from 'similar' countries may be used.
d) Estimating missing and confidential data. Some NSIs (e.g. the UK) 'hide' certain cells in their SUT and SIOT. Practice will tell what approach to use here. Sometimes for other years data may have been given and can be used to make estimates. Sometimes secondary sources can be of help.

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[26] This may include a re-allocation of Financial Intermediation Service Indirectly Measured (FISIM). Some countries show this as a separate column in their SUT and SIOT, where others allocate imputed bank service chargers directly to purchasing sectors.

[27] Note that in one go this 'reverse engineering' combines two elements. First, the underlying valuation matrix that links the Use table in basic with purchasers' prices, but also the (probably mixed) technology assumption that was used to produce the SIOT.

RAS may have to be applied if estimates unbalance the table (Yamano and Ahmad, 2006).

e) Estimating data of missing countries via 'similar' countries. For some EU countries, no SUT nor SIOT exists. Rueda Cantuche et al. (2007) used data from countries with a similar economic structure, scaled down to GDP and e.g. known sector outputs, as a proxy. See also Eurostat (2002).

Harmonizing SUT across countries

f) Mapping the country SUT on the EXIOPOL classification. In a many-to-one correspondence this is easy (just aggregation). In a one-to-many correspondence, sectors / products need to be split up (see j). In a many-to-many correspondence, sectors / products also need to be split up and re-allocated to the EXIOPOL classification. FISIM can be handled as by Yamano and Ahmad (2006).

g) Adjusting to a common base year. Here, one can simply scale up or down the SUT to match the base year output. More sophisticated methods also would adjust technical co-efficients. An example is the method given in the Input Output manual of Eurostat (2002) that uses GDP, imports, added value by industries and final demand in the adjustment procedure.

h) Adjustment to a common unit. Except for 1-2 examples, EXIOPOL will use monetary unit in the SUT only. The common currency will be Euro in the base year. The Market Exchange Rate will be used for transformation. This transformation will be done using a vector rather than a scalar in the database, so that in later stages analysts may combine information on physical flows and product-specific prices. In some cases, also conversion from current to constant prices needs to take place.

Detailing sectors

i) A variety of approaches probably has to be used in enhancing sector detail. Data on environmental extensions may be of some help (e.g. MFA data reveal what mining sectors are relevant for a country). Energy statistics may help to differentiate electricity production. Etc. Alternatively, technology transfer assumptions from countries with detailed tables may be applied.

Other adjustments

j) A variety of other adjustments may be needed, that probably must be done on an ad-hoc basis. Mis-allocated re-exports for e.g. the Netherlands or Singapore may be estimated on the basis of studies dedicated to this issue.

4.9 Environmental extensions and related physical flows

4.9.1 Introduction

The DoW lists a number of substances (emissions to air, water and soil), resources and other stressors which should be considered – if feasible – in the EE-IO framework. The stressors should be chosen in such a way, that a number of well known indicators for environmental impact can be calculated: the LCA impact categories Global warming, Ozone depletion, Acidification, Photochemical Oxidant formation and Eutrophication; the ecological footprint, total material requirement, and external costs.

EXIOPOL wants to develop its database as close as possible according to principles laid down in documents like ESA95, the UN System of Integrated Environmental and Economic Accounting – SEEA 2003 (United Nations et al. 2003) etc. On this basis, we will group the environmental extensions into two generic categories discerned in SEEA 2003:

- Natural resources (physical inputs to the economy): material inputs, land, water, and energy use
- Residuals (physical outputs out of the economy): air emissions, emissions to water, waste

Since some of such data will be calculated using physical information on flows in the economy (e.g. use/combustion of a specific energy carrier), also physical flows will be inventoried. These will have to be classified in the same way as products in the SUT, and form a physical layer 'under' the SUT.

The options for data sources to be used are rather straightforward:

- Material inputs: a Eurostat-funded project will produce for the EU27 a dataset for 1970-2005 that discerns about 15 material categories (food, feed, animals, forestry, non edible biomass, construction minerals, industrial minerals, ores, coal, crude oil, natural gas and other fossils). The MOSUS project has produced material input data disaggregated into 200 categories for 188 countries in a time series from 1980 to 2002, which can be used for the non EU countries[28]. A problem is that in most IO tables mining and mineral extraction is just one sector and hence all material input would be allocated here. This is solved by the proposed split of this sector to distinguish the ca. 5 most relevant material extraction processes[29]. Note that some of the materials as used in calculating MFA indicators are in fact agricultural products, that already

[28] For this non-EU27 set data on the unused extraction (i.e the overburden for mining activities and unused residuals of biomass extraction) are far less reliable than for Europe. The same applies for the coverage of construction minerals in non-OECD countries.

[29] Another solution was proposed by Statistics Germany, who proposed to allocated material input to later production stages. This somewhat artificial solution is not needed in our case due to our better resolution.

are listed in monetary terms in the SUT. We hence chose to place such obvious products in the SUT framework, rather than as an extension[30].

- Land use: FAOSTAT-land gives all information on land-use data for agriculture and forestry. It is recommended to leave land use related to build-up area out due to lack of data, although extrapolated estimates may be used from countries with data (cf Nijdam and Wilting, 2003). Inclusion of build up land is mainly relevant for Ecological Footprint calculations, but the share of this element tends to be just 3-5%. It may not be worth the effort to inventory this due to the difficulties to allocate built-up area to the economic branches and private households.
- Water use: FAOSTAT-Aquastat and the study 'Water Footprints of Nations by UNESCO-IHE based on this source provide the most logical data source. It discerns three main use categories: agriculture, industry (excluding cooling water) and domestic (i.e. household and services) water use. The data source allows for further breakdown of water use in agriculture; for allocation to industry sectors and making the split between households and services auxiliary variables like (employed) persons or value added need to be used.
- Energy use: Energy statistics by IEA and Eurostat form the obvious primary data source to derive NAMEA-type energy use tables linkable to SUTs(forming in fact a an energy use matrix in the SUT format). The NAMEA-energy tables will show only actual emission-relevant forms of energy use by industries and/or products and contain only parts of the comprehensive IEA energy balances.
- Emissions: there is a great variety of emission databases available, e.g. UNFCCC for greenhouse gases and CLRTAP for a number of other substances (PM10, metals, POPS). The problem is that many countries are not covered by these conventions. In Europe for a very limited number of substances NAMEA type of tables are published that are directly linkable to SIOTs and SUTs. As a consequence, we will have to develop reasonable estimation methods to create our own IO-compatible emission data based on other sources and information. At this stage, we foresee to approach this job using an emission factor approach, which will ensure a systematic and coherent approach to estimating emissions for all sectors and all countries. Energy related emissions can be estimated quite well in this approach (Pulles et al., 2007). Other activity related emissions can be estimated using other activity variables (e.g. material throughput, animal stock, etc.). Such approaches have as great advantage that all emissions from all countries will be estimated via a coherent approachAs a last resort, we may be forced to extrapolate known emissions per activity in one country to other countries (Nijdam and Wilting, 2003).

[30] Such agricultural crops are produced extracting CO_2, water and nutrients from the environment. In MFA, it is simply too complicated to calculate these 'true' primary extractions and therefore the weight of biotic products is used as a proxy. Typical indicators such as TMR of course still can easily be calculated by adding the produced mass of agricultural products to the primary extracted material in the extensions

Our database should also contain for the most important natural resources the stocks or reserves. They will work as constraints in e.g. the work with the World Trade Model. With regard to the qualities of reserves, different categories need to be distinguished (see also USGS, 2007):

- proven reserves that can be technically and economically extracted at current conditions,
- proven reserves that can not be exploited due to either technological or economic reasons.

Since stock data are difficult to assess it is suggested to focus on selected natural resources. We currently foresee to collect such data for oil, gas, coal, iron ore, bauxite, and copper ore. Information on stocks will only be added in physical units (e.g. tons of metal reserves), skipping the part of the economic valuation of the resource stocks.

4.9.2 Proposed list and data sources for environmental extensions

Annex III lists the environmental extensions and physical flows to be covered in EXIOPOL. The extensions are divided in the categories Natural resources (inputs into the economy) and Residuals (outputs from the economy). The list allows calculating the proposed indicators in the following way

1. GWP, ODP, POCP Acidification and Eutrophication: following standard Life cycle impact assessment (LCIA) methodologies (e.g. Guinée et al. 2002) our list of emissions in Annex III includes all relevant greenhouse gases, acidifying substances, substances responsible for POCP, and nutrients to water.
2. MFA indicators require coverage of the domestic extractions of natural resources listed in Annex III Comprehensive MFA indicators like TMR and TMC require also insight in the so-called 'unused domestic extraction'; here it has to be accepted that such data will be poor for particularly non OECD countries.
3. External costs will be calculated by using average external costs per kg substance emitted per country, as provided by Cluster II partner IER in EXIOPOL. From previous Externality research it is known that the substances inventoried for the LCIA indicators plus those listed under 'other toxic substances' are the most important in external cost calculations.
4. Ecological footprint is a composite indicator comprising several components of which the most important ones (representing more than 90%) can be derived from material inputs (biomass use) and CO2-emissions from fossil fuel use (cf. Wackernagel et al., 2005).

Note that consistent with SEEA 2003 waste is treated as being part of the economy. Hence waste treatment, including landfill, will be part of the regular SUT and SIOT. To this end, the existing NACE category 90.2 on waste treatment is split up into incineration and landfill.

Note that in principle one should avoid overlap in category definitions between the environmental extensions, and the product, industry and added value components in the SUT. If the same item is meant, one should solve this in the accounting system by characterising the same flow with different units (e.g. monetary value, kg, or MJ). The following issues play a role here:

- Biotic materials produced in agriculture used in calculating MFA indicators such as TMR. We see them as product flows and hence will list them as physical value in the SUT proper.
- Royalties on resource extraction (traditionally a value added component). If levied per volume of resource extracted, there is a direct relation with the extension giving the physical flow of that resource. In many cases, though there is no such one on one relation. We hence decided to keep royalties (paid by a sector) separate from the physical amount extracted.
- Land rents (for economists traditionally a value added component) probably are directly related to the Land use occupation (for environmental experts usually seen as an environmental resource). Here, we pragmatically decided to list land two times, once as 'Rents on land' in the value added block, and once as 'Land use occupation' in the extension block.

4.10 Linking individual SUT data via trade

4.10.1 Introduction

The individual country SUTs have to be linked via trade. The various commodity trade databases available do not give precise information on the sector of origin and give zero information on the sector and final demand category of destination. Besides that, several problems arise when using such databases. Reported imports by country A from country B match often not with reported exports by country B to country A (e.g. due to pricing issues and classification and registration errors). Import and export data given in country SUTs do not exactly match with trade values in commodity trade databases, etc. Another problem is that SUTs and IOTs are balanced per country. But when a trade linked system is build, it is more than likely that total imports and total exports across countries are not balanced, as they should be.

It is obviously out of the question that EXIOPOL could set up own surveys to overcome such problems and so called 'non-survey methods' have to be applied. Most of this work until now concentrated on linking IOTs rather than SUTs. Oosterhaven et al. (2007) describe four non-survey methods to link national tables to arrive at an international table. Each of the methods uses an increasing degree of information. The methods are applied and tested with the ten countries Asian-Pacific international IOT of 2000 constructed by IDE/JETRO (Inomata et al. 2006). In their first method, the national IOTs with world-wide inputs are first split-up into a domestic origin IOT and an import IOT by means of the aggregate sectoral self-sufficiency ratios that may be derived from any national IOT. Most national IO accounting frameworks, however, already incorporate this split-up, including the ten Asian-Pacific countries.

Their next step is to partition the national import tables according to the country of origin by applying the bilateral import ratios from import trade statistics. As the services import ratios are lacking the import ratio of the total of the commodity sectors is used as proxy. The national IO export columns are split up by country of destination by export ratios derived from export trade statistics. Destinations of IO services exports are estimated by using the total commodity export ratio. For the first and second method the export columns of the Asian-Pacific countries are all aggregated into one export column for the rest of the Asian-Pacific area. This export column is then re-scaled to match the total of the intercountry import matrix constructed by applying the import data. The difference between the original and the re-scaled column in put in an extra column. The re-scaled export column is used as a row constraint for the intercountry import matrix in the GRAS method (Junius and Oosterhaven, 2003).

The third method uses the individual country export columns as row constraints for the block-column matrix that consists of the import sub-matrices per purchasing country. In this fashion ten re-scaling columns are obtained, each with an accompanying re-scaling factor. These are then used as constraints in the GRAS method. The fourth method uses the spatial information from the import trade statistics as these are assumed to contain more reliable information. The import block-column matrices are re-priced from ex-customs prices to producer's prices. The bilateral export columns are re-scaled to their corresponding value in the bilateral import block-column sub-matrices. Again there are ten re-scaling columns, but now there are different re-scaling sub-factors. The re-scaling columns are combined into a single column and used in the GRAS method for balancing.

In all cases, using GRAS implicitly results in re-pricing the c.i.f. prices of the import matrices into the f.o.b. prices of the export columns of the Asian-Pacific IOTs. The overall result of the study is that methods that use a larger amount of information perform better than methods that use less information. The largest difference is found between method one, which uses self-sufficiency ratios, and method two that uses the actual domestic origin and import IOTs.

4.10.2 Proposed approach

In EXIOPOL the choice is made to construct an intercountry SUT. This intercountry SUT can also serve as input for an intercountry IO model. The methodology to trade-link the SUTs is not available yet and will therefore be developed within the EXIOPOL project.

The nationally balanced SUTs will not result in a balanced intercountry system after trade-linking due to the fact that there is imperfect information on the additional pricing layers of goods at different locations. This fact, in combination with other problems associated with trade data, like classification errors, transit trade, time lags in registration, etc., causes inconsistency between import and export data.

A two-tiered methodology has to be developed that will first disaggregate and trade-link the SUTs with the best information available. The second tier will consists of the balancing of the resulting preliminary intercountry SUT to regain consistency in international trade flows.

The trade-linking of the table requires as a first step that the national use tables are split into a matrix with domestically produced inputs and a matrix with imported inputs. In addition, the multiple pricing layers of the values reported in the use table (which is in general given in purchaser prices) have to be 'peeled off'. For example, the price layer between basic prices and purchaser prices in the same country includes domestic trade and transport margins, and taxes and subsidies. Both of these steps will be undertaken by other work packages (III-2-a and III-3-a) that supply the prepared SUTs to the work package that will trade-link the tables (III-4-a).

The next step is to disaggregate the national import use tables into bilateral import use tables that specify the country of origin. This will be done by applying import ratios obtained from an international trade database. The national import tables specify country of destination, the product that is imported, and the industry that uses the product as input. The trade data contain information on which product is traded and the country of origin and destination, but do not specify the buying industry. Combining these two sources of trade data will result (under some assumptions) in the four-dimensional data required for the construction of an intercountry table. It specifies both country of origin and destination, the product that is traded, and the buying industry.

The resulting intercountry use table will have to be subjected to the GRAS procedure in order to reach consistency of the international product flows and the supply tables. Here the explicit choice can be to retain the import and export data that are given in the national SUTs. The GRAS technique will reduce and increase values in the combined bilateral import matrices until they equal the import and export data that are given in the national SUTs. This implies that the bilateral import matrices are restructured. Note that the domestic use tables are not subjected to the GRAS procedure and will thus be kept constant. A direct effect of the GRAS procedure is that a summation of the domestic use table (of country A) and the bilateral use tables (all of country A's imports) will not add up to the national use table. Alternatively, the national use table can be taken as given (excluding the export and import data). However, this implies that the export and import data as given in the SUTs will be changed.

Both methodologies are viable choices to arrive at an intercountry use table. However, in both cases the original national use table including the import and export data from the SUTs cannot be retrieved from this intercountry use table.

As the methodology of trade-linking the SUTs is still under development it might be the case that other alternatives will be discovered. In addition, the treatment of the national supply tables still needs to be specified. It might be useful (or even necessary) to split these in a domestic supply table and an export table, and further disaggregate the export table into bilateral export tables. Further, it has to be noted that using the intercountry SUTs as input in an intercountry IO model requires a respecification of the existing methods to arrive at a national IO model from national SUTs.

A definite choice between all viable alternatives can be made after the four country test. The test period can uncover additional issues that need to be resolved which might favor one of the alternatives. Additionally, the structural effects of the two methods can be investigated and their implications for the environmental applications that are envisioned for the final database.

4.11 Other issues: definitions and notations

Annex 1 gives a list of abbreviations and Annex 2 a list of notations to be used in EXIOPOL. The notation list is a result of a discussion in the team, where we followed as much as possible standard literature such as SNA 1993, ESA95 and SEEA 2003, and dominant text books (e.g. Miller and Blair, 1986).

5 Overall outline database management system

5.1 Introduction

The EE I-O will be based on several data sources: SUTs, IOTs, NAMEAs from EUROSTAT, EPER, FAO data, LCA data for consumer activities, etc. Some of these data sources are very well structured, but for other data sources the situation will be less clear. The issue in EE I-O will be to reserve a place for all primary data sources, to define transformation and aggregation steps, and to create a well-structured end result, both SUTs and IOTs with satellites. Below we will outline this basic principle in some more detail.

5.2 The database at a glance

Figure 5.1 presents an outline of the structure of the database, see also the legend.

We can discern 5 pieces, from left to right. At the extreme left, we find the various data sources. In principle, these are in various formats, languages, sectoral classifications, and so on. Complicated transformation procedures are needed to bring these into the well-structured harmonized second part.

This second part represents the 27 EU supply-use tables, covering industry, consumers and environmental (and other) extensions, as well as a number of tables for the rest-of-the-world countries.

In the third part, the trade links will connect the different domestic tables to form a truly multi-region supply-use table.

In the fourth part, multiregion trade-linked input-output tables will be derived from the multiregion trade-linked supply-use table. In principle, different options are conceivable here: the commodity-by-commodity format versus the industry-by-industry format, using the commodity technology assumption versus the industry technology assumption, giving the transactions table versus the coefficient table, etc. To what extent all varieties will be made available is not yet clear.

In the fifth and last part, additional procedures may be added to compute indicators, to generate graphs, etc. This will not be part of Cluster III. It may be part of the illustrative applications of Cluster IV, but that is not yet clear. In any case, it is good to create the possibility of adding such procedures.

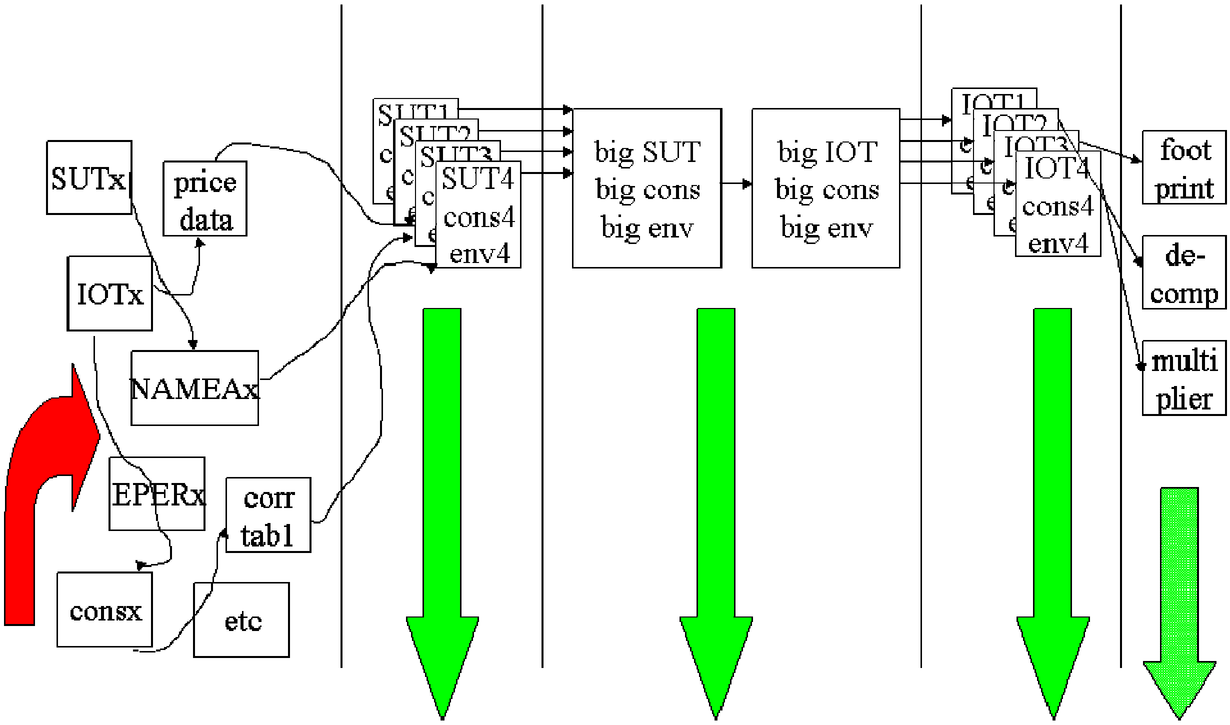


Figure 5.1. Schematic overview of the database management system. The red arrow represents the input of "raw" datasets from diverse data suppliers (EUROSTAT, FAO, etc.). The bright green arrows represent information that can be easily extracted from the system. The soft green arrow represents information (indicators, etc.) that can in principle be obtained from the system, but for which additional procedures (scripts, etc.) are needed, not being part of Cluster III. The terms "big SUT", etc. refer to the multi-region tables, covering EU-27 and a number of rest-of-the-world countries. The boxes with "SUT, cons, env" refers to tables that contain interindustry information, consumer activities, and environmental extensions, as well as a number of non-environmental factor inputs.

5.3 Requirements for the database management system

With respect to the design of the DBMS the following points to be discussed:

1) Modular set-up. Among things this means that the SUTs, the trade linked MRSUT and the trade linked MRIOT will be in separate databases (although 1 interface might be provided). Transforming the data from SUT to trade-linked SUT to trade-linked IOT will be carried out in an automated fashion.

2) Specification of all transformations methods is responsibility of CML except the transformation methods creating the trade linked (world) model. The transformation methods needed for the creation of the trade linked world model is responsibility of RUG. CML will only specify in this case the requirements that make it possible to incorporate these transformation methods in the DBMS.

3) The method for the transformation of the basic data (specified in whatever classification (ESA95, NAICS, BEA) to the classification in the DBMS will be specified by CML. The data necessary for this transformation (basic data + transformation data) will be delivered by the partner responsible for the particular set of data. At this point, there is still a choice of options:

- Option a: The transformation will be reported transparently by the partner responsible for the particular set of data. CML will implement the transformation in the system. Main advantage is that whenever a revision of a certain raw dataset is available it is possible to insert it in the system, and that the consequences for the MRSUT and MRIOT will be processed "automatically", as long as the format (i.e. sectoral classification) of the raw data is unchanged.
- Option b: The transformation will be carried out and reported transparently by the partner responsible for the particular set of data. CML will prescribe the format for reporting of the data. CML will not carry out the transformation itself. Main advantage is that the system will not contain one hundred different sectoral classifications, formats, script languages, etc.
- Option c: A compromise between the options a and b. CML will implement the transformations, but only in a limited and prescribed number of formats, e.g. requiring that the raw data must be transformed into MS-Excel by the responsible partner.

5.4 The database in some more detail

5.4.1 Modular set-up

In our proposal the DBMS can be seen as a series of coupled databases each containing data at a different level. Main reasons to make three separate DBMSs each consisting of a large number of tables are:

1) Flexibility.

Data in databases will always be used in a different way then originally envisaged. For instance instead of creating industry-by-industry tables commodity-by-commodity tables are going to be created. In a modular system it is easy to use the existing SUTs. In a monolithic system the alternative used of the SUTs might be problematic. Having a modular set-up creates also flexibility in terns of project management. If the mathematics of all the transformation steps have not been worked out in full detail yet, the design and the making of the DBMSs may still proceed.

2) Performance

As discussed in the IPTS E-IOA report the calculation of the IOTs can be computational intensive. It is therefore practical to do the transformation steps in separate modules that could for instance run overnight/week without interfering with the DBMSs. Having such computational intensive routines in a (monolithic) system might be very problematic.

A drawback of using separate DBMSs is the likely possibility that the different levels of data are in an inconsistent state. A change in the raw data might not be yet reflected in the final tables (unless you explicitly have recalculated all levels of data). Therefore we advise to provide no simultaneously access to all three DBMSs at the same time outside this project.

Another drawback is that the use of separate DBMSs implies a redundancy of data, as the same data is present at different places. This applies, for instance, to sector classifications and substance lists. Changing one such data item should then be carried out at different places to ensure consistency.

5.4.2 Preliminary high level database design for the storage of SUTs

A database can be described at three levels

1) The multiple views held by a variety of applications

    user- or application level

2) The physical lay-out of data in storage

    internal storage / physical level

3) Specification of the information content of the database

    Conceptual level

The classic design principles for a RDBMS include a series of so-called normalisation rules. The goal of these rules is to avoid duplicating data in your database (partially to save space but mainly to avoid ending up with incongruous data). After applying a set of normalisation rules the design is in a particular normal form. Six levels have been distinguished but in practice normalisation does not go beyond the fourth level which is actual called the Boyce/Codd normal form (BCNF).

In the following sections we will discuss two normalised designs. One design is flawed but serves as an example and explanation for the other (superior) design. After having discussed the structure of the database, features that are not supported by the current database design will be explicitly addressed.

Flexibility of the Exiopol system does not only come from the design of the database but also in the way the implementation is carried out. That is discussed in the section on the quality of the implementation process. The final section in this chapter is a list of the aspects of the database design that still needs to be worked out in more detail.

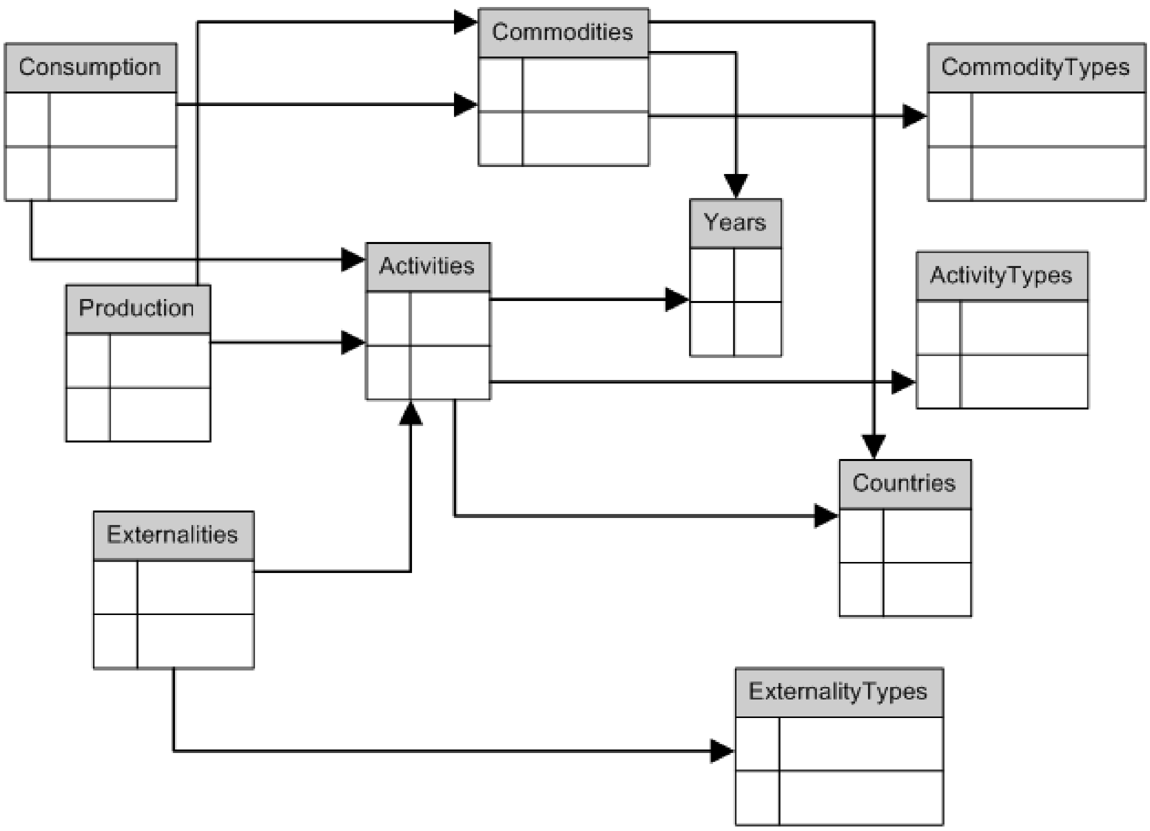
Entities and relationships

The following main entities are distinguished in the current design:

- Commodities

- Activities
- Consumption
- Production
- Externalities

Entities of a subsidiary character that are distinguished are:
- Years
- Countries
- CommodityTypes
- ActivitityTypes
- ExternalityTypes



All the entities are stored in a separate table.

Figure 5.2: Preliminary high level design of the database tables and relationships.

The Commodities table stores all the commodities distinguished within the Exiopol system. A single commodity is of a certain commodity type, has been produced in a certain year and in a certain country. If we assume that 5 years, 40 countries and 100 commodity types are distinguished 5x100x40 = 20000 commodities are distinguished in the Exiopol system. However it is likely that not all commodities are being used in all countries and these do not have to be specified in this table. Thus this design makes it possible to query quickly not only what's being used in countries but also what is not being used in countries. This last question is just as interesting as the first and is especially useful for quality checks. We can check if there are strange gaps in the existence of commodities (either consumed or produced) in countries.

The CommodityTypes table stores the different commodity types distinguished in the Exiopol system. Likely the CommodityTypes table will consist of several layers of tables. At the top layer the table will contain the “ideal” commodity classification system at all its specified levels (and even beyond in cases that seems necessary for Exiopol) in a hierarchical way. At a lower layer a table will contain information on the commodity types that are actual used in the Exiopol system and this classification will likely not be stored in a hierarchical way. The possibility will exist to specify several of these derived commodity classifications. This makes it possible to use different levels from the “ideal” commodity classification in future updates of the system. The exact details of this part of the database design have not been worked out yet. It is however crucially important to do it right. If it turns out that it will not be possible (or only with a large effort) to make changes to the classification or to calculate aggregates based on the hierarchical classification, the system has failed. Approaches under examination are the adjacency list model and the nested set model (Celko, 2004).

The Activities table stores all the activities distinguished within the Exiopol system. These activities encompass industrial, consumer and waste management activities. Maybe all these activities will be stored in 1 table but perhaps industrial and consumer activities will need to be stored on two separate tables. No decision has been reached on this subject yet. Waste management activities are part of the industrial activities. A single activity is of a single activities type , take place in a single year and a single country.

The ActivityTypes table will be organised in the same way as the CommodityTypes table. It will store the activities types as distinguished in the Exiopol system in a two layered structure to be flexible in the designation of the activity types. The exact details of this part of the database design have not been worked out yet.

The Consumption table stores the Use table in “raw” format i.e. the amount of a commodities consumed by a particular industry or consumer activity. The default assumption will be that the amount is represented in monetary terms. However the possibility will be created to store different representations of the amount e.g. kilograms, number of pieces etc. This will make it possible to create PIOTs. Storage of multiple representations of the amount will require multiple tables.

The Production table stores the make table in “raw” format i.e. the amount of commodities produced by a particular industry or consumer activity. If and how consumer activities need to be part of the make table is not known at the current stage. In the same way as in the Consumption table it will be possible to store the produced amount in different representations.

The Externalities table will be used to store both factor input data as well as environmental extensions. The externalities are of a particular type (as specified in the ExternalityTypes table) and belong to a certain industry. For the moment it is assumed that the amount of an externality produced are represented in only 1 system. For example, emissions of carbon dioxide are only specified in kg and not also in metric tonnes. This is different from the situation in the Consumption and Production tables where it was chosen to represent the amount in more than 1 way. It might be desirable to split the Externalities table into two separate tables one containing the data with factor inputs and 1 table with the environmental interventions. Separation of the tables might be advantageous from a "psychological" point of view and performance point of view. If in practice 9 out of 10 times only the environmental interventions will queried and not the factor inputs it is better to use two separate tables.

The ExternalityTypes table contains the environmental interventions and factor inputs distinguished in the Exiopol system. The environmental interventions can be emissions of substances to a certain compartment, either soil, water or air. The storage of cas no and synonyms for substance names should be made possible because naming of chemical substances can be quite confusing. Likewise the Externality table might have to be split into two parts the ExternalityTypes table might have to be split into the a part that specifies the factor input types and the environmental intervention types.

Finally, the Years table and Countries table are used to indicate the years and the countries. The simple Years table might be used to illustrate some of the features that a well designed database makes available. It might be questioned why we use a separate table for the indication of years. It seems trivial, but it is not. Years can be indicated in many ways like '07, 2007 or 4705 according the Chinese calendar. The current design makes it possible to extend the database in the future with more than 1 year representation. Currently we are satisfied with 1 representation :). So using a seperate table for the specification of years enforces the use of 1 system for the indication of years and guards therefore the integrity of the data. Furthermore it makes it possible to extend the database in the future with more year representations which gives flexibility. But there is even more to it. Because the database guards referential integrity (and if we like cascade update and cascade delete of data) we can delete for instance only 1 year from the Years table and all data referring to the deleted year will be deleted. This prevents that "orphan" records remain in other tables that are not connected to any year. So a further important feature is that the database is robust.

An alternative high level design

The big advantage of creating separate tables for Commodities and Industries first before specifying the Consumption and Production table is the flexibility it creates. However it creates complexity in terms of querying the database.

Consider the alternative logical design of the database that does not explicitly considers the entities commodities and industries in Figure 5.3

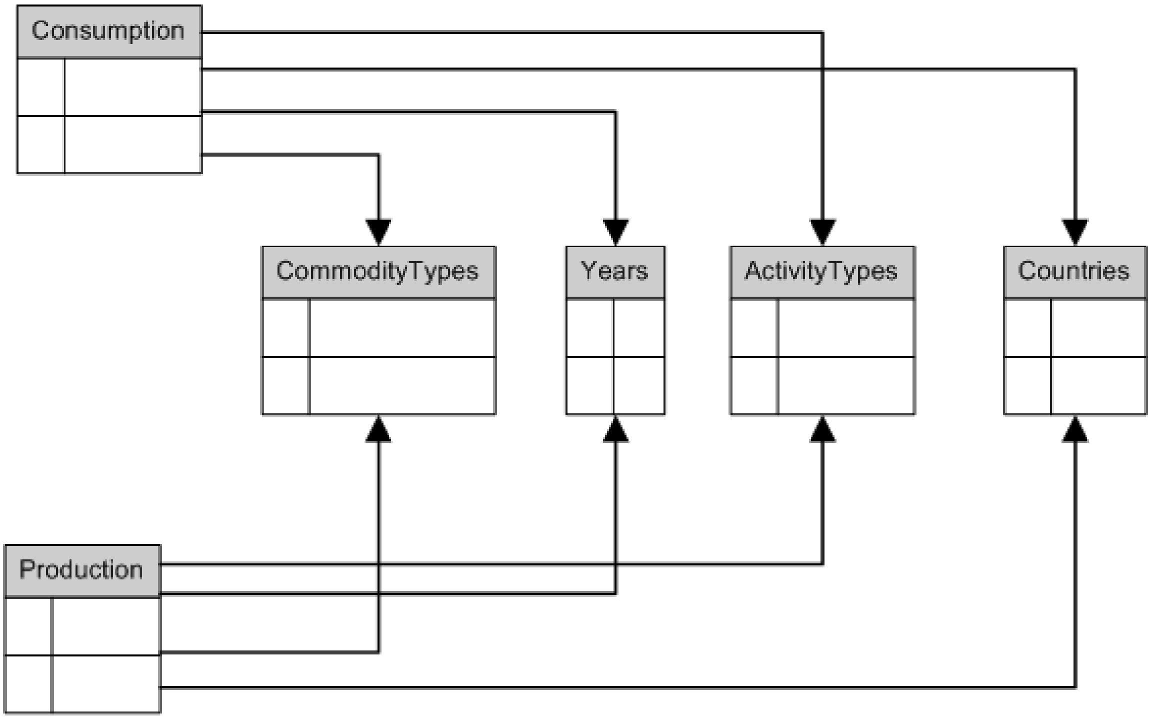


Figure 5.3: Alternative high level design of the database tables and relationships. Externalities are not shown. This alternative has been rejected as explained in the text.This design was inspired by the way we would like to have the output from the database. As an example such an output is given in Table 5.1.

Table 5.1: Example of a desirable output from the Exiopol system. It shows the commodities used by a hypothetical carbon intensive steel production process in the Netherlands in 1982.

IndustryType	Year	Country	CommodityType	Amount
steel production	1982	NL	coal	500000 tonnes
steel production	1982	NL	electricity	6 kWh
steel production	1982	NL	iron ore	40 kg
steel production	1982	NL	scrap	5 mg
steel production	1982	NL	limestone	87987 kg

In the design given in Figure 5.3, the commodities and industries in a certain year and certain country only exist when they have been specified in the Consumption and/or Production table (i.e. a transaction has occurred). Although this set-up is simpler, it is also very limited. It will not be possible to specify the use of commodities produced in country A by an industry in country B. Likewise it is not possible to specify the use of commodities produced in year X by an industry in year Y. Moreover because the industries only exists implicitly it will not be possible to connect environmental extension to an industry unless it has already been involved in a transaction. Therefore we reject this design.

However having a use table in the form as shown in chapter 2 is a very desirable output of the Level II database, needed to create the industry coefficients matrix. Below we show the query needed to create a table as shown in Chapter 2 from the design given in Figure 5.2.

```
SELECT tbl_Consumption.ConsumptionID,
      tbl_Consumption.ConsumptionAmount, tbl_Years.YearName,
      tbl_Countries.CountryName, tbl_IndustryTypes.IndustryTypeName,
      tbl_CommodityTypes.CommodityTypeName
FROM tbl_Countries
INNER JOIN (tbl_Years
INNER JOIN (tbl_CommodityTypes
INNER JOIN (tbl_Commodities
INNER JOIN (tbl_IndustryTypes
INNER JOIN (tbl_Industries
INNER JOIN tbl_Consumption
ON tbl_Industries.IndustryID=tbl_Consumption.IndustryID)
ON tbl_IndustryTypes.IndustryTypeID=tbl_Industries.IndustryTypeID)
ON tbl_Commodities.CommodityID=tbl_Consumption.CommodityID)
ON
tbl_CommodityTypes.CommodityTypeID=tbl_Commodities.CommodityTypeID)
ON (tbl_Years.YearID=tbl_Commodities.YearID)
AND (tbl_Years.YearID=tbl_Industries.YearID))
ON (tbl_Countries.CountryID=tbl_Commodities.CountryID)
AND (tbl_Countries.CountryID=tbl_Industries.CountryID);
```

The current preliminary high level design of the entities and their relationships as depicted in Figure 5.2 seems very clean and simple. Be warned though, the final design will be a lot more complicated and “messy”, although with the same backbone as in Figure 5.2.

Entities and their attributes

At the current stage of the design process only very little attention has been given to the more detailed design of the tables which contain the entities and their attributes.

Missing features

In the previous sections the database structure was introduced. Less obvious are features that are not accounted for in this high level database design. Two important features are missing which are normally part of database design.

Nothing has been specified in the database about user right. According the requirements, the Exiopol system will run as a stand-alone desktop application. Everybody has its own copy of the Exiopol system and therefore only 1 user at a time will access the database. This user will have full access to everything in the database. Therefore there is no need to specify user rights explicitly in the system. Notice that with this power comes responsibility. Having the power to make changes to the database structure will mean that you can create havoc in the database. Thus the Exiopol system has to be managed by an expert.

A second feature that is not present in the database is the storage of version information. You cannot store different versions of the same data in the database. Again we left out this feature because the Exiopol system is meant to run as a stand-alone desktop application. New versions of data will be handled by copying the database deleting the old data from it and importing the new data.

Furthermore several items that may be part of the SUT framework did not find a place in the database yet. These are the items that may be found outside the commodity × industry table i.e. investments/capital goods, import, export and value added tax.

Quality of the implementation process

Almost all of today's RDBMS' support structured query language (SQL). SQL is a “language” that is used for the interaction with RDBMS'. SQL was original developed by IBM in the 70's for their DB2 RDBMS product. The SQL language has been standardised by the American National Standards Institute (ANSI). Nowadays most of the RDBMS support ANSI SQL92.

SQL statements fall in two categories:

1) The data definition language (DDL) which is used the manipulate the structure of the database.
2) The data manipulation language (DML) which is used to manipulate the data within the database.

The database design will be implemented using the data definition language. As an example we show the SQL-statement to create the Consumption table:

```
CREATE TABLE tbl_Consumption (
  ConsumptionID AUTOINCREMENT,
  CommodityID INTEGER NOT NULL,
  IndustryID INTEGER NOT NULL,
  ConsumptionAmount FLOAT NOT NULL,
  PRIMARY KEY(ConsumptionID),
  FOREIGN KEY (CommodityID) REFERENCES tbl_Commodities(CommodityID),
  FOREIGN KEY (IndustryID) REFERENCES tbl_Industries(IndustryID)
);
```

The previous statement can in principle be used in every RDBMS to create the Consumption table. The advantage of this procedure is that the design and implementation is independent of the RDBMS that will be used in the Exiopol system. For instance this means that the development version of the RDBMS might be chosen differently from the production version. It also means that we can rather easily change the RDBMS when there is a need for larger capacity. The only catch here is that different RDBMS often have small differences in their support for SQL which means that the SQL statements must be tweaked for the particular RDBMS product. MS-Access is particular example of an RDBMS that has it's own flavor of SQL.

Already a test database has been created in MS-Access 2003 according the Entity-Relationship diagram in Figure 5.2 to examine the performance of this database design in MS-Access 2003 as RDBMs.

The database was filled with sample data for 5 years, 40 Countries, 120 CommodityTypes, 100 industryTypes and 200 ExternalityTypes. Within each Country and Year a random number of random a Commodity was assigned to each Industry. Also a random number of a random Externality was assigned to each Industry. This resulted in a database that contained about 500000 consumption items and about 500000 externalities which we think is in the order of the amount of data that will be stored in this part Exiopol RDBMs. Quering these data to obtain the complete SUT table in the form of a matrix that contains as columns all the industries (40 countries 1000 industrytypes = 4000 columns) and all commodities (40 countries 120 commoditytypes = 4800 rows) takes about 1 minute if we also export it as tab delimited file. That's seems a very reasonable performance.

Issues that need further work

This scoping document is not the place to develop the full RDBM; this will be a work package on its own in the main phase of the project. Elements that need further work include:

- Two or more layered structure to store CommodityTypes and IndustryTypes.
- Introduce a structure for the multiple representation of the consumption and production amounts.
- Decide upon the separation of consumer activities and industry activities into two separate tables.
- Find out if consumer activities should be in the Production table.
- Decide upon the separation of the Externalities table into a separate Factor inputs table and Environmental interventions table.
- How to include quantitative and qualitative information about the quality of the data.
- If and how to incorporate import, export, investments/capital goods, value added tax into the database.
- Specify which questions will be asked to the Exiopol system and see if these can be satisfied by the system. This might be seen as the user- or application level design.

5.4.3 Transformation of the raw "data"

We explicitly have excluded the transformation step of the raw data into the main classification in force in the DBMSs from the DBMS itself. Because the raw data have been classified in perhaps hundred different classification systems each requiring different transformation data the size the DBMS might quickly be unmanageable on regular hardware.

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Annex I: Abbreviations

c.i.f. cost, insurance, freight

COFOG Classification of the Functions of Government

COICOP Classification of Individual Consumption by Purpose for Households

CPA Classification of Products by Activity

EC European Communities

ESA European System of Accounts

EU European Union

FISIM financial intermediation services indirectly measured

f.o.b. free on board

GDP gross domestic product

GNI gross national income

GNP gross national product

ILO International Labour Organisation

IMF International Monetary Fund

ISIC Rev. 3 International Standard Industrial Classification of all Economic Activities (Revision 3)

KAU kind-of-activity unit

NACE Rev. 1 General Industrial Classification of Economic Activities within the European Communities (Revision 1)

n.e.c. not elsewhere classified

NG neutral holding gain

NPI non-profit institution

NPISH non-profit institutions serving households

NUTS Nomenclature of Territorial Units for Statistics

OECD Organisation for Economic Cooperation and Development

PPP purchasing power parity

R and D research and development

ROW rest of the world

SAM social accounting matrix

SNA System of National Accounts

UN United Nations

VAT value added tax

Annex II: Notations

Supply-use framework

i subscript for products

j subscript for industries

m vector of product imports

q vector of total supply or use of products

U consumption matrix (product*industry)

V production matrix (product*industry)

w vector or matrix of value added by industries

x vector of inputs to or outputs from industries

y vector or matrix of final demand for products

IO framework (restricted to industry-by-industry type)

A normalized input-output matrix (industry*industry)

i subscript for industries

j subscript for industries

w vector or matrix of value added by industries

x vector of inputs to and outputs from industries

y vector or matrix of final demand for industries

Z input-output matrix (industry*industry)

Environmental extensions

S Matrix of environmental extensions (stressors) per unit output

s Vector of total environmental extensions as in $s = S(I-A)^{-1}y$

Multi-region

A^{rs} Normalized flows from region r to region s *(ij subscripts reserved for industries and rs superscripts to regions)*

Similarly, superscripts for all other components

General

e vector of ones

I identity matrix

T	subscript for transpose of a vector or matrix
^	used to indicate the diagonal matrix form of a vector
–1	used to indicate the inverse of a square matrix

Annex III: Harmonized classification to be used in EXIOPOL

As indicated already in chapter 2, supply- and use tables can visualised as in Figure AIII.1 and AIII.2. Next to the SUT, valuation matrices and import matrices have to be constructed, but they have the same dimensions as the Use table. Including environmental extensions, their structure is fixed when the following lists are defined:

- Industry sectors
- Products
- Value added elements
- Final demand elements
- Environmental extensions and supportive physical flow data[1].

Other key elements defining the database are the list of countries, and the base year (2000). This annex includes all these lists.

Annex III.1: Country list

Country
EU27 (each country individually)
United States
Japan
China
Canada
South Korea
Brazil
India
Mexico
Russia
Australia
Switzerland
Turkey
Taiwan
Indonesia
Indonesia
South Africa
Rest of World (resource extracting and high impact sectors only, plus 'source' and 'sink' function of remaining exports to and imports from the EXIOPOL country set)

[1] Inventoried e.g. as auxiliary variables allowing for calculating emissions

Figure AIII.1: Supply table

	Industries	**Imports (c.i.f)**	**Total**	**Valuation**	**Total**
Products	**Production matrix:** Output by products and industries	**Imports** broken down by products	Supply of products at basic prices	**Valuation adjustment items by product**: + Taxes less subsidies on products +Trade and transport margins	Supply at purchasers' prices
Total	**Output by industry at basic prices**	Total Imports	Total supply at basic prices		**Total supply**

Table 2.2: Use table (after Eurostat, 2002)

	Industries	Sub-total	**Final use**			**Total**
			Final consum-ption	Gross capital formation	Exports, f.o.b.	
Products	**Intermediate consumption at pruchaser's prices by product and industry**		**By house-holds, NPISH, govern-ment**	**Gross fixed capital forma-tion and changes in invent-tories**	**Intra- and extra EU**	Use at purcha-sers' prices
Subtotal (1)	Total intermediate consumption by industry		Total final use by type			**Total use**
Compensation of employees	**Components of value added by industry**					
Other net taxes on production						
Consumption of fixed capital						
Operating surplus, net						
Subtotal (3)	Value added					
Total (1)+(3)	**Output by industry at basic prices**					

Table AIII.2: Sectors (Code and level correspond with NACE 1.1; a letter is used if an own sub-classification had to be used).

No	Code	Level	Description
1	01.a	4	Cultivation of Paddy rice
2	01.b	4	Cultivation of Wheat
3	01.c	4	Cultivation of Cereal grains nec
4	01.d	4	Cultivation of Vegetables, fruit, nuts
5	01.e	4	Cultivation of Oil seeds
6	01.f	4	Cultivation of Sugar cane, sugar beet
7	01.g	4	Cultivation of Plant-based fibers
8	01.h	4	Cultivation of Crops nec
9	01.i	4	Cattle farming
10	01.j	4	Pigs farming
11	01.k	4	Poultry farming
12	01.l	4	Meat animals nec
13	01.m	4	Animal products nec
14	01.n	4	Raw milk
15	01.o	4	Wool, silk-worm cocoons
16	02	3	Forestry, logging and related service activities
17	05	3	Fishing, fish farming and related service activities
18	10	3	Mining of coal and lignite; extraction of peat
19	11.a	4	Extraction of crude petroleum and services related to crude oil extraction, excluding surveying
20	11.b	4	Extraction of natural gas and services related to crude oil extraction, excluding surveying
21	11.c	4	Extraction / liquefaction / regasification of other petroleum and gaseous materials
22	12	3	Mining of uranium and thorium ores
23	13.10	5	Mining of iron ores
24	13.20.a	6	Mining of Copper ores and concentrates
25	13.20.b	6	Mining of Nickel ores and concentrates
26	13.20.c	6	Mining of Aluminium ores and concentrates
27	13.20.d	6	Mining of Precious metal ores and concentrates
28	13.20.e	6	Mining of Lead, zinc and tin ores and concentrates
29	13.20.f	6	Mining of Other non-ferrous metal ores and concentrates
30	14.1	4	Quarrying of stone
31	14.2	4	Quarrying of sand and clay
32	14.3	4	Mining of chemical and fertilizer minerals, production of salt, other mining and quarrying n.e.c.
33	15.a	4	processing of meat cattle
34	15.b	4	processing of meat pigs
35	15.c	4	processing of meat poultry
36	15.d	4	production of Meat products nec
37	15.e	4	processing Vegetable oils and fats
38	15.f	4	Processing of Dairy products
39	15.g	4	Processed rice
40	15.h	4	Sugar refining
41	15.i	4	Processing of Food products nec
42	15.j	4	Manufacture of beverages
43	15.k	4	Manufacture of fish products
44	16	3	Manufacture of tobacco products

No	Code	Level	Description
45	17	3	Manufacture of textiles
46	18	3	Manufacture of wearing apparel; dressing and dyeing of fur
47	19	3	Tanning and dressing of leather; manufacture of luggage, handbags, saddlery, harness and footwear
48	20	3	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
49	21	3	Manufacture of pulp, paper and paper products
50	22	3	Publishing, printing and reproduction of recorded media
51	23.10	5	Manufacture of coke oven products
52	23.20.a	6	Manufacture of motor spirit (gasoline)
53	23.20.b	6	Manufacture of kerosene, including kerosene type jet fuel
54	23.20.c	6	Manufacture of gas oils
55	23.20.d	6	Manufacture of fuel oils n.e.c.
56	23.20.e	6	Manufacture of petroleum gases and other gaseous hydrocarbons, except natural gas
57	23.20.f	6	Manufacture of other petroleum products
58	23.30	5	Processing of nuclear fuel
59	24	3	Manufacture of chemicals and chemical products
60	25	3	Manufacture of rubber and plastic products
61	26.a	4	Manufacture of glass and glass products
62	26.b	4	Manufacture of ceramic goods
63	26.c	4	Manufacture of bricks, tiles and construction products, in baked clay
64	26.d	4	Manufacture of cement, lime and plaster
65	26.e	4	Manufacture of other non-metallic mineral products n.e.c.
66	27.a	4	Manufacture of basic iron and steel and of ferro-alloys and first products thereof
67	27.b	4	Precious metals production
68	27.c	4	Aluminium production
69	27.d	4	Lead, zinc and tin production
70	27.e	4	Copper production
71	27.f	4	Other non-ferrous metal production
72	27.g	4	Casting of metals
73	28	3	Manufacture of fabricated metal products, except machinery and equipment
74	29	3	Manufacture of machinery and equipment n.e.c.
75	30	3	Manufacture of office machinery and computers
76	31	3	Manufacture of electrical machinery and apparatus n.e.c.
77	32	3	Manufacture of radio, television and communication equipment and apparatus
78	33	3	Manufacture of medical, precision and optical instruments, watches and clocks
79	34	3	Manufacture of motor vehicles, trailers and semi-trailers
80	35	3	Manufacture of other transport equipment
81	36	3	Manufacture of furniture; manufacturing n.e.c.
82	37.10	5	Recycling of metal waste and scrap
83	37.20	5	Recycling of non-metal waste and scrap
84	40.11.a	6	Production of electricity by coal
85	40.11.b	6	Production of electricity by gas
86	40.11.c	6	Production of electricity by nuclear
87	40.11.d	6	Production of electricity by hydro
88	40.11.e	6	Production of electricity by wind
89	40.11.f	6	Production of electricity nec (including biomass and waste)

No	Code	Level	Description
90	40.12	5	Transmission of electricity
91	40.13	5	Distribution and trade of electricity
92	40.2	4	Manufacture of gas; distribution of gaseous fuels through mains
93	40.3	4	Steam and hot water supply
94	41	3	Collection, purification and distribution of water
95	45	3	Construction
96	50.a	4	Sale, maintenance, repair of motor vehicles, motor vehicles parts, motorcycles, motor cycles parts and accessoiries
97	50.b	4	Retail sale of automotive fuel
98	51	3	Wholesale trade and commission trade, except of motor vehicles and motorcycles
99	52	3	Retail trade, except of motor vehicles and motorcycles; repair of personal and household goods
100	55	3	Hotels and restaurants
101	60.1	4	Transport via railways
102	60.2	4	Other land transport
103	60.3	4	Transport via pipelines
104	61.10	5	Sea and coastal water transport
105	61.20	5	Inland water transport
106	62	3	Air transport
107	63	3	Supporting and auxiliary transport activities; activities of travel agencies
108	64	3	Post and telecommunications
109	65	3	Financial intermediation, except insurance and pension funding
110	66	3	Insurance and pension funding, except compulsory social security
111	67	3	Activities auxiliary to financial intermediation
112	70	3	Real estate activities
113	71	3	Renting of machinery and equipment without operator and of personal and household goods
114	72	3	Computer and related activities
115	73	3	Research and development
116	74	3	Other business activities
117	75	3	Public administration and defence; compulsory social security
118	80	3	Education
119	85	3	Health and social work
120	90.01	5	Collection and treatment of sewage
121	90.02.a	6	collection of waste
122	90.02.b	6	Incineration of waste
123	90.02.c	6	Landfill of waste
124	90.03	5	Sanitation, remediation and similar activities
125	91	3	Activities of membership organizations n.e.c.
126	92	3	Recreational, cultural and sporting activities
127	93	3	Other service activities
128	95	3	Activities of households as employers of domestic staff
129	96	3	Undifferentiated goods producing activities of private households for own use
130	97	3	Undifferentiated services producing activities of private households for own use
131	99	3	Extra-territorial organizations and bodies

Table AIII.3: Products (Code and level correspond with CPA 1.1; a letter is used if an own sub-classification had to be used)

No	Code	Level	name
1	01.a	4	Paddy rice
2	01.b	4	Wheat
3	01.c	4	Cereal grains nec
4	01.d	4	Vegetables, fruit, nuts
5	01.e	4	Oil seeds
6	01.f	4	Sugar cane, sugar beet
7	01.g	4	Plant-based fibers
8	01.h	4	Crops nec
9	01.i	4	Cattle
10	01.j	4	Pigs
11	01.k	4	Poultry
12	01.l	4	Meat animals nec
13	01.m	4	Animal products nec
14	01.n	4	Raw milk
15	01.o	4	Wool, silk-worm cocoons
16	02	3	PRODUCTS OF FORESTRY, LOGGING AND RELATED SERVICES
17	05	3	FISH AND OTHER FISHING PRODUCTS; SERVICES INCIDENTAL TO FISHING
18	10	3	COAL AND LIGNITE; PEAT
19	11.a	4	crude petroleum and services related to crude oil extraction, excluding surveying
20	11.b	4	natural gas and services related to crude oil extraction, excluding surveying
21	11.c	4	other petroleum and gaseous materials
22	12	3	URANIUM AND THORIUM ORES
23	13.10	5	Iron ores
24	13.20.a	6	Copper ores and concentrates
25	13.20.b	6	Nickel ores and concentrates
26	13.20.c	6	Aluminium ores and concentrates
27	13.20.d	6	Precious metal ores and concentrates
28	13.20.e	6	Lead, zinc and tin ores and concentrates
29	13.20.f	6	Other non-ferrous metal ores and concentrates
30	14.1	4	Stone
31	14.2	4	Sand and clay
32	14.3	4	Chemical and fertilizer minerals, salt and other mining and quarrying products n.e.c.
33	15.a	4	products of meat cattle
34	15.b	4	products of meat pigs
35	15.c	4	products of meat poultry
36	15.d	4	Meat products nec
37	15.e	4	products of Vegetable oils and fats
38	15.f	4	Dairy products
39	15.g	4	Processed rice
40	15.h	4	Sugar
41	15.i	4	Food products nec
42	15.j	4	Beverages
43	15.k	4	Fish products

No	Code	Level	name
44	16	3	TOBACCO PRODUCTS
45	17	3	TEXTILES
46	18	3	WEARING APPAREL; FURS
47	19	3	LEATHER AND LEATHER PRODUCTS
48	20	3	WOOD AND PRODUCTS OF WOOD AND CORK (EXCEPT FURNITURE); ARTICLES OF STRAW AND PLAITING MATERIALS
49	21	3	PULP, PAPER AND PAPER PRODUCTS
50	22	3	PRINTED MATTER AND RECORDED MEDIA
51	23.10	5	Coke oven products
52	23.20.a	6	motor spirit (gasoline)
53	23.20.b	6	kerosene, including kerosene type jet fuel
54	23.20.c	6	gas oils
55	23.20.d	6	fuel oils n.e.c.
56	23.20.e	6	petroleum gases and other gaseous hydrocarbons, except natural gas
57	23.20.f	6	other petroleum products
58	23.30	5	Nuclear fuel
59	24	3	CHEMICALS, CHEMICAL PRODUCTS AND MAN-MADE FIBRES
60	25	3	RUBBER AND PLASTIC PRODUCTS
61	26.a	4	Glass and glass products
62	26.b	4	Ceramic goods
63	26.c	4	Bricks, tiles and construction products, in baked clay
64	26.d	4	Cement, lime and plaster
65	26.e	4	Other non-metallic mineral products
66	27.a	4	basic iron and steel and of ferro-alloys and first products thereof
67	27.b	4	Precious metals
68	27.c	4	Aluminium and aluminium products
69	27.d	4	Lead, zinc and tin and products thereof
70	27.e	4	Copper products
71	27.f	4	Other non-ferrous metal products
72	27.g	4	Foundry work services
73	28	3	FABRICATED METAL PRODUCTS, EXCEPT MACHINERY AND EQUIPMENT
74	29	3	MACHINERY AND EQUIPMENT N.E.C.
75	30	3	OFFICE MACHINERY AND COMPUTERS
76	31	3	ELECTRICAL MACHINERY AND APPARATUS N.E.C.
77	32	3	RADIO, TELEVISION AND COMMUNICATION EQUIPMENT AND APPARATUS
78	33	3	MEDICAL, PRECISION AND OPTICAL INSTRUMENTS; WATCHES AND CLOCKS
79	34	3	MOTOR VEHICLES, TRAILERS AND SEMI-TRAILERS
80	35	3	OTHER TRANSPORT EQUIPMENT
81	36	3	FURNITURE; OTHER MANUFACTURED GOODS N.E.C.
82	37.10	5	Metal secondary raw materials
83	37.20	5	Non-metal secondary raw materials
84	40.11.a	6	Electricity by coal
85	40.11.b	6	Electricity by gas
86	40.11.c	6	Electricity by nuclear
87	40.11.d	6	Electricity by hydro
88	40.11.e	6	Electricity by wind
89	40.11.f	6	Electricity nec (including biomass and waste)

No	Code	Level	name
90	40.12	5	Transmission services of electricity
91	40.13	5	Distribution and trade services of electricity
92	40.2	4	Manufactured gas and distribution services of gaseous fuels through mains
93	40.3	4	Steam and hot water supply services
94	41	3	COLLECTED AND PURIFIED WATER; DISTRIBUTION SERVICES OF WATER
95	45	3	CONSTRUCTION WORK
96	50.a	4	Sale, maintenance, repair of motor vehicles, motor vehicles parts, motorcycles, motor cycles parts and accessoiries
97	50.b	4	Retail trade services of motor fuel
98	51	3	WHOLESALE TRADE AND COMMISSION TRADE SERVICES, EXCEPT OF MOTOR VEHICLES AND MOTORCYCLES
99	52	3	RETAIL TRADE SERVICES, EXCEPT OF MOTOR VEHICLES AND MOTORCYCLES; REPAIR SERVICES OF PERSONAL AND HOUSEHOLD GOODS
100	55	3	HOTEL AND RESTAURANT SERVICES
101	60.1	4	Railway transportation services
102	60.2	4	Other land transportation services
103	60.3	4	Transportation services via pipelines
104	61.10	5	Sea and coastal water transportation services
105	61.20	5	Inland water transportation services
106	62	3	AIR TRANSPORT SERVICES
107	63	3	SUPPORTING AND AUXILIARY TRANSPORT SERVICES; TRAVEL AGENCY SERVICES
108	64	3	POST AND TELECOMMUNICATION SERVICES
109	65	3	FINANCIAL INTERMEDIATION SERVICES, EXCEPT INSURANCE AND PENSION FUNDING SERVICES
110	66	3	INSURANCE AND PENSION FUNDING SERVICES, EXCEPT COMPULSORY SOCIAL SECURITY SERVICES
111	67	3	SERVICES AUXILIARY TO FINANCIAL INTERMEDIATION
112	70	3	REAL ESTATE SERVICES
113	71	3	RENTING SERVICES OF MACHINERY AND EQUIPMENT WITHOUT OPERATOR AND OF PERSONAL AND HOUSEHOLD GOODS
114	72	3	COMPUTER AND RELATED SERVICES
115	73	3	RESEARCH AND DEVELOPMENT SERVICES
116	74	3	OTHER BUSINESS SERVICES
117	75	3	PUBLIC ADMINISTRATION AND DEFENCE SERVICES; COMPULSORY SOCIAL SECURITY SERVICES
118	80	3	EDUCATION SERVICES
119	85	3	HEALTH AND SOCIAL WORK SERVICES
120	90.01	5	Collection and treatment services of sewage
121	90.02.a	6	collection of waste
122	90.02.b	6	Incineration of waste
123	90.02.c	6	Landfill of waste
124	90.03	5	Sanitation, remediation and similar services
125	91	3	MEMBERSHIP ORGANIZATION SERVICES N.E.C.
126	92	3	RECREATIONAL, CULTURAL AND SPORTING SERVICES
127	93	3	OTHER SERVICES
128	95	3	SERVICES OF HOUSEHOLDS AS EMPLOYERS OF DOMESTIC STAFF

No	Code	Level	name
129	96	3	UNDIFFERENTIATED GOODS PRODUCED BY PRIVATE HOUSEHOLDS FOR OWN USE
130	97	3	UNDIFFERENTIATED SERVICES PRODUCED BY PRIVATE HOUSEHOLDS FOR OWN USE
131	99	3	SERVICES PROVIDED BY EXTRA-TERRITORIAL ORGANIZATIONS AND BODIES

Table AIII.4a: Value added elements

▪ Compensation of employees: wages and salaries + employers' social contributions o Low skilled o Medium skilled o High skilled
▪ Net taxes on production (production taxes paid by industry excluding non-deductible VAT and those ad valorem taxes used to derive the total supply of products in the supply matrix at basic prices; MINUS production subsidies received by industry exclusing those ad valorem subsidies used to derive the supply matrix at basic prices).
▪ Gross operating profit, divided into o 3a) Consumption of fixed capital: amount of fixed assets used up during a certain year (excluding any rents on land) o 3b) Rents on land o 3c) Royalties on resources: 'profit transferred to the owner of the resource extracted' (inventoried for oil, gas, coal, iron, aluminium and copper) o 3d) Remaining Net operating profit

Table III.4.b: Labour demand (and supply) in physical parameters (note: hourly wages x hours demand equals labor compensation in SUT)

Labour	1	Supply	Low
	2	(persons)	Medium
	3		High
	4		Total
	5	Demand	Low
	6	Persons	Medium
	7		High
	8		Total
	9	Demand	Low
	10	Hours	Medium
	11		High
	12		Total
	13	Demand	Low
	14	FTE	Medium
	15		High
	16		Total
	17	Demand	Low
	18	Hourly wages	Medium
	19		High
	20		Total

Table III.5: Final use (note: final consumption expenditure may be split up into activity categories to allow a link to extensions relevant for the use phase).

- Final consumption expenditure
  - Final consumption expenditure by households
  - Final consumption expenditure by non-profit organisations serving households (NPISH)
  - Final consumption expenditure by government
- Gross capital formation
  - Gross fixed capital formation
  - Changes in inventories
- Exports

Table AIII.6: List of Environmental Extensions and related physical flows

code	*label*
Materials, 96 items [kilograms]. Note: products will be listed as physical flow, others as extensions	
Products from agriculture: to be included as physical flow in SUT	
DEU_1.1.1	Domestic Extraction Used - Primary Crops - Rice
DEU_1.1.2	Domestic Extraction Used - Primary Crops - Wheat
DEU_1.1.3	Domestic Extraction Used - Primary Crops - Other cereals
DEU_1.1.4	Domestic Extraction Used - Primary Crops - Roots and tubers
DEU_1.1.5	Domestic Extraction Used - Primary Crops - Sugar crops
DEU_1.1.6	Domestic Extraction Used - Primary Crops - Pulses
DEU_1.1.7	Domestic Extraction Used - Primary Crops - Nuts
DEU_1.1.8	Domestic Extraction Used - Primary Crops - Oil crops
DEU_1.1.9	Domestic Extraction Used - Primary Crops - Vegetables
DEU_1.1.10	Domestic Extraction Used - Primary Crops - Fruits
DEU_1.1.11	Domestic Extraction Used - Primary Crops - Fibres
DEU_1.1.12	Domestic Extraction Used - Primary Crops - Other crops
DEU_1.2.1	Domestic Extraction Used - Crop Residues - Straw
DEU_1.2.2	Domestic Extraction Used - Crop Residues - Other crop residues
DEU_1.3.1	Domestic Extraction Used - Fodder Crops - Fodder crops
DEU_1.3.2	Domestic Extraction Used - Fodder Crops - Biomass harvested from grasslands
Gifts from nature': to be listed as Environmental Extension	
DEU_1.4.1	Domestic Extraction Used - Grazing - Grazing
DEU_1.5.1	Domestic Extraction Used - Wood - Timber
DEU_1.5.2	Domestic Extraction Used - Wood - Other extractions
DEU_1.6.1	Domestic Extraction Used - Animals - Marine fish
DEU_1.6.2	Domestic Extraction Used - Animals - Inland water fish
DEU_1.6.3	Domestic Extraction Used - Animals - Other aquatic animals
DEU_1.6.4	Domestic Extraction Used - Animals - Hunting

code	label
DEU_2.1	Domestic Extraction Used - Metal Ores - Iron ores
DEU_2.2.1	Domestic Extraction Used - Metal Ores - Bauxite and aluminium ores
DEU_2.2.2	Domestic Extraction Used - Metal Ores - Copper ores
DEU_2.2.3	Domestic Extraction Used - Metal Ores - Lead ores
DEU_2.2.4	Domestic Extraction Used - Metal Ores - Nickel ores
DEU_2.2.5	Domestic Extraction Used - Metal Ores - Tin ores
DEU_2.2.6	Domestic Extraction Used - Metal Ores - Uranium and thorium ores
DEU_2.2.7	Domestic Extraction Used - Metal Ores - Zinc ores
DEU_2.2.8	Domestic Extraction Used - Metal Ores - Precious metal ores
DEU_2.2.9	Domestic Extraction Used - Metal Ores - Other metal ores
DEU_2.3	Domestic Extraction Used - Non-Metallic Minerals - Chemical and fertilizer minerals
DEU_2.4	Domestic Extraction Used - Non-Metallic Minerals - Clays and kaolin
DEU_2.5	Domestic Extraction Used - Non-Metallic Minerals - Limestone, gypsum, chalk, dolomite
DEU_2.6	Domestic Extraction Used - Non-Metallic Minerals - Salt
DEU_2.7	Domestic Extraction Used - Non-Metallic Minerals - Slate
DEU_2.8	Domestic Extraction Used - Non-Metallic Minerals - Other industrial minerals
DEU_2.9	Domestic Extraction Used - Non-Metallic Minerals - Building stones
DEU_2.10	Domestic Extraction Used - Non-Metallic Minerals - Gravel and sand
DEU_2.11	Domestic Extraction Used - Non-Metallic Minerals - Other construction minerals
DEU_3.1	Domestic Extraction Used - Fossil Fuels - Hard coal
DEU_3.2	Domestic Extraction Used - Fossil Fuels - Lignite/brown coal
DEU_3.3	Domestic Extraction Used - Fossil Fuels - Crude oil
DEU_3.4	Domestic Extraction Used - Fossil Fuels - Natural gas
DEU_3.5	Domestic Extraction Used - Fossil Fuels - Natural gas liquids
DEU_3.6	Domestic Extraction Used - Fossil Fuels - Peat for energy use
UDE_1.1.1	Unused Domestic Extraction - Primary Crops - Rice
UDE_1.1.2	Unused Domestic Extraction - Primary Crops - Wheat
UDE_1.1.3	Unused Domestic Extraction - Primary Crops - Other cereals
UDE_1.1.4	Unused Domestic Extraction - Primary Crops - Roots and tubers
UDE_1.1.5	Unused Domestic Extraction - Primary Crops - Sugar crops
UDE_1.1.6	Unused Domestic Extraction - Primary Crops - Pulses

code	*label*
UDE_1.1.7	Unused Domestic Extraction - Primary Crops - Nuts
UDE_1.1.8	Unused Domestic Extraction - Primary Crops - Oil crops
UDE_1.1.9	Unused Domestic Extraction - Primary Crops - Vegetables
UDE_1.1.10	Unused Domestic Extraction - Primary Crops - Fruits
UDE_1.1.11	Unused Domestic Extraction - Primary Crops - Fibres
UDE_1.1.12	Unused Domestic Extraction - Primary Crops - Other crops
UDE_1.2.1	Unused Domestic Extraction - Crop Residues - Straw
UDE_1.2.2	Unused Domestic Extraction - Crop Residues - Other crop residues
UDE_1.3.1	Unused Domestic Extraction - Fodder Crops - Fodder crops
UDE_1.3.2	Unused Domestic Extraction - Fodder Crops - Biomass harvested from grasslands
UDE_1.4.1	Unused Domestic Extraction - Grazing - Grazing
UDE_1.5.1	Unused Domestic Extraction - Wood - Timber
UDE_1.5.2	Unused Domestic Extraction - Wood - Other extractions
UDE_1.6.1	Unused Domestic Extraction - Animals - Marine fish
UDE_1.6.2	Unused Domestic Extraction - Animals - Inland water fish
UDE_1.6.3	Unused Domestic Extraction - Animals - Other aquatic animals
UDE_1.6.4	Unused Domestic Extraction - Animals - Hunting
UDE_2.1	Unused Domestic Extraction - Metal Ores - Iron ores
UDE_2.2.1	Unused Domestic Extraction - Metal Ores - Bauxite and aluminium ores
UDE_2.2.2	Unused Domestic Extraction - Metal Ores - Copper ores
UDE_2.2.3	Unused Domestic Extraction - Metal Ores - Lead ores
UDE_2.2.4	Unused Domestic Extraction - Metal Ores - Nickel ores
UDE_2.2.5	Unused Domestic Extraction - Metal Ores - Tin ores
UDE_2.2.6	Unused Domestic Extraction - Metal Ores - Uranium and thorium ores
UDE_2.2.7	Unused Domestic Extraction - Metal Ores - Zinc ores
UDE_2.2.8	Unused Domestic Extraction - Metal Ores - Precious metal ores
UDE_2.2.9	Unused Domestic Extraction - Metal Ores - Other metal ores
UDE_2.3	Unused Domestic Extraction - Non-Metallic Minerals - Chemical and fertilizer minerals
UDE_2.4	Unused Domestic Extraction - Non-Metallic Minerals - Clays and kaolin
UDE_2.5	Unused Domestic Extraction - Non-Metallic Minerals - Limestone, gypsum, chalk, dolomite

code	*label*
UDE_2.6	Unused Domestic Extraction - Non-Metallic Minerals - Salt
UDE_2.7	Unused Domestic Extraction - Non-Metallic Minerals - Slate
UDE_2.8	Unused Domestic Extraction - Non-Metallic Minerals - Other industrial minerals
UDE_2.9	Unused Domestic Extraction - Non-Metallic Minerals - Building stones
UDE_2.10	Unused Domestic Extraction - Non-Metallic Minerals - Gravel and sand
UDE_2.11	Unused Domestic Extraction - Non-Metallic Minerals - Other construction minerals
UDE_3.1	Unused Domestic Extraction - Fossil Fuels - Hard coal
UDE_3.2	Unused Domestic Extraction - Fossil Fuels - Lignite/brown coal
UDE_3.3	Unused Domestic Extraction - Fossil Fuels - Crude oil
UDE_3.4	Unused Domestic Extraction - Fossil Fuels - Natural gas
UDE_3.5	Unused Domestic Extraction - Fossil Fuels - Natural gas liquids
UDE_3.6	Unused Domestic Extraction - Fossil Fuels - Peat for energy use

Land use occupation, 1 item [hectares/yr] (extensions); derived from FAOSTAT

L_0	Land use

N.B. the following FAOSTAT categories allow for allocating land use to agricultural sectors

L_1.1.	Arable Land - Rice
L_1.2.	Arable Land - Wheat
L_1.3.	Arable Land - Other cereals
L_1.4.	Arable Land - Roots and tubers
L_1.5.	Arable Land - Sugar crops
L_1.6.	Arable Land - Pulses
L_1.7.	Arable Land - Nuts
L_1.8.	Arable Land - Oil crops
L_1.9.	Arable Land - Vegetables
L_1.10.	Arable Land - Fruits
L_1.11.	Arable Land - Fibres
L_1.12.	Arable Land - Other crops
L_1.13.	Arable Land - Fodder crops
L_2	Pasture - Permanent pasture
L_3	Forest - Wood land

code	*label*	
Water, 1 item [litres] (extension), derived from FAOSTAT		
W_0	Primary fresh water use (river or ground water), excluding cooling water	
N.B. the following FAOSTAT categories allow for allocating water use to sectors		
W_1.1.	Agricultural Water Use - Rice	
W_1.2.	Agricultural Water Use - Wheat	
W_1.3.	Agricultural Water Use - Other cereals	
W_1.4.	Agricultural Water Use - Roots and tubers	
W_1.5.	Agricultural Water Use - Sugar crops	
W_1.6.	Agricultural Water Use - Pulses	
W_1.7.	Agricultural Water Use - Nuts	
W_1.8.	Agricultural Water Use - Oil crops	
W_1.9.	Agricultural Water Use - Vegetables	
W_1.10.	Agricultural Water Use - Fruits	
W_1.11.	Agricultural Water Use - Fibres	
W_1.12.	Agricultural Water Use - Other crops	
W_1.13.	Agricultural Water Use - Fodder crops	
W_2	Industrial Water Use	
Emissions, 56 items [kilograms] (extension)		
	CO2	air
	N2O	air
	CH4	air
	HFCs	air
	PFCs	air
	SF6	air
	NOX	air
	SOx	air
	NH3	air
	NMVOC	air
	CO	air

code	*label*
CFCs	air
HCFCs	air
Pb	air
Cd	air
Hg	air
As	air
Cr	air
Cu	air
Ni	air
Se	air
Zn	air
Aldrin	air
Chlordane	air
Chlordecone	air
Dieldrin	air
Endrin	air
Heptachlor	air
Hexabr.-biph.	air
Mirex	air
Toxaphene	air
HCH	air
DDT	air
PCB	air
dioxin	air
PM10	air
BaP	air
Benzene	air
1,3 Butadiene	air
Formaldehyd	air
N	water
P	water

code	label	
	BOD	water
	N	soil
	P	soil
	Cd	soil
	Cu	soil
	Zn	soil
	Pb	soil
	Hg	soil
	Cr	soil
	Ni	soil
	PM2.5	air
	Furans	air
	Benzo-[a]-pyrene (PAHs)	air
	PBDEs	air

Energy, 122 items [Joule] (mostly physical flows; primary extraction as extension). Derived from IEA energy database

Primary energy carriers extracted, overlap with category UDE and DEU 3 in material database and will be harmonized

S_NATGAS	Natural Gas
S_CRUDEOIL	Crude Oil
S_ANTCOAL	Anthracite
S_COKCOAL	Coking Coal
S_BITCOAL	Other Bituminous Coal
S_SUBCOAL	Sub-Bituminous Coal
S_LIGNITE	Lignite/Brown Coal
S_PEAT	Peat

code	*label*
Secondary energy products, will be linked to the EXIOPOL product classification	
S_PATFUEL	Patent Fuel
S_OVENCOKE	Coke Oven Coke
S_GASCOKE	Gas Coke
S_COALTAR	Coal Tar
S_BKB	BKB/Peat Briquettes
S_GASWKSGS	Gas Works Gas
S_COKEOVGS	Coke Oven Gas
S_BLFURGS	Blast Furnace Gas
S_OXYSTGS	Oxygen Steel Furnace Gas
S_MANGAS	Elec/Heat Output from Non-spec. Manuf. Gases
S_INDWASTE	Industrial Waste
S_MUNWASTER	Municipal Waste (Renew)
S_MUNWASTEN	Municipal Waste (Non-Renew)
S_SBIOMASS	Primary Solid Biomass
S_GBIOMASS	Biogas
S_BIOGASOL	Biogasoline
S_BIODIESEL	Biodiesels
S_OBIOLIQ	Other Liquid Biofuels
S_RENEWNS	Non-specified Combust. Renewables + Wastes
S_CHARCOAL	Charcoal
S_NGL	Natural Gas Liquids
S_REFFEEDS	Refinery Feedstocks
S_ADDITIVE	Additives/Blending Components
S_NONCRUDE	Other Hydrocarbons
S_REFINGAS	Refinery Gas
S_ETHANE	Ethane
S_LPG	Liquefied Petroleum Gases (LPG)
S_MOTORGAS	Motor Gasoline
S_AVGAS	Aviation Gasoline
S_JETGAS	Gasoline Type Jet Fuel

code	*label*
S_JETKERO	Kerosene Type Jet Fuel
S_OTHKERO	Kerosene
S_GASDIES	Gas/Diesel Oil
S_RESFUEL	Residual Fuel Oil
S_NAPHTHA	Naphtha
S_WHITESP	White Spirit & SBP
S_LUBRIC	Lubricants
S_BITUMEN	Bitumen
S_PARWAX	Paraffin Waxes
S_PETCOKE	Petroleum Coke
S_ONONSPEC	Non-specified Petroleum Products
S_HEATNS	Heat Output from non-specified comb fuels
S_NUCLEAR	Nuclear
S_HYDRO	Hydro
S_GEOTHERM	Geothermal
S_SOLARPV	Solar Photovoltaics
S_SOLARTH	Solar Thermal
S_TIDE	Tide, Wave and Ocean
S_WIND	Wind
S_OTHER	Other Sources
S_ELECTR	Electricity
S_HEAT	Heat
S_TOTAL	Total of All Energy Sources
U_ANTCOAL	Anthracite
U_COKCOAL	Coking Coal
U_BITCOAL	Other Bituminous Coal
U_SUBCOAL	Sub-Bituminous Coal
U_LIGNITE	Lignite/Brown Coal
U_PEAT	Peat
U_PATFUEL	Patent Fuel
U_OVENCOKE	Coke Oven Coke

code	*label*
U_GASCOKE	Gas Coke
U_COALTAR	Coal Tar
U_BKB	BKB/Peat Briquettes
U_GASWKSGS	Gas Works Gas
U_COKEOVGS	Coke Oven Gas
U_BLFURGS	Blast Furnace Gas
U_OXYSTGS	Oxygen Steel Furnace Gas
U_MANGAS	Elec/Heat Output from Non-spec. Manuf. Gases
U_INDWASTE	Industrial Waste
U_MUNWASTER	Municipal Waste (Renew)
U_MUNWASTEN	Municipal Waste (Non-Renew)
U_SBIOMASS	Primary Solid Biomass
U_GBIOMASS	Biogas
U_BIOGASOL	Biogasoline
U_BIODIESEL	Biodiesels
U_OBIOLIQ	Other Liquid Biofuels
U_RENEWNS	Non-specified Combust. Renewables + Wastes
U_CHARCOAL	Charcoal
U_NATGAS	Natural Gas
U_CRUDEOIL	Crude Oil
U_NGL	Natural Gas Liquids
U_REFFEEDS	Refinery Feedstocks
U_ADDITIVE	Additives/Blending Components
U_NONCRUDE	Other Hydrocarbons
U_REFINGAS	Refinery Gas
U_ETHANE	Ethane
U_LPG	Liquefied Petroleum Gases (LPG)
U_MOTORGAS	Motor Gasoline
U_AVGAS	Aviation Gasoline
U_JETGAS	Gasoline Type Jet Fuel
U_JETKERO	Kerosene Type Jet Fuel

code	*label*
U_OTHKERO	Kerosene
U_GASDIES	Gas/Diesel Oil
U_RESFUEL	Residual Fuel Oil
U_NAPHTHA	Naphtha
U_WHITESP	White Spirit & SBP
U_LUBRIC	Lubricants
U_BITUMEN	Bitumen
U_PARWAX	Paraffin Waxes
U_PETCOKE	Petroleum Coke
U_ONONSPEC	Non-specified Petroleum Products
U_HEATNS	Heat Output from non-specified comb fuels
U_NUCLEAR	Nuclear
U_HYDRO	Hydro
U_GEOTHERM	Geothermal
U_SOLARPV	Solar Photovoltaics
U_SOLARTH	Solar Thermal
U_TIDE	Tide, Wave and Ocean
U_WIND	Wind
U_OTHER	Other Sources
U_ELECTR	Electricity
U_HEAT	Heat
U_TOTAL	Total of All Energy Sources