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EXIOPOL

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

Technical report focusing on economic data sources for SUT/IO tables for EU25 and RoW

Scoping report WP III.2.a and WPIII.3.a

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Preamble

EXIOPOL ("A New Environmental Accounting Framework Using Externality Data and Input-Output Tools for Policy Analysis") is an Integrated Project set up by FEEM and TNO with funding from the EU's 7th Framework Program. It runs between March 2007 and 2011. The main project set-up is in three content clusters, one on externalities modelling (Cluster II), one on a SUT/IO accounting framework with environmental extensions (Cluster III), and one on using the combined result in modelling for decision support (Cluster IV). Furthermore, one overarching cluster is dedicated to keeping the scope of this conceptually complex project focused (Cluster I), one is reserved for management (Cluster VI), and a final one is for dissemination of results (Cluster V).

The present report is one of the scoping reports in Cluster III, focusing on setting up the harmonized SUT/IO dataset to be used in the project. The elaboration and collection of real data will take place later, in two working packages on data gaterhing for the EU27 (WP III.2.a) and data gathering for non EU countries (WP III 3.a). ,

Signature

(signed)

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July 2007

Executive Summary

This report is part of the Scoping of Cluster III in EXIOPOL (WP III.1.a). It focuses on the availability of Supply and Use Tables (SUT) and Input Output Tables (IOT) for the 27 countries in the European Union, and a selection of other countries in the world. These data have to become part of a harmonized environmentally extended input-output (EE IO) database, that can support environmental and economic policy making in three ways:

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 approaches that allow for decomposition analysis of differences
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.

This scoping report recommends basing the EXIOPOL database on a SUT rather than an IOT framework. For the EU27, we propose to take the Eurostat ESA95 SUT (rather than national tables) as a basis, due to the harmonisation already performed. For the Rest of the World, on the basis of criteria like GDP and trade with Europe we propose to include at least 15 other countries in the database (US, Japan, China, Canda, Korea, Brazil, India, Russia, Australia, Switzerland, Turkey, Taiwan, Norway, Indonesia and South Africa). Many other countries with significant trade with Europe or GDP in fact are resource producing countries, and rather than inventorying and harmonizing full SUT or IOT, we may model the most relevant sectors in such countries as a true Rest of World. In principle, we will aim to source SUT and IOT directly from National Statistical Institutes rather than using secondary (if even harmonized) sources like OECD or GTAP.

The process of bringing the primary data into the harmonized EXIOPOL format requires various transformation and harmonization steps, for instance dealing with confidential data, harmonizing sector and product classifications and monetary units, scaling up or down to a common base year, ensuring that all data are in the same price type (basic prices), etc. The report lists over a dozen of such harmonization issues, and does a first proposal for an approach of dealing with them (where in practice the method may be adjusted or adapted to the experience with the factual data situation once the harmonization work has started).

Finally, the report pays attention to data verification and cross checking methods. The whole idea behind discerning different countries is that they may have different technology structures, and we must avoid gathering data that just show differences due to statistical artefacts and other anomalies.

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1 Introduction

The Integrated Project (IP) EXIOPOL (A New Environmental Accounting Framework Using Externality Data and Input-Output Tools for Policy Analysis) aims to achieve the following goals (FEEM and TNO 2006):

(a) to synthesise and develop further estimate of the external costs of key environmental impacts for Europe

(b) to set up an environmentally extended (EE) Input-Output (IO) 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

(c) to apply the results of the external cost estimates and EE IO 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

The EE IO part of the project was inspired by results of the Environmental Impacts of Products (EIPRO) project, where a 500x500 sector database with environmental extensions was developed for the EU25 (Tukker, Huppes et al. 2006). A main drawback of that database was, however, that the high level of detail was realised by applying technology transfer assumptions using a US IO table. Further, pollution embodied in trade with Europe was poorly estimated (assuming that imported goods were made with EU technology), and the database did not discern the individual EU member states. EXIOPOL has much more resources available to do the job fundamentally right.

The EE IO work in EXIOPOL has as main goal to develop an operational and detailed EU27 input-output table (IOT) with environmental extensions. This is basically an economic IOT to which per sector discerned information about emissions and resource use is added. The database that will be developed will include external costs data calculated in other parts of EXIOPOL as well. The EE IO table for the EU27 will be embedded in a global context. This is essential to be able to take pollution and externalities embedded in imports to the EU27 into account (Lenzen, Pade et al. 2004; Nijdam, Wilting et al. 2005; Peters and Hertwich 2006), but also to be able to analyse the effects of sustainability measures taken in Europe on the economic competitiveness of the EU27. *De facto* EXIOPOL hence aims to develop a global, multi-regional input output table with environmental extensions. To this end, the Cluster of Work Packages in EXIOPOL on EE I-O will perform the following tasks:

(a) First, for the countries included in the table individual IO tables have to be gathered, uniformed, and enhanced in sector detail. 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. This is far from trivial and actually one of the crucial issues to be solved in Cluster III

(d) Fourth, it should be possible to link the whole database with various key models in use at IPTS, and the World Trade Model of RPI.

(e) Fifth, all data have to be embedded in a user-friendly general purpose database system, that can support e.g. LCA, direct scenario analysis, CGE models, etc.

In the Description of Work for the project, important operational criteria for the database have been specified (see box 1.1). They include full or almost full transparency, applying an open source and non-commercial philosophy, staying as close as possible to the European System of Accounts (ESA95) and related classifications, etc.

The work on the EE IO cluster started in April 2007 with the development of Scoping Reports with regard to each of the main tasks listed above. The key goal of these Scoping Reports is to identify the availability of the necessary data and to identify issues using the data in EXIOPOL. This Scoping Report is focussed on identifying the necessary economic data listed under point a). The necessary economic data covers industry linkages – either input-output tables (IOT) or supply and use tables (SUT) – and factor linkages – such as capital, employment, land, resources, and so on. While factor inputs from the environment are an important economic linkage, they are discussed as a part of the Scoping Report on environmental extensions. This Scoping Report focuses on key *economic* data only.

EXIOPOL is not the first project to require an extensive global IO database. The Global Trade Analysis Project (GTAP) has maintained a global, trade linked I-O database since the 1990's that now discerns over 80 world regions and 57 industry sectors. Similarly, the OECD has developed a harmonised database of industry by industry IO tables for OECD member states and their main trade partners. While the GTAP and OECD databases are of obvious interest for EXIOPOL, they do have several disadvantages which imply that EXIOPOL could not decide upfront that they could form the core of the EXIOPOL database. A primary goal of EXIOPOL is environmental analysis and neither the GTAP nor OECD databases contain the necessary environmental extensions. Furthermore, neither GTAP nor OECD covers all specifications desired by EXIOPOL (see box 1.1). For instance, GTAP uses a sector and product classification which deviates significantly from the European System of Accounts 1995 (European Communities 1996), sometimes uses rather old IO tables which are extrapolated to a recent base year, and while transparency is pursued, in practice not all transformations can be followed in full. The OECD covers a sub-set of the EU27, and publishes IO tables for individual countries – where EXIOPOL needs to have them linked as well via trade. Resolutions of particularly the minerals and mining sector and energy sectors are insufficient from an environmental point of view[1]. In the particular case of GTAP, the

[1] GTAP has in the agricultural sectors and food industry a level of detail that is much better than in many other databases, which is environmentally relevant.

database undergoes significant modifications to meet the demands of CGE modelling (Dimaranan 2006). While it is envisaged that EXIOPOL will link to various economic models, the database will not be constructed to favour one approach over another. Given the specific requirements of EXIOPOL, it is apparent that currently available global databases may not be sufficient. The implication is that EXIOPOL will of course look at how and if GTAP and OECD data and experiences can be used, but must also analyse the broader availability of IO and related data and consider doing a significant harmonisation job in the project.

The general structure of this Scoping Report is as follows. First, there are various ways to map economic relations. Traditionally, for environmental applications IO databases with environmental extensions are mostly used (e.g., Suh 2004; Weidema, Nielsen et al. 2005; Wiedmann, Lenzen et al. 2007). But in economic accounting it is now generally acknowledged that National Statistical Institutes (NSI) can best use Supply and Use Tables (SUT) for organising their primary data (European Communities 1996; Eurostat 2002). Various forms of IOT can be derived from the SUT. In Chapter 2 we therefore discuss SUTs, IOTs and the relation between them in more detail.

Second, this scoping report must assess the SUT and IOT availability for the EU, which is discussed in Chapter 3, and other countries, discussed in Chapter 4. An important element in the latter chapter is to identify the number of countries necessary to adequately cover the EU's global environmental impacts.

Third, since the data comes from a variety of sources, it is necessary to harmonize the economic data into a consistent format and structure. Transformations needed and the methods we envisage for this are discussed in Chapter 5.

Fourth, sector and regional differences in pollution intensity drives the environmental profiles of different countries. To ensure fair comparisons it needs to be verified that there is consistency between economic data from different data sources. To this end, various quality control mechanisms to be applied in the data gathering will be discussed in Chapter 6.

Finally, Chapter 7 ends with conclusions. A key issue discussed there is, amongst others given data availability, it is recommended to use SUTs or IOTs as the primary basis for EXIOPOL's database development.

Box 1.1: Some basic design criteria

In its DoW, EXIOPOL mentioned a number of points of departures:

1. To stay as close as possible to official statistics, particularly of EUROSTAT. This implies using for the EU27 the ESA95 SUT and IOT.
2. To use open sources only, and produce a fully transparent database for the public domain rather than that is ends up behind the commercial walls of consortium members.
3. To realize a sector detail that is meaningful for most environmental applications, which implies that the ESA95 classification of 60 sectors and products has to be detailed in the areas of agriculture, mining and mineral extraction, energy production, and waste management.
4. To choose a set of environmental extensions that allows to calculate at least indicators such as the Ecological Footprint, Total Material Requirement, external costs, and themes from Life cycle impact assessment such as GWP, ODP, Eutrophication, Acidification, and where possible eco-toxicity and human toxicity.
5. To orient the database as a guidepost for 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[2]
6. To ensure that the database can be linked 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 (e.g. different types of labour, capital, but also land and resources, the latter being covered in the WPs on environmental extensions.

[2] The idea is that the project should set a reasonable benchmark in terms of structure, and that will form a guidepost for data generators in the future. However, different uses will pose different demands to the EE IOT (see Section 2.1).

2 Background to the economic data

2.1 Introduction to the SUT and IOT

The 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 (ESA; 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). In more layman terms, the supply table shows what products each industry produces and hence the extent of secondary production. 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). In layman terms, the use table shows the purchases of products by industries and consumers. The SUT are a central component of the ESA as they show the flows of money through an economy and are used for both statistical and analytical purposes.

A symmetric input-output table (SIOT, IOT for short) gives a detailed description of the domestic production processes and transactions within an economy. The IOT is constructed by merging the SUT into one single table and is expressed as either a product-by-product or industry-by-industry table. 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).

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 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 to facilitate decision making in EXIOPOL.

2.1.1 Relationship between SUT and IOT

To realistically discuss the various options available for EXIOPOL it is important to discuss some background theory for SUT and IOT. The SUT is based on two balance equations and conceptually it can be instructive to think of these in physical units; the supply table describes the goods and services supplied by the producers (including imports) and the use table describes the goods and services purchased by the users (industries, households, government and export). The IOT is a simplification of the SUT to a system with one balance equation based on assumptions about secondary production.

It is possible for EXIOPOL to use either SUT or IOT and the decision will likely be based on both theoretical, empirical, modelling, and data availability issues. In this section we discuss two mathematical treatments of secondary production which are most likely to be applied by EXIOPOL. The intention here is not to give a detailed analysis, but rather outline the key issues to facilitate decision making. It is unavoidable that EXIOPOL will need to apply assumptions on secondary production since for some countries we need to convert the SUT to IOT and in others we need to convert the IOT to SUT. More detailed discussions on secondary production can be found elsewhere (Miller and Blair 1985; United Nations 1999; ten Raa and Rueda-Cantuche 2003; ten Raa and Rueda-Cantuche 2007).

The combined SUT for closed economy is shown in Table and two balance equations follow. Products can be used by either industry or final demand,

$$q = Ue + y \tag{1}$$

where e is a vector of ones for summation. In terms of the supply, each industry produces various products (that is, there is secondary production),

$$g = Ve \tag{2}$$

Ultimately, we want to determine the output for an arbitrary final demand. For an arbitrary demand, the use of products by industry will depend on the industry output, which implies normalizing the system with respect to industry output,

$$q = \left(U\hat{g}^{-1}\right)g + y \tag{3}$$

where the hat converts the vector into a diagonal matrix. 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, (2). In its un-normalized form, the supply balance (2), does not provide enough information to solve the system of equations (one equation in two unknowns). We consider two common assumptions for secondary production: The industry-technology assumption and the commodity-technology assumption.

Table 1: The general structure of the SUT.

	Products	Industry	Final Demand	Outputs
Products	*0*	*U*	*y*	$q=e^TV$
Industry	*V*	*0*	*0*	$g=Ve$
Value Added	*0*	v^i		
Outputs	V^Te	e^TV^T		

2.1.1.1 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,

$$g = \left(V\hat{q}^{-1}\right)q \tag{4}$$

The SUT leads to two equations in two unknowns and the system can be uniquely solved for either unknown. The system of equations, (3) and (4), can easily be represented in a supply-use block

$$\begin{pmatrix} q \\ g \end{pmatrix} = \begin{pmatrix} 0 & U\hat{g}^{-1} \\ V\hat{q}^{-1} & 0 \end{pmatrix} \begin{pmatrix} q \\ g \end{pmatrix} + \begin{pmatrix} y \\ 0 \end{pmatrix} \tag{5}$$

Solving this system for industry output gives the industry-by-industry requirements matrix,

$$g = A^{g} g + y^{g} \tag{6}$$

where

$$A^{g} = V\hat{q}^{-1}U\hat{g}^{-1} \tag{7}$$

and

$$y^{g} = V\hat{q}^{-1} y \tag{8}$$

Solving the system for product output gives the product-by-product requirements matrix,

$$q = A^{q} q + y \tag{9}$$

where

$$A^{q} = U\hat{g}^{-1}V\hat{q}^{-1} \tag{10}$$

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

$$g = \left(I - A^{g}\right)^{-1} V\hat{q}^{-1} y \tag{11}$$

Alternatively, this same equation can be solved as

$$g = V\hat{q}^{-1}\left(I - A^{q}\right)^{-1} y \tag{12}$$

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.

2.1.1.2 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,

$$g = \left(\hat{g}V^{-T}\right) q \tag{13}$$

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

$$\begin{pmatrix} q \\ g \end{pmatrix} = \begin{pmatrix} 0 & U\hat{g}^{-1} \\ \hat{g}V^{-T} & 0 \end{pmatrix} \begin{pmatrix} q \\ g \end{pmatrix} + \begin{pmatrix} y \\ 0 \end{pmatrix} \tag{14}$$

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,

$$g = A^{i} g + y^{g} \tag{15}$$

where

$$A^{g} = \hat{g}V^{-T}U\hat{g}^{-1} \tag{16}$$

and

$$y^{g} = \hat{g}V^{-T} y \tag{17}$$

Solving (3) and (13) for product output gives the product-by-product requirements matrix,

$$q = A^{\mathrm{p}} q + y \quad (18)$$

where

$$A^{\mathrm{q}} = UV^{-T} \quad (19)$$

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

$$g = \left(I - A^{\mathrm{g}}\right)^{-1} \hat{g} V^{-T} y \quad (20)$$

2.1.2 Cross-cutting issues using SUT or IOT

Generally there can be significant debate on the use of SUT or IOT and much of this debate may relate to misunderstanding in definitions (Yamano and Ahmad 2006). Common cross-cutting issues include the use of SUT versus IOT for analysis, product-by-product versus industry-by-industry IOT, and ITA versus CTA. The above mathematical background provides enough material to highlight many misunderstandings and gives a platform to discuss more relevant SUT and IOT issues.

Before proceeding, it is worth recalling that the choice of ITA or CTA relates to how the supply table is normalized; equations (4) and (13). The following identifies four *main* types of IOT; a) ITA industry, b) ITA products, c) CTA industry, and d) CTA products. Most debates on SUT and IOT relate to the preferences in these four options. In the following we discuss the key issues; choice of ITA or CTA, use of product or industry tables, and finally the use of SUT or IOT for analysis.

2.1.2.1 ITA versus CTA

Significant debate relates to the choice of technology assumption. This issue is important for EXIOPOL since for some countries SUT will need conversion to IOT or IOT will need conversion to SUT. 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).

The ITA versus CTA debate can be concisely summarized. 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[3]. 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.

2.1.2.2 Products versus industries

Once the IOT have been derived (using either the ITA or CTA), then the choice of a product or industry table arises. The SUT represents two equations in two

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

unknowns. Assuming a unique solution exists, mathematically, the choice of products or industries does not matter. It is just a matter of whether you present the results as industry or products. Once a user has the solution in one variable (products, say), it is straight-forward to use the SUT to derive the solution in the other variable (industry in this example). The connection is made through the normalized supply table.

In practice, 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.

The choice of products versus industry tables should be selected so that it is consistent with the data-sets that will ultimately link to the EXIOPOL database (such as trade statistics, final demands, emission intensities, and so on). Ultimately, the EXIOPOL database structure should retain flexibility for either choice depending on the user's requirements.

2.1.2.3 SUT versus IOT

Another possible decision for EXIOPOL is whether to use supply-use blocks, such as (5), as opposed to using an IOT. The supply-use blocks simply express the normalized SUT in matrix form. Due to uniqueness, solving the SUT in matrix form gives the same solution as constructing the IOT from the SUT. Thus, from a theoretical point of view, the choice of system is arbitrary. However, from a computation point of view, using a constructed IOT is preferable since it requires less memory and computational effort.

Empirically it could be argued that the supply-use block is an advantage as it allows a clearer description of the data as some data, for example environmental extensions, may for some countries be in industries and others in products. However, in the process of performing a calculation on the SUT or IOT, the supply table is implicitly used to transform data to the correct format (industry or product). Thus, while SUT may be a superior method for data presentation, IOT is superior for computational performance.

2.2 Introduction to economic factor inputs

To link the EXIOPOL database with various economic models, selected factor inputs and factor endowments are required (Neuwahl, Duchin et al. 2007):

- Factor inputs
- Factor prices (including any resource rents associated with them)
- Factor stocks and endowments

Another scoping report deals with environmental factor inputs such as land and resources, while this scoping report considers the economic factors – primarily labour and capital.

For the economic factors, an important question is how many classes the factor inputs labour and capital should be divided. For labour, one can discern compensation and hours worked for low-skilled, medium-skilled, and high-skilled persons, making further distinctions between employed and self-employed persons, age group, and gender. For capital, one can discern different types of assets, construction (subdivided in residential, non residential and infrastructure), machinery and equipment, other tangible assets, and total intangible assets.

Compiling detailed accounts of factor inputs is no panacea. Indeed, the EU funded a project of similar size to EXIOPOL to produce time series of such data in the EU KLEMS project (Timmer, van Moergastel et al. 2007). With EXIOPOL primarily geared towards environmental analysis, we probably will use a rather pragmatic approach to inventory of factor inputs and related data, using what is readily available and probably ending up with a rather low level of specification per type of factor input.

3 Economic data for the EU25

3.1 SUT and IOT

3.1.1 Introduction

In this section the overall availability of tables for the EU is discussed. There are arguably two *main* options for sourcing SUT and IOT tables in the EU and two additional sources for the ROW:

1. Eurostat
   - Directly from Eurostat; or
   - Modified version from DG JRC IPTS
2. National Statistical Institutes (NSI)
3. OECD (only foreign data – see later)
4. GTAP (only foreign data – see later)

In terms of EXIOPOL it is most likely that the EU27 data will be sourced from Eurostat since this comes in a standardized format. An alternative source of these data is DG JRC IPTS, who work on producing a full set of SUT and IOT in basic prices for all EU27 countries for 2000, thereby filling various gaps in the dataset available from Eurostat (Rueda-Cantuche, Beutel et al. 2007). It is possible to collect the data from NSI, but this data will come in different formats, classifications, valuations, and so on, and hence will require significant resources to harmonize. Thus, in this section it is assumed that EU data comes primarily from Eurostat or DG JRC IPTS. Details from NSI are only necessary when the Eurostat data does not provide the necessary requirements, such as adequate sector or product detail.

The work of DG JRC IPTS gave significant experience in overcoming the problems in converting the Eurostat database into a consistent and uniform format. Much of this experience is relevant for EXIOPOL (Rueda-Cantuche, Beutel et al. 2007)

3.1.2 Eurostat

The general overview of the annual data availability is provided in Table 2 with more specific details on the type of data in XXX. At least initially, sourcing data from Eurostat is an advantage as EU countries must regularly submit SUT and SIOT data according to the European System of National Accounts (ESA95) (European Communities 1996). Under the ESA95 the data is in a uniform format, however, the SUT and SIOT are derived independently by NSI. The tables have a resolution of 60 industries (classified according to NACE[4]) and 60 products (classified according to CPA[5]). The supply table is given in basic prices, and the use table in purchaser prices. Given that NSI often use in-house information and more disaggregated data to construct SIOT from SUT, this

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[4] NACE Rev.1.1: Statistical Classification of Economic Activities in the European Community, Rev. 1.1 (2002): http://ec.europa.eu/eurostat/ramon/

[5] CPA 2002: Statistical Classification of Products by Activity in the European Economic Community, (2002): http://ec.europa.eu/eurostat/ramon/

makes it impossible for a data user to covert a Eurostat SUT to the corresponding Eurostat SIOT. Further, while the ESA data is harmonized, the user does not know if each NSI uses identical definitions and approaches in constructing the data. Thus direct comparability of the data between countries cannot be fully guaranteed.

According to ESA95, countries must submit:

- Supply Table: In basic prices (annually)
- Use Table: Total use of products in purchaser prices (annually)
- SIOT: Domestic, Imports, and Total table in basic prices (every 5 years)

According to Table 2 this is followed by many countries but not all. Countries with data generally have SUT availably annually and IOT available every five years (1995, 2000, 2005, etc). Some countries have only submitted SUT, but not IOT. Cyprus, Bulgaria, and Romania have not submitted any SUT or IOT. Some countries submit additional data such as more frequent IOT submission or extra data on margins and taxes allowing the use table to be converted to basic prices. The latest data is generally for 2003, but not all countries have submitted 2003 data. Countries must submit 2004 SUT to Eurostat by 31-12-2007, but various derogations exist and the experience is that delays are not uncommon. The 2005 SUT and IOT formally only have to be submitted by 31-12-2008[6]. Since the EXIOPOL database must be finalized by 1-3-2009, waiting for the 2004 or 2005 SUT and IOT is not possible.

According to Table 3 the SUT and IOT have 60 sectors with only minor problems with missing data (such as confidential data). About half the tables are valued in Euros, with the remainder valued in national currencies. The IOT are in a mix of industry-industry and commodity-commodity format. Etc…

Given the variations in the types of data available conversions will be needed to make a complete set of SUT or IOT for a given base-year. Conversions are needed to adjust for the base year, currency, industry or commodity tables, valuation, and transformations between SUT and IOT. The SUT are more complete, but in the wrong valuation. These manipulations are discussed in Chapter 5. The IPTS documentation gives a good overview of harmonizing the available ESA data into a harmonized EU27 database for the year 2000 (Rueda-Cantuche, Beutel et al. 2007).

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[6] Eurostat, personal communication, July 2007

Table 2: The annual availability of SUT and IOT from Eurostat.

	ESA 95 Table	1500 Supply and Use										1700 SIOT				
Code	Country	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	1995	2000	2001	2002	2003
AT	Austria	x		x		x	x	x	x	x		x	x			
BE	Belgium	x		x		x	x	x	x			x	x			
BG	Bulgaria						x									
CY	Cyprus															
CZ	Czech Republic	x	x	x	x	x	x	x	x	x	x					
DK	Denmark	x	x	x	x	x	x	x	x	x		x	x	x	x	x
EE	Estonia	/	/	~~x~~		/	x	~~x~~	x	x		97	x	/		
FI	Finland	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
FR	France	x		x		x	x	x					x			
DE	Germany	x		x	x	x	x	x	x	x		x	x	x	x	
GR	Greece	x	x	x	x	x						97	98			
HU	Hungary				x	x	x	x	x	x		98	x			
IE	Ireland				x		x					98	x			
IT	Italy	x	x	x	x	x	x	x	x	x		x	x			
LV	Latvia		x		x							96	98			
LT	Lithuania						x	x	x	x			x			
LU	Luxembourg	x	x	x	x	x	x	x	x	x						
MT	Malta						x	x								
NL	Netherlands	x	~~x~~	x	~~x~~	x	x	x		x		x	x	x		
PL	Poland	x	x	x	x	x	x					x	x			
PT	Portugal	x	x	x	x	x	x	x	x	x	x		99			
RO	Romania															
SK	Slovakia	x	x	x	x	x	x	x	x	x		x	x			
SI	Slovenia		x				x	x	x	x		96	x	x		
ES	Spain	x	x	x	x	x	x	x				x	x			
SE	Sweden	x	x	x	x	x	x	x	x	x		x	x			
UK	United Kingdom	x	x	x	x	x	x	x	x	x		x				
		17	**15**	**18**	**17**	**18**	**23**	**20**	**16**	**16**	**3**	**18**	**15**	**4**	**3**	**1**

Table 3: Specific details of the SUT and IOT data available from Eurostat

Code	Name	Supply Table	Use Table	Margins Table	Tax Table	IOT	Imported IOT	Product or Industry IOT	Number of products	Number of industries	Currency
AT	Austria	Y	Y			Y	Y	P	60	60	EUR
BE	Belgium	Y	Y	Y	Y	Y	Y	P	60	60	EUR
BG	Bulgaria										
CY	Cyprus										
CZ	Czech R.	Y	Y						60	60	CZK
DK	Denmark	Y	Y	Y	Y	Y	Y	I	60	60	DKK
EE	Estonia	Y	Y			Y	Y	P	60	60	EEK
FI	Finland	Y	Y	Y	Y	Y	Y	I	60	60	FIM
FR	France	Y	Y			Y	Y	P	60	60	EUR
DE	Germany	Y	Y			Y	Y	P	60	60	EUR
GR	Greece	Y	Y			Y		P	60	60	EUR
HU	Hungary	Y	Y			Y	Y	PI	60	60	HUF
IE	Ireland	Y	Y			Y	Y	P	60	60	EUR
IT	Italy	Y	Y			Y	Y	P	60	60	EUR
LV	Latvia	Y	Y			Y	Y	P	60	60	LVL
LT	Lithuania	Y	Y			Y	Y	P	60	60	LTL
LU	Luxembourg	Y	Y						60	60	EUR
MT	Malta	Y	Y						60	60	MTL
NL	Netherlands	Y				Y	Y	I	60	60	EUR
PL	Poland	Y	Y			Y	Y	P	60	60	PLN
PT	Portugal	Y	Y			Y	Y	P	60	60	EUR
RO	Romania										
SK	Slovakia	Y	Y			Y	Y	P	60	60	SKK
SI	Slovenia	Y	Y			Y	Y	P	60	60	EUR
ES	Spain	Y	Y	Y	Y	Y	Y	P	60	60	EUR
SE	Sweden	Y	Y			Y	Y	P	60	60	SEK
UK	United Kingdom	Y	Y			Y	Y	P	60	60	GBP

3.1.3 Other data sources

The GTAP, OECD, and EU-KLEMS all have European databases.

The GTAP database distinguishes 57 product sectors, although the underlying data is a mix of product and industry tables. For some countries the GTAP database is rather out-dated with some IOT dating to 1985 (e.g., Sweden). The GTAP sector classification is more aggregated that the Eurostat data, except for the agricultural and food sectors. In addition GTAP performs manipulations to the raw data for the needs of their project (Dimaranan 2006). Given these points the GTAP EU27 data is too far from the original statistical sources to be considered by EXIOPOL. It is worth noting that IPTS will update the EU27 for the GTAP for Version 7 of the GTAP database (personal communication, IPTS) and since IPTS is a part of EXIOPOL there will be some beneficial knowledge spill-overs.

The OECD database discerns 48 industry sectors. and contains IOT for most EU countries in the industry-by-industry format with a base year around 2000. The OECD IOT are usually sourced from Eurostat or NSI (Yamano and Ahmad 2006). As with the GTAP database, the OECD EU27 database is one-step removed from the original Eurostat data and is consequently not an option for EXIOPOL.

The EU KLEMS project collected SUT in a consistent time-series and is consistent with the Eurostat SUT (personal communication with EU-KLEMS). Despite possible overlaps, the EU-KLEMS SUT is not available outside the project and is consequently not an option for EXIOPOL. As discussed below, the economic factor inputs from EU-KLEMS will be used in EXIOPOL.

3.2 Economic factor inputs

A recent EU funded project EU-KLEMS (www.euklems.net) has constructed database of economic factor inputs in both physical and monetary units that map directly to the ESA SUT and IOT. It is an obvious choice to use this data in EXIOPOL.

The EU KLEMS project "aims to create a database on measures of economic growth, productivity, employment creation, capital formation and technological change at the industry level for all European Union member states from 1970 onwards…The database should facilitate the sustainable production of high quality statistics using the methodologies of national accounts and input-output analysis. The input measures will include various categories of capital, labour, energy, material and service inputs."

EXIOPOL will collect physical unit data for energy and material inputs. Thus, only the labour accounts and capital flow accounts are needed from EU-KLEMS. The EU-KLEMS labours accounts are in both in both physical and monetary units, and are further disaggregated into several labour types – gender, age categories and skill. The EU-KLEMS capital flow accounts provides measures of investment in seven asset categories with subsequent estimation of capital stocks and users costs of these assets.

The EU-KLEMS data is ESA95 consistent, in a time-series from 1970 to 2005, and publicly available. It contains the necessary data for EXIOPOL.

4 Economic data for the RoW

4.1 Introduction

For a variety of reasons, the EXIOPOL database cannot focus on IOT and environmental extensions for the EU27 alone. European countries cause significant environmental impacts outside the EU through international trade (Nijdam, Wilting et al. 2005; Peters and Hertwich 2006). To understand the economic and environmental consequences of measures taken in the EU27, one also has to take this international context into account. Hence, it is necessary to collect data for the Rest of the World (RoW).

There several options to represent RoW in EXIOPOL and ultimately a trade-off between detail and available resources is required. One extreme is to have one country representing the RoW (inaccurate) and the other is to collect economic data for all countries outside of the EU (most accurate). Since technology, factor inputs and energy mixes vary across regions it is apparent that more than one region is needed for the RoW. On the other hand, with limited resources it is not possible to collect or construct the necessary data for every country. This chapter first discusses which countries are necessary to adequately represent the RoW and then catalogues the availability of the necessary economic data in those countries.

4.2 Country selection

4.2.1 Selection criteria

Several approaches have been used previously to handle imports in EE IO studies:

1. Model the RoW as a single region using the technology of a *representative* country, such as:
    a. the US or China (Ahmad and Wyckoff 2003; Weidema, Nielsen et al. 2005)
    b. Australia (Lenzen, Pade et al. 2004)
2. Collect real data for the 6-7 main trading partners, and allocate the trade of any other country to the main trading partner with the most similar technology (Peters and Hertwich 2006). A variation on this approach is that where regional data is available, allocate the trade from the rest of the region to the average technology in that region (Dimaranan 2006).
3. Use an existing database, most notably GTAP, to construct a few aggregated RoW regions with a typical technology mix, for instance, the EU, other OECD, and non OECD (Nijdam, Wilting et al. 2005).

These approaches differ in the number of countries they require. Option one requires only one country to represent RoW, while the others require more. Since EXIOPOL has many key trading partners with different energy mixes and economic characteristics – China, Russia, and the USA – it is likely that a number of countries will be used for RoW. Some of the above approaches are not true multi-regional models, but rather have a ‘central’ country or country cluster, bilaterally trading with some other countries or regions. The trade *between* these other regions is not covered.

To overcome such drawbacks, in the DoW EXIOPOL made the strategic decision to develop a true multi-regional database and include a significant number of non-EU countries (15+). Having said this, criteria are needed to prioritize which countries to include. In evaluating the criteria one must recall that EXIOPOL is an EU-focussed database to analyze environmental extensions. Some obvious criteria to select countries include:

1. GDP – appropriate for a global model, but not an EU focussed model
2. Total environmental impacts – similar disadvantage to GDP
3. Major EU trading partners (as used in Peters and Hertwich 2006) – assumes environmental impacts proportional to trade flows
4. Share of emissions embodied in imports – but with such data mainly available for embodied energy or CO_2 emissions, this may easily neglect non-energy related impacts (data from Peters 2007)
5. A weighting between the above options

Of course, no ranking scheme is perfect. The criteria above may miss several more qualitative issues and considerations, such as:

1. Some smaller European countries may need inclusion in EXIOPOL since they are a part of an expanding EU – Albania, Croatia, Norway, Turkey, among others
2. Country size may bias the rankings (gravity model). The USA and China will rank highly in all options due to their immense size. On the other hand, individual countries may rank lowly despite the importance of that country in an aggregated region – such as South East Asia
3. For global coverage a representative country might be needed from each continent or trade bloc
4. Countries with low GDP, but high environmental impact (for instance, under-developed countries) may be left out
5. Countries that have in absolute terms a low GDP and low trade with the EU, may still export a significant part of their GDP to the EU, and hence may be significantly affected by environmental and economic policies by the EU.

4.2.2 Selection criteria comparisons

Table 4 to 7 show where non-EU27 countries are ranked on the basis of their GDP, trade volume with Europe, and embodied CO_2 emissions in trade with Europe, and the ratio of the exports to the EU27 and GDP. The tables indicate if GTAP or OECD have IOT available, hence whether an SUT or IOT can be sourced from that countries' NSI (an issue to be analysed in more detail in section 4.3).

Table 4: Main trading partners of the EU25 (Source Eurostat), ranked by GDP and availibilty of IO tables at OECD or GTAP.

		GDP	Cumulated GDP as % of ROW total	OECD, GTAP and other (e.g. NSI) availibility
1	United States	10051	44	OECD
2	Japan	3680	60	OECD
3	China	1791	68	OECD
4	Canada	910	72	OECD
5	Korea	638	74	OECD
6	Brazil	638	77	OECD
7	India	624	80	OECD
8	Russia	617	83	OECD
9	Australia	570	85	OECD
10	Switzerland	296	86	Available
11	Turkey	292	88	Available
12	Taiwan	279	89	OECD
13	Saudi Arabia	248	90	
14	Norway	238	91	Available
15	Indonesia	222	92	OECD
16	South Africa	193	93	GTAP
17	Iran, Islamic Republic of	158	93	Available
18	Argentina	146	94	OECD
19	Hong Kong SAR	143	95	GTAP
20	Thailand	136	95	GTAP
21	United Arab Emirates	108	96	
22	Malaysia	105	96	GTAP
23	Israel	99	97	OECD
24	Singapore	95	97	OECD
25	Chile	92	98	GTAP
26	New Zealand	87	98	OECD
27	Algeria	82	98	
28	Nigeria	80	99	
29	Romania	79	99	
30	Ukraine	66	99	
31	Kazakhstan	45	99	
32	Morocco	42	100	GTAP
33	Libya	31	100	
34	Tunisia	24	100	GTAP
35	Syrian Arab Republic	21	100	
36	Côte d'Ivoire	13	100	
37	Iraq		100	

Table 5: Main trading partners of the EU25 (Source Eurostat), ranked by trade to the EU and availibilty of IO tables at OECD or GTAP

		GDP	Cumulated GDP as % of ROW total	OECD GTAP and other (e.g. NSI) availibility
1	United States	162.9	15	OECD
2	China	158.0	30	OECD
3	Russia	106.7	41	OECD
4	Japan	73.0	48	OECD
5	Norway	67.1	54	Available
6	Switzerland	66.1	60	Available
7	Turkey	33.5	63	Available
8	Korea	33.2	67	OECD
9	Taiwan	23.8	69	OECD
10	Brazil	23.2	71	OECD
11	Saudi Arabia	22.1	73	
12	Algeria	20.7	75	
13	Libya	19.5	77	
14	India	18.9	79	OECD
15	Singapore	18.2	80	OECD
16	Canada	17.2	82	OECD
17	South Africa	16.7	84	GTAP
18	Malaysia	15.9	85	GTAP
19	Romania	15.3	87	
20	Thailand	12.9	88	GTAP
21	Iran, Islamic Republic of	11.4	89	Available
22	Indonesia	10.7	90	OECD
23	Hong Kong SAR	10.7	91	GTAP
24	United Arab Emirates	9.9	92	
25	Israel	9.6	93	OECD
26	Australia	9.5	94	OECD
27	Kazakhstan	9.1	95	
28	Morocco	9.0	95	GTAP
29	Nigeria	8.3	96	
30	Chile	7.9	97	GTAP
31	Ukraine	7.7	98	
32	Tunisia	6.8	98	GTAP
33	Argentina	6.4	99	OECD
34	Iraq	3.6	99	
35	Syrian Arab Republic	2.9	100	
36	New Zealand	2.9	100	OECD
37	Côte d'Ivoire	1.9	100	

Table 6: Share of monetary imports and emissions embodied in imports into the EU27 by GTAP region (Peters 2007).

	Monetary Imports			**Emissions Embodied in Imports**			
	Imports into EU27	*Relative Imports*	*Rank*	*Imports into EU27*	*Relative Imports*	*Rank*	*Total Rank*
China	75661	2.8	3	155137	8.9	1	3
United States	271979	10.1	1	140607	8.1	3	3
Russian Federation	46585	1.7	5	154632	8.9	2	10
Japan	86155	3.2	2	31776	1.8	8	16
Rest of Middle East	44014	1.6	6	63882	3.7	5	30
EFTA other	40956	1.5	7	21091	1.2	10	70
RoF Soviet Union	14717	0.5	20	66086	3.8	4	80
Switzerland	61032	2.3	4	5665	0.3	24	96
Turkey	24787	0.9	11	25303	1.5	9	99
Canada	28181	1	9	20433	1.2	11	99
Korea	29584	1.1	8	18012	1	13	104
India	17973	0.7	17	32978	1.9	7	119
South Africa	13096	0.5	22	41911	2.4	6	132
Rest of North Africa	22256	0.8	15	19998	1.1	12	180
Malaysia	24661	0.9	12	14727	0.8	16	192
Brazil	19867	0.7	16	16687	1	14	224
Hong Kong	25954	1	10	5109	0.3	25	250
Taiwan	23538	0.9	14	13393	0.8	19	266
Thailand	15888	0.6	19	16049	0.9	15	285
Australia	13983	0.5	21	14672	0.8	17	357
Singapore	24463	0.9	13	4489	0.3	28	364
Sub-Saharan Africa	16801	0.6	18	10535	0.6	21	378
Indonesia	12421	0.5	23	14358	0.8	18	414
Rest of FTAA	8240	0.3	25	8025	0.5	22	550
Mexico	11389	0.4	24	5944	0.3	23	552
Rest of Europe	3600	0.1	38	10818	0.6	20	760
Argentina	6713	0.2	28	4158	0.2	29	812
Chile	5914	0.2	31	4646	0.3	27	837
Vietnam	5206	0.2	33	5085	0.3	26	858
Tunisia	6544	0.2	29	3829	0.2	30	870
Morocco	6836	0.3	27	3634	0.2	33	891
Luxembourg	7868	0.3	26	2057	0.1	40	1040
Philippines	5989	0.2	30	3169	0.2	36	1080
Rest of South Asia	3722	0.1	37	3754	0.2	32	1184
Central America	5230	0.2	32	2534	0.1	38	1216
Croatia	4699	0.2	34	2660	0.2	37	1258
New Zealand	4085	0.2	36	3351	0.2	35	1260

Table 7: Main trading partners of the EU25 (Source Eurostat), GDP 2005, export to the EU25 and growth 1999-2005

		GDP 2005	Export of EU 25	Export to EU/GDP country	Growth import
		Billion E	*Billion E*		*99-05*
1	Libya	31.2	19.5	62.4	19
2	Norway	238.3	67.1	28.2	14
3	Tunisia	24.3	6.8	27.9	6
4	Algeria	82.1	20.7	25.2	18
5	Switzerland	295.8	66.1	22.3	3
6	Morocco	41.8	9.0	21.5	8
7	Kazakhstan	45.2	9.1	20.2	30
8	Romania	79.3	15.3	19.3	16
9	Singapore	94.9	18.2	19.2	5
10	Russia	616.8	106.7	17.3	21
11	Malaysia	105.3	15.9	15.1	2
12	Côte d'Ivoire	13.0	1.9	14.9	-2
13	Syrian Arab Republic	21.3	2.9	13.7	5
14	Ukraine	65.7	7.7	11.7	17
15	Turkey	291.8	33.5	11.5	14
16	Nigeria	79.8	8.3	10.4	20
17	Israel	99.4	9.6	9.6	3
18	Thailand	135.9	12.9	9.5	3
19	United Arab Emirates	107.7	9.9	9.2	32
20	Saudi Arabia	247.8	22.1	8.9	17
21	China	1791.0	158.0	8.8	20
22	South Africa	192.5	16.7	8.7	7
23	Chile	91.7	7.9	8.6	14
24	Taiwan	278.6	23.8	8.5	2
25	Hong Kong SAR	143.1	10.7	7.5	0
26	Iran, Islamic Rep. of	158.1	11.4	7.2	15
27	Korea	638.4	33.2	5.2	9
28	Indonesia	222.2	10.7	4.8	3
29	Argentina	146.2	6.4	4.4	5
30	Brazil	638.1	23.2	3.6	9
31	New Zealand	87.4	2.9	3.3	4
32	India	624.2	18.9	3.0	10
33	Japan	3679.9	73.0	2.0	0
34	Canada	909.8	17.2	1.9	3
35	Australia	569.9	9.5	1.7	5
36	United States	10051.0	162.9	1.6	0
37	Iraq		3.6		-1

We see in fact that all criteria pretty much lead to the same country set, with the exception of Table 7 (the importance of trade with the EU compared to GDP). Since the criterion behind Table 7 would imply including a lot of small countries with low GDP, trade with the EU, and environmental impacts, we decided not to include these. The implication will be that our database will be less suitable to analyse impacts of EU policies on such smaller countries with high trade with the EU, but this was not foreseen as a primary use of our database in the first place. Table 4 and 5 show that with just 16 countries, we cover 92% of the non-EU global GDP. Almost the same country set covers over 80% of the trade with the EU, and also most of the pollution embodied in trade. This is summarised in Table 8. Furthermore, it is likely that trade with and economic activities of Saudi Arabia, Libya, Algeria and Malaysia are mainly consisting of oil or mineral resource extraction, which causes a significant environmental impact. Hence, an appropriate strategy may be that EXIOPOL focuses on collecting and harmonising full SUT and IOT for about 15 countries with a high GDP and trade with the EU – but that also have a diverse economy. For countries that are mainly relevant due to export of oil and minerals, a specific and less time consuming solution can be worked out in line with the approach taken in the GINFORS model (Meyer, Lutz et al. 2007). There, for instance, most OPEC countries were modelled in the form of a single oil production sector, since this covered most of their economic activities. The country choice will be finalised after the analysis of data availability in the next section.

Table 8: Top 16 non EU countries concerning GDP, Trade with EU25, and embodied CO2 in trade with the EU25

Country	GDP	Trade with EU25	Embodied CO_2 (GTAP classification)
United States	1	1	1
Japan	2	4	2
China	3	2	3
Canada	4	16	9
Korea	5	8	8
Brazil	6	10	16
India	7	14	--
Russia	8	3	5
Australia	9	--	--
Switzerland	10	6	4
Turkey	11	7	11
Taiwan	12	9	14
Saudi Arabia	13	11	6 [Rest of Middle East]
Norway	14	5	7 [EFTA other]
Indonesia	15	--	--
South Africa	16	--	--
Hong kong	-- [19]	--	10
Singapore	-- [24]	15	13
Malaysia	-- [22]	--	12
Algeria	-- [27]	12	15 [Rest of North Africa]
Libya	-- [33]	13	15 [Rest of North Africa]

4.3 Sources for SUT and IOT

4.3.1 Introduction

For the RoW data we can use data from NSI, GTAP or the OECD. Each will have various advantages and disadvantages.

4.3.2 National Statistical Institutes (NSI)

From the outset, it is reasonable to assume that data quality will be better from the NSI rather other secondary sources. However, using and harmonizing NSI data for many countries will take a lot of resources. In Table 9 we have inventoried the availability of primary SUT and IOT from the NSI of the countries listed in Table 8 and their characteristics (prices, base year, how frequently published, industry and product classification, etc.). This is in fact the same data sourced by OECD and GTAP for their databases, but here we would use the original NSI data and transform them directly into the EXIOPOL structure.

4.3.3 OECD

The OECD maintains an IO database with data for 28 OECD and 9 non-OECD countries with an approximate base year of 2000 and covering 48 industry sectors (Yamano and Ahmad 2006). The OECD publishes industry by industry tables based on the industry technology assumption. The original data is obtained from NSI and Eurostat. While OECD does perform manipulations on the data, it is mainly to transform the data into a consistent and uniform data set ready for modelling. Thus, after the NSI, we would put preference on the OECD data.

4.3.4 GTAP

The Global Trade and Analysis Project (GTAP) maintains an IO, trade, protection and energy database covering 87 world regions and 57 industry sectors for the base year 2001 (Dimaranan 2006). The GTAP source the IO data from various NSI, usually through voluntary submission of the GTAP users in return for free membership. While this is an efficient way to reduce resource requirements, it means that the data is not always the most recent. This is a particular problem for the EU countries which have IO data as far back as 1985. Once the data is submitted to GTAP it is then transformed into the necessary classification and adjustments made for the specific needs of the GTAP which makes "significant adjustments to ensure that the I-O tables matches the external macroeconomic, trade, protection, and energy data" (Dimaranan 2006, Chapter 11).

Given the fact that EXIOPOL will have to use ESA95 data for the EU27 in any case, and just has to add around 16 other countries to get a reasonable global coverage, we feel that basing ourselves on primary data rather than using GTAP may be preferable. While redoing work on transformations, the added value may be better transparency, the use of more recent data, etc…

Table 9: Availability of primary SUT and IOT for priority 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	Russian Federation	Australia	Switzerland	Turkey	Taiwan	Saudi Arabia	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	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		ii	Pp	?		pp	pp	
	# sectors	500	500	124		404		115	22	96(106)	42		160?		59		
	Currency	$	Yen		C$	Kwon		Lakh	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	

4.4 Matching country selection and availability

In sum, while using OECD or GTAP data would reduce the demands on EXIOPOL, this probably would be done at the expense of data quality. To ensure the EXIOPOL data is as close as possible to the original statistical source, our preference is to use data directly from NSI, followed by OECD and then GTAP. Table 9 shows in more detail the data availability from the about 20 countries listed in Table 8. Rather than performing a detailed assessment of the data available for all countries, we only give a detailed account of the data available for the selected countries. For most countries, primary data in the form of SUT or IOT are available. Some special issues include:

1. In principle, for most of the priority countries data are available. Question marks include Saudi Arabia and South Africa, but particularly Saudi Arabia probably can be modelled by mainly taking the oil extraction and related sectors into account.
2. The most recent tables tend to be from around 2000-2002, although for some countries data can be quite a bit older (e.g. Brazil, 1996).
3. There is a significant diversity in type of tables (SUT versus various types of IOT), sector or product resolution, or valuation basis (basic, purchaser or producer prices)
4. Information that allows for transforming tables into a different valuation seems often lacking; specific import tables often are available.

The (probably not too surprising) conclusion is that the match between country selection and data availability is probably good enough, and that the main challenge will be transforming and harmonizing the data.

4.5 Factor inputs

Factor inputs concern the proportion of capital and labour use in the production goods and services. In general, this is measured by the proportion of wages in value added. The rest of value added is considered as capital input. Also, the amount of labour and capital related to total value added is considered. Therefore, we need the amount of labour in full time equivalent and the capital stock.

To calculate this, full time equivalents and capital stock is required. Table 9 suggests that such data may not easily available directly from statistical offices. Total investment is given by the IMF by country (180 countries). Labour data are available at the International Labour Organisation – more than we ever could handle. Labour productivity should not be an issue. Total capital stock is also possible, but will need a starting value by country. It also requires an assumption on depreciation.

As discussed earlier, the EU KLEMS project has inventoried such data for the EU. Yet, for reasons of comparison they also inventoried data for a few main trade partners, i.e. Japan and the US. Such data can also be used in EXIOPOL

5 Transformations of the SUT and IOT

5.1 Introduction

The data availability chapters have identified several challenges for EXIOPOL. For all the countries required in the database (both EU27 and RoW) there is not a complete set of SUT or a complete set of IOT. A further complication is that the SUT and IOT often have different valuations and some IOT may need transformation between industries and products. To make a complete database of SUT or IOT it is necessary to have a variety of transformations for each country. Once there is a complete database of SUT or IOT, it is necessary to make a variety of transformations to harmonize the tables for cross-country analysis or linkages. These transformations will harmonize the tables into a common classification, currency, base-year, and so on.

This chapter discusses the various transformations necessary to construct a harmonized database for EXIOPOL. It is split into three sections: the first discussions transformations to make the database complete, the second discusses the transformations to harmonize the database, and the third section describes options for detailing (disaggregating) environmentally important sectors.

5.2 Completing the database

The original SUT and IOT are in a variety of formats and neither the set of SUT nor IOT is complete. EXIOPOL needs a complete set of either SUT or IOT. To meet this requirement a series of transformations are needed to fill in the gaps in the database. The transformations are not necessarily general, but specific to the various data sources. For instance, the Eurostat supply tables are in basic prices, the use table in purchaser prices, and the IOT in basic prices. To obtain the use table in basic prices a conversion is needed. Further, conversions are needed to calculate an IOT when only SUT are available. Other common problems are that some tables are available in products and other industry, and tables often vary in valuation (basic, producer, purchaser prices).
This section discusses the most common transformations likely to arise in EXIOPOL and poses various options for completing the database. In the case of the EU27, the IPTS documentation describes most of these manipulations (Rueda-Cantuche, Beutel et al. 2007).

5.2.1 Constructing an IOT from an SUT in correct valuation

In some cases an IOT needs construction based on the available SUT. If the SUT is in basic prices then an application of either technology assumption produces the IOT. The various transformations are described in section 2.1.1.

5.2.2 Constructing an SUT from an IOT in correct valuation

In many cases, particularly the RoW, an IOT is available in basic prices, but an SUT is not available. In these cases an SUT needs estimation. The simplest approach is to assume there is no secondary production and populate the supply table with the product or industry output on the diagonal. A more complicated approach is to assume, based on other supply tables, an “average” supply table. This involves extra work and is not necessarily any more accurate. While this option can be explored further, a best first approach is to assume no secondary production.

An alternative route for obtaining a Use table in basic prices is ‘reverse engineering’. For the years 1995 and 2000 EU countries have IOT and Supply tables available in basic prices, and Use tables in purchaser prices. From the IOT and Supply table the Use table in basic prices can be derived, if the technology assumption applied for producing the IOT is known (see section 2.1.1).

5.2.3 Constructing an IOT from an SUT in wrong valuation

Particularly for the Eurostat tables, the supply table is in basic prices and the use table is in purchaser prices. To construct the IOT in basic prices requires converting the use table to basic prices. In the ideal case, this requires availability of a set of valuation matrices reflecting trade margins, transport margins, taxes and subsidies. If such information is not available, the IPTS approach can be followed by assuming the margins and taxes from other countries (Rueda-Cantuche, Beutel et al. 2007). In the case of the EU27, about four countries have submitted use tables in basic prices. By taking a weighing of the margins and taxes in those countries and then scaling to the country requiring conversion a reasonable estimate can be obtained of the basic prices data.

5.2.4 Constructing an IOT in basic prices from an IOT in the wrong valuation

In several RoW countries only an IOT is available in the wrong valuation. In the absence of additional information, the approach in section 5.2.3 can be followed by assuming the margins and taxes from other countries in the database. By taking a weighing of these data and scaling to the country requiring conversion a reasonable estimate can be obtained of the basic price data. Once the IOT is in basic prices, the SUT in basic prices can be estimated using the method in section 5.2.2.

5.2.5 Converting between products and industries

The ROW data will often come in either a product-product or an industry-industry IOT. By using the above four methods to complet the SUT and IOT database, enough information is available to construct product or industry tables in the desired format using the methods in section 2.1.1.

5.2.6 SUT and IOT conversions in different base-years

Particularly for the EU27, the latest SUT and latest IOT have different base years. It is possible to use a hybrid of the SUT and IOT in these cases. For instance, if the IOT is from 2000 it can be normalized to give the coefficient (technology) matrix for the year 2000. Then the SUT data from another year, 2004 say, can be used to “adjust” the table to 2004. In this case the 2004 supply table would be used with the 2000 IOT to estimate a 2004 use table. This method assumes that the technology remained approximately constant from 2000 to 2004. This approach can have various drawbacks though and must be further evaluated in the project.

5.2.7 Missing and confidential data

Sometimes data points are missing or are confidential. For instance, in the case of Norway the refinery sector is confidential and is aggregated to the chemical industry. A method is required to split this sector apart to make Norway consistent with other countries in the dataset. Similarly, the UK SUT has confidential data and methods are required to estimate the missing data.

In some cases additional statistical sources may help estimating missing or confidential data. In the case of Norway, the refinery sector is only confidential in some years. The missing data can simply be estimated using a different base-year. In other cases, the RAS procedure may be required to re-balance the tables if estimation unbalances them (Yamano and Ahmad 2006).

5.2.8 Missing countries

In some cases we will see that for the EU27 and about 16 relevant non-EU countries SUT or IO data will not have been published at all. We may decide to leave such countries out of our database, but given the background of the project for EU countries this probably is not an option. Here, probably the only approach is to use reference countries for which data is available, and use these to project data of non-available SUT and IOT. We will follow the approach used by the IPTS for completing the EU27 database (Rueda-Cantuche, Beutel et al. 2007):

"In the Cypriot and Latvian cases, Greece and Estonia were taken as reference countries to elaborate their SIOTs by means of the Euro approach. The starting points for both cases were value added and final demand for Greece and Estonia in 2000, respectively. Next, macroeconomic forecasts of Cyprus and Latvia for 2000 were considered as the objectives to be achieved by the iterative projections. With respect to the Romanian and Bulgarian SIOTs, we took Poland as reference country to fill the remaining gaps due to the still little available information concerning the National Accounts of these countries. Here, we opted for a basic RAS procedure on the basis of available gross value added by industry and the official structural composition of final demand".

5.3 Harmonizing the database across countries

Once a complete database of SUT and IOT is constructed for the necessary countries it is necessary to harmonize the data. All the data needs to be in a consistent format, classification, base year, currency, and so on. Many of these problems are familiar in environmental MRIO and more specific details can be found elsewhere (Ahmad and Wyckoff 2003; Lenzen, Pade et al. 2004; Peters and Hertwich 2004; Peters and Hertwich 2006; Peters 2007; Peters and Hertwich 2007; Weber and Matthews 2007). The key issues are discussed here.

5.3.1 Common sector classifications

Outside of the EU countries different sector classifications will be used by different countries. Occasionally these will be relatively easy to map to the EU classification. In other cases, the sector classifications may be quite different (eg, China) or the data may be more aggregated then the EU data (eg, Russian Federation).

If there is a many-to-one correspondence between the original classification and the EU classification then the concordance table is a simple mapping between sectors. For instance if in the original classification sectors X and Y map to NACE sector 21, then the rows and columns of the X and Y sectors in the original table are added together. This is easily implemented using matrix multiplication.

If there is a one-to-many correspondence between the original classification and the EU classification, then the original classification needs to be disaggregated. For instance, if sector Z maps to NACE 22 and 23, then sector Z needs to be split proportionally. In some cases additional data might be available to estimate the proportions, but failing that, it is possible to disaggregate based on the output in another "representative" table.

Both cases lead to a concordance matrix with dimensions of the EU classification and the old classification. The elements of the matrix describe the relationship between the sectors, with the columns sums adding to one. If there are multiple entries in a row then there is a many-to-one mapping. If there is a single number in a row (it will be a one) then there is a one-to-one mapping. If there are many numbers in a column (all adding to one) then there is a one-to-many mapping. Once the concordance matrix, P, has been derived the SUT and IOT – flows, not coefficients – can be converted to the EU classification using multiplication. For vectors,

$$x_{EU} = Px_{old} \tag{21}$$

and for matrices

$$Z_{EU} = PZ_{old}P^{T} \tag{22}$$

where the superscript T represents transpose.

5.3.2 Common Unit

When performing an international analysis it is necessary to convert the SUT and IOT to a common unit to allow some, but not all, comparisons. The unit could represent tonnes, kilowatt-hours, dollars, units (as in numbers of cars), and so on. Currently, SUT and IOT are only available in monetary units (except for a few rare aggregated tables) and often the monetary unit varies for different countries. For EXIOPOL, the Euro will be the most common currency unit covering about 13 EU countries. A common approach to match tables is to convert them to a common currency, but this often misrepresents physical flows.

Due to price variations of products across countries it is desirable to represent those sectors in a physical unit[7]. As an example, representing electricity consumption in joules is more reliable than using monetary units. However, electricity prices not only vary between countries, but also between sectors within a country (see section 6.5.1). To realistically capture the electricity sector requires collecting physical data on electricity consumption by sector for each country. This needs to be repeated for all sectors that are best represented in physical units. An additional issue is that physical unit tables might require some disaggregation from the monetary counterparts since the product mix in a

[7] Often, arguably the most appropriate physical unit will be monetary, for example, in service sectors.

given economic sector might be very heterogeneous physically. Given the limited resources of EXIOPOL it is unlikely that the underlying SUT and IOT will be constructed in mixed units, with perhaps the exception of one or two environmentally significant sectors.

Given the problems of constructing SUT and IOT in physical units, a next best approach is to estimate physical units using sector price data[8]. This approach would involve converting a given sector in each country to physical units using price data, such as the price of electricity[9]. This method would assume each country retains the same use structure based on the monetary tables, but converts the entire use row into a physical unit to allow international comparisons. Since it is sector-based, each country would have a price vector for the conversion process, that is, each sector has a different price.

With this general price-vector formulation the database still retains the flexibility of using purely monetary tables. If the analyst wishes to retain monetary units for all sectors then the price vector would simply represent the Market Exchange Rate (MER) for a common currency, such as Euro. Note that the MER would be used and not the Purchasing Power Parity (PPP) which compares countries on a specified bundle of consumed products.

To retain some flexibility for potential uses of the EXIOPOL database it is important that the database structure allows for a price vector to convert to a common currency. A price vector retains consistency with the IOA assumption of uniform sector prices and allows conversion to physical units if necessary. This formulation easily simplifies to the more specific case of converting all the SUT and IOT to a common currency unit.

5.3.3 Common base-year

Often the problem arises where the SUT or IOT is valued at a different base-year then required by EXIOPOL. In these cases the SUT and IOT need to be scaled up or down to match the EXIOPOL base-year. This assumes that technology is constant between the SUT and IOT base-year and the EXIOPOL base-year.

A promising approach is given in the ESA Input-Output Manual (Eurostat 2002), which was applied by (Rueda-Cantuche, Beutel et al. 2007) in their work on developing a symmetric IOT for the EU. Official relevant information of macro-economic forecasts (GDP, imports, added value by industries and final demand) is used as exogenous input in an iterative procedure. Rueda Cantuche et al. opted for this approach, since it uses limited data and has a potentially high degree of automation compared to other more elaborated methods described in literature (Eurostat 2002). Column and row vectors for intermediate consumption and final demand are derived as endogenous

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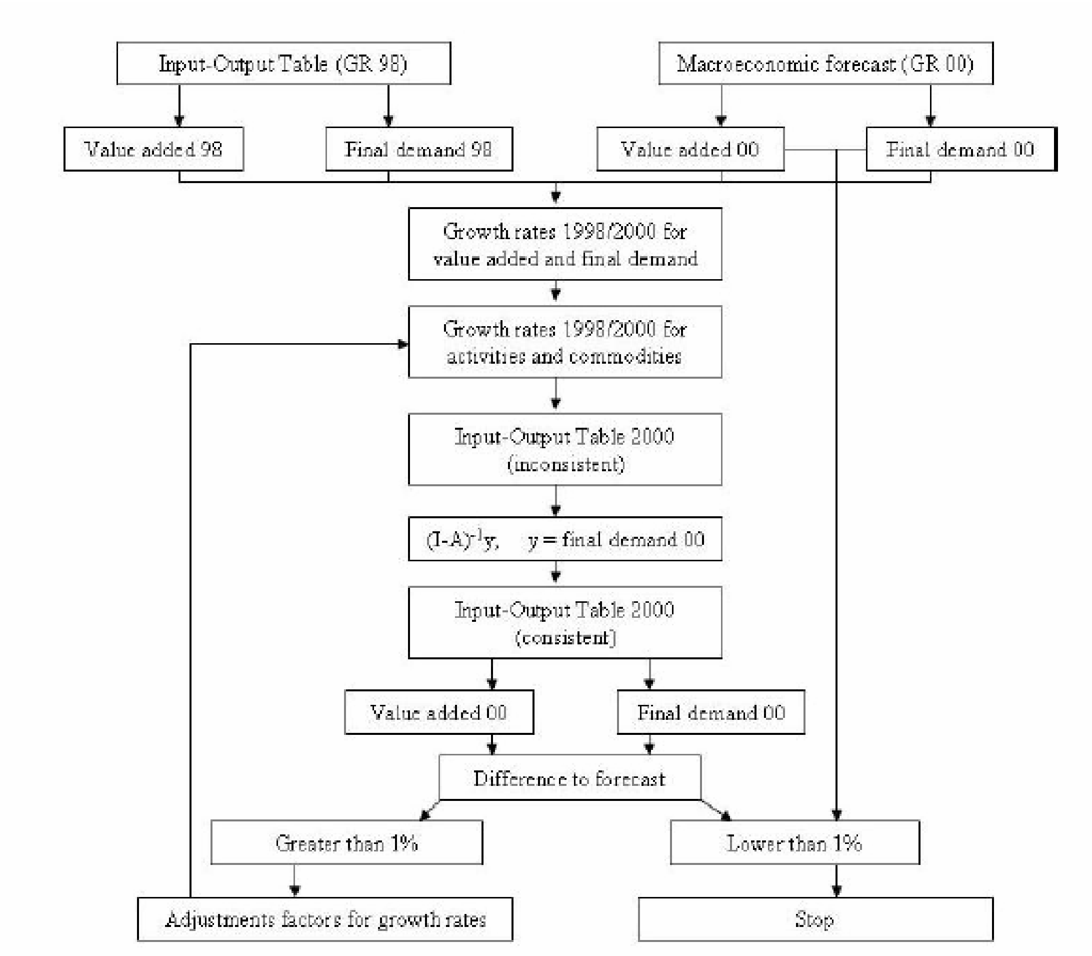
[8] If the data was collected in physical *and* monetary units there would be an underlying price "matrix". This conflicts with the underlying assumption in IOA of uniform sector prices Weisz, H. and F. Duchin (2006). "Physical and monetary input-output analysis: What makes the difference?" Ecological Economics **57**(3): 534--541..

[9] While similar to puchasing power parity (PPP) concepts, this actually differs as published PPP refer to aggregated consumption bundles and not individual products.

variables, rather than accepted as exogenous variables from unspecified sources (Eurostat 2002).

The approach we propose for EXIOPOL is to use the Eurostat method for the EU27 countries where we don't have data for the right base year (for 2000, this problem only exists for Greece). For the non-EU countries, data availability will determine if we may be forced to use simpler approaches, such as a simple scaling of the tables to match GDP in the EXIOPOL base-year (as performed in GTAP; Dimaranan 2006).

Figure 1: Eurostat's method for projection of SIOTs (taken from: Rueda-Cantuche et al., 2007).



5.3.4 Re-exports

Some countries act as trading points where they import products and then re-export them without further processing. However, often value is added to the product for providing the "warehousing" services. Countries which are most affected by this include Hong Kong, Singapore, and the Netherlands. For EXIOPOL the Netherlands is particularly important. While the Netherlands theoretically does not include re-exports under its reporting schemes, considerable differences exist between reported trade data. This is primarily due to ambiguity in how products should be allocated (Dimaranan 2006). Where re-export activity causes substantial differences between statistical sources, corrections are required. Dutch members of the EXIOPOL team have looked into this issue in earlier work, and adjustments will be made on the basis of that experience where needed.

5.3.5 Separating domestic and imported products

Some countries do not separate the use of domestically produced and imported products. In these countries estimates are required to make the separation. In the absence of additional information, a simple proportionality assumption can be used whereby it is assumed that in each sector a fixed share of imported products are used based on the import data.

5.3.6 CIF and FOB adjustments

This description is drawn from the OECD IO database (Yamano and Ahmad 2006):

"For some countries specific adjustments are required to deal with valuation differences in imports. In the United States, France and Brazil for example imports of goods are valued at c.i.f prices (*i.e.* including cost, insurance and freight), as they should be, but with negative adjustments made to the imports of insurance and freight services (water transport only for France and transport more generally for Brazil) to correct for these services provided by resident producers (whose value is reflected in the c.i.f price of the imported product). Applying the proportionality method in this case to derive the import use matrix can lead to negative imports of these services however and so instead these negative values are removed from exports."

5.3.7 FISIM

This description is drawn from the OECD IO database (Yamano and Ahmad 2006):

"The allocation of financial intermediation services indirectly measured (FISIM) is treated differently across countries. For their most recent tables Australia, Japan, Canada, China, India, Indonesia, Chinese Taipei and the United States allocate imputed bank service charges directly to purchasing sectors, including, in some cases, households. EU countries have recently begun to adopt this process in their national accounts but the input-output tables received by the OECD do not yet reflect these changes – FISIM is instead shown as a separate column in their national input-output and supply-use tables; or as intermediate consumption of the finance industry (ISIC 65) with a corresponding deduction from gross operating surplus and value-added of the same industry."

"For analytical purposes, and harmonisation, FISIM in the OECD database has been allocated separately to consuming industries as intermediate consumption of financial services, on the basis of each industry's share of total gross value-added for all countries (except those where FISIM has already been allocated), but not including the household and government sector. Value added in each industry is reduced by a corresponding amount. This treatment is consistent with the approach used in the 2002 edition of the IO Database. SNA93, of course, recommends that FISIM should be allocated to all consumers; including final demand; however the information to do this is not readily available, in any case, doing so would lead to estimates of GDP and gross value-added that differed from those published by NSIs."

It is suggested the same approach be taken for EXIOPOL.

5.3.8 Balancing with RAS

When completing the database of SUT and IOT situations may arise where the tables become unbalanced. The RAS procedure can be applied to rebalance the tables. The disadvantage of the RAS procedure is that it may adjust cells that have a high degree of certainty. Based on this, is recommended that EXIOPOL first attempt to perform manipulations without upsetting the balance of the tables and to use RAS only as a last resort. If RAS is required, the degree to which it modifies individual cells needs to be clearly documented.

5.4 Options for detailing existing SUT or IOT data sets

5.4.1 Introduction

Disaggregation of environmentally relevant sectors or sectors under investigation may be desirable to improve the model results. A good example of this is the GTAP detailing of agriculture into 12 sectors and food products into seven sectors. While any sectors can be potentially detailed, the use of too many assumptions to perform the detailing may in fact increase uncertainty. Detailing generally requires a trade-off between aggregation error in the original aggregated data and increased uncertainty in the detailed data. For instance, the GTAP aggregation of land transport and ancillary transport services will lead to a large aggregation error for environmental issues. On the other hand, disaggregation may introduce new errors if crude assumptions are used to perform the detailing. Particularly given the likely workload to detail sectors, detailing should only be performed when it is necessary and when decent data is available. The sectors to detail should be motivated by both the EXIOPOL applications and improving the accuracy of environmental studies.

From earlier studies it has become obvious that agriculture and food, energy and mining, and waste management usually are highly aggregated in SUT and IOT where the environmental impacts of underlying sub-sectors can differ substantially (Nijdam, Wilting et al. 2005; Weidema, Nielsen et al. 2005; Tukker, Huppes et al. 2006). For instance, fishery, meat production and crop production often are part of one agricultural sector, but have very different emission or resource use patterns. The DoW for EXIOPOL hence already suggested the following list of sector for detailing in EXIOPOL includes:

1. Agriculture and food (probably about 10 viz 5 extra sectors))
2. Mining and raw materials (needs to be differentiated between the 8-10 most relevant primary resources: Oil, gas, coal, iron, aluminium, copper, some others)
3. Energy intensive metals production (needs to be differentiated between about 5 metals)
4. Electricity (needs to be differentiated by generation: fossil, nuclear, hydro, renewables)
5. Transport (if not divided between modalities and person and freight transport)

6. Waste management (needs to be differentiated at least between landfill, incineration, recycling)

In many instances, the detailing may amount to converting the relevant sectors into physical units.

5.4.2 Approaches and available data sets

The approach for realising further detail will be developed further in the project on a country by country basis, pragmatically using available statistics. We will give here the main lines of the strategy to be followed.

First, for some countries it will not be necessary to create additional detail. The original SUT or IOT can have sufficient detail in themselves (which probably is the case with the US and Japan, who publish SUT or IOT with about 500 sectors or products).

Second, as a very crude approach it will always be possible to copy the approach used in EIPRO (Tukker, Huppes et al. 2006) by using technology transfer assumptions from countries that have SUT and IOT at the required level of detail. Particularly for countries that are likely to have a similar technology structure, this assumption should not lead to too much distortion.

Third, more sophisticated approaches would use additional statistics to create additional detail, specifically per country. Per sector or product group, we see the following possibilities

1. Agriculture and food. IPTS is currently working on a considerable improvement of the EUS95 tables in this field, for use in the GTAP database. Results are available end 2008 and probably can be used in EXIOPOL. For non EU countries, it will probably be possible to differentiate between animal farming, agriculture and fishery and probably further sub-divisions on the basis of FAO statistics, and information about agricultural land use per country.
2. For detailing mining and primary materials extraction much of the necessary data is collected as a part of the EXIOPOL work on environmental extensions. The databases on primary material extraction of Wuppertal Institute and SERI will give very good insight what primary materials are extracted per country. For most countries the mining sector just will have to be split up in 2 or 3 sub-sectors since other materials will not be extracted in that country, leading to zero's in the SUT and IOT for the extraction process of that material.
3. Electricity mixes and the related division of electricity production probably can be estimated on the basis of IEA statistics.
4. Transport is in most cases already well split up in modalities and personal/freight transport; again, additional transport statistics may be a way of further detailing.
5. For waste management, EEA gives basic insights per EU member state about the ratio between landfill, incineration and recycling, and sector of origin of waste. For specific non-EU countries such data may be harder to get, and expert judgement may be the only solution.

6 Data verification and cross-checking

6.1 Introduction

Even though there are increasing reporting standards with manuals on construction and presentation of national accounts, it is likely that variations still remain across countries. According to Eurostat there is already considerable variability between the SUT submitted by different countries (personal communication with Eurostat). Individual countries may use different definitions for products and industries, may treat secondary production differently, and there may be inconsistencies between the methods used for the SNA and NAMEA reporting. This section will highlight a few of these issues and areas where data consistency needs verification.

6.2 Cross-country comparisons of SUT and SIOT

The SUT and IOT should have variations due to different regional technologies; however we do not if the regional variations will be swamped by different NSI methodologies and empirical uncertainty. The degree to which variations exist between reported data should at least be checked. Post analysis it is possible to analysis if the variations represent realistic regional differences in technology or data anomalies.

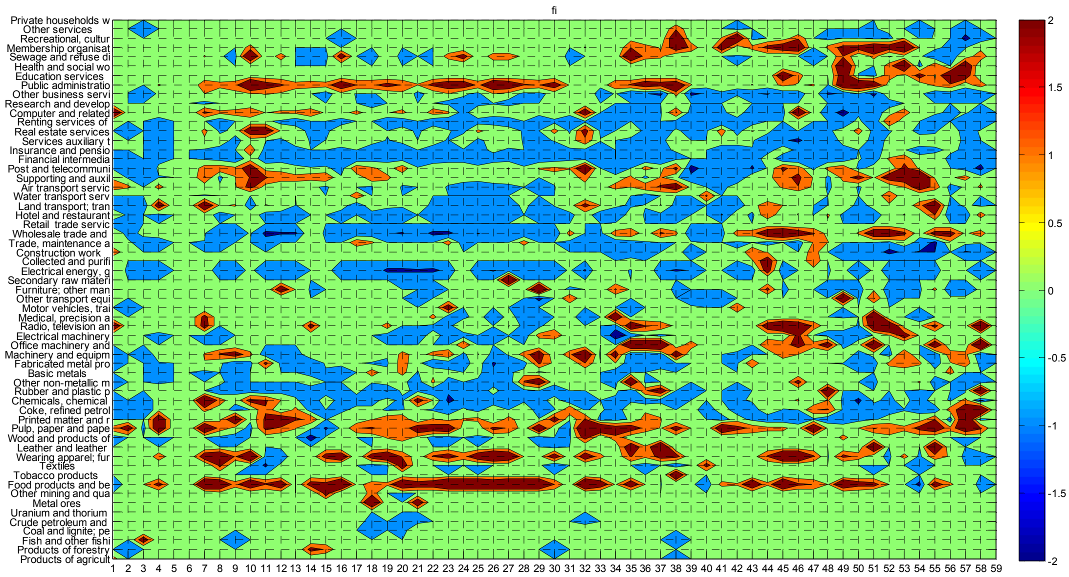
To highlight the possible variations we have used a preliminary version of the IPTS EU25 database (Rueda-Cantuche, Beutel et al. 2007). For the comparisons we used the total flows for each of the EU25 countries to construct technology matrices. Based on the sample of 25 EU countries we then constructed the mean and standard deviation for the sample. For each country we then plotted the distance of A_{ij} from the mean,

$$V_{ij} = \frac{\left(A_{ij} - B_{ij}\right)}{\sigma_{ij}} \qquad (23)$$

where A is the estimated table, B is the mean (reference table) and σ is the standard deviation of the sample. To avoid noise from small numbers we only considered elements where $A_{ij} > 10^{-3}$. Figure 2 shows a sample for Finland. While the labels are too small to read, the relevant message is easily extracted. The green shades represent zero difference, which in this case usually is forced by our criteria that $A_{ij} > 10^{-3}$. The other shades represent the number of standard deviations from the EU mean, for instance, dark red is more than two standard deviations from the mean. It is worth noting that Finland is by no means an outlier. Interestingly some sectors show considerable variations, and in the case of Finland the variations occur in the rows. This means that in Finland, most industries purchase significantly more than EU average from "Food products and beverages", "Public administration", "Wearing apparel", and so on. They buy less from sectors such as "Electrical energy". The manufacturing sectors buy less of "Wholesale and retail trade" while the services sectors buy more relative to the EU average.

It is reasonable to ask whether these variations in Finland represent realistic technological differences which are worth investigating or whether they represent empirical issues such as uncertainty, reporting differences and so on.

Figure 2: The number of standard deviations between the Finnish interindustry coefficients and the EU mean. Only elements where $A_{ij} > 10^{-3}$ were considered. More details in the text.



A problem with using a simple statistical comparison of tables is that large differences in small coefficients can dominate the results. An alternative approach used by GTAP is the entropy difference (Walmsley and McDougall 2007),

$$E_{ij} = \tfrac{1}{2}\left(S^{A}{}_{ij} - S^{B}{}_{ij}\right)\ln\left(\frac{S^{A}{}_{ij}}{S^{B}{}_{ij}}\right) \tag{24}$$

where

$$S^{A}{}_{ij} = A\left(1-\varepsilon\right) + B\varepsilon \tag{25}$$

$$S^{B}{}_{ij} = A\varepsilon + B\left(1-\varepsilon\right) \tag{26}$$

and A represents the estimated table, B represents the reference table (mean of the sample of tables[10]), and ε is small number to include zeros and balance comparisons between two small coefficients and two large coefficients. Figure 3 shows the results for Finland with $\varepsilon=0.1$. By sorting the results from the entropy method it is possible to prioritize which data to check. The biggest entropy differences for Finland are shown in Table 10 with the table also indicating the

[10] Initially the mean of the sample was taken since it was compared to the standard deviation. However, in the case of the entropy method it would make more sense to compare with the coefficients derived from the total flows in the EU.

significance of the results. For instance, the highest entropy difference is for the path “Chemicals” to “Metal ores”. In Finland (second last column) this transaction represents 27% of costs, while in the EU average the costs represent only 3%. Similarly, the second highest entropy is for the self-purchase of electricity by electricity and this represents 1% of the costs in Finland, but 16% in the EU-average. The remainder of the table shows the significant comparisons that may exist between Finland and the EU average.

Figure 3: The entropy approach applied to Finland. See text for a description.

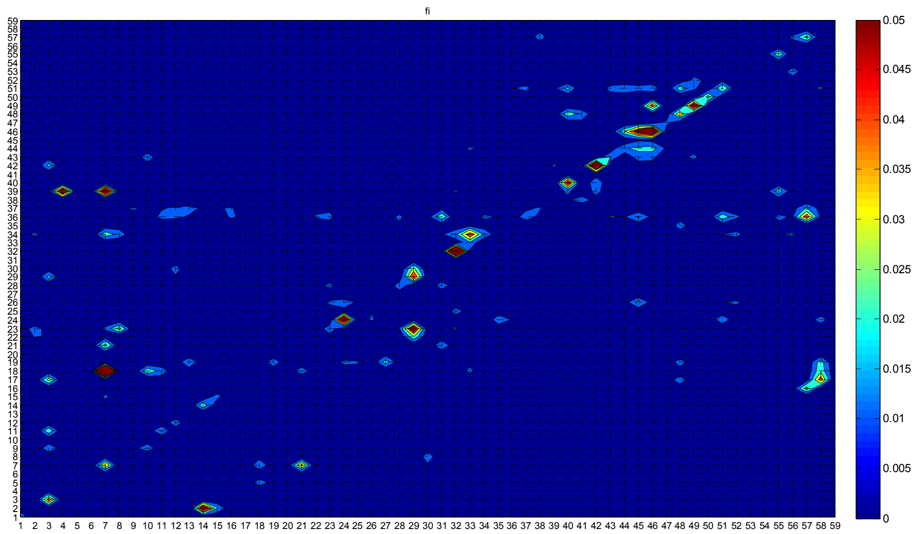


Table 10: The five largest Entropy results for Finland.

	From sector	To sector	Entropy	A	B
1	Chemicals, chemical products and man-made fibres	Metal ores	0.158189	0.274882	0.026119
2	Electrical energy, gas, steam and hot water	Electrical energy, gas, steam and hot water	0.111761	0.006133	0.153604
3	Supporting and auxiliary transport services; travel agency services	Supporting and auxiliary transport services; travel agency services	0.084587	0.010931	0.137775
4	Services auxiliary to financial intermediation	Services auxiliary to financial intermediation	0.082905	0.002118	0.104148
5	Office machinery and computers	Office machinery and computers	0.075554	0.520373	0.228124

The comparisons show that there can be considerable variation between values. The entropy approach is probably preferable since it accounts for the different absolute value of the coefficients (comparing two small coefficients or two large coefficients). Perhaps a more important question is what should be made of the differences between the coefficients? It would be a time-consuming task to cross check all possible “errors”, certainly some of the errors may in fact be realistic regional technology differences.

6.2.1 MRIO modelling with GTAP

To construct the MRIO model using GTAP the bilateral trade was split between industry and final demand using the information in the imports IOT (Peters and Hertwich 2006). Using this method, variations in the share to industry and final demand becomes important and this drives the results of the MRIO model. For instance, you would expect that the import of non-ferrous metals goes primarily to industry while the import of clothing goes primarily to final demand. This is type of result is roughly true for many sectors and countries, but in many sectors there are huge variations. For instance, imports of one product might be 90% to final demand in one country and 10% in another. The degree to which this varies across countries needs consideration.

6.3 Product mixes

Different countries might produce different product mixes within the same industry classification. This aggregation related problem may make it appear that one country is worse than the other in one sector, when in reality they are producing different products. We follow the example of steel used in the OECD study (Ahmad and Wyckoff 2003), "a high emission factor for a product in one country compared to another does not necessarily imply that the product, or production process, is more carbon-intensive. The comparison requires that an industry in any country produces the same mix of goods as the same industry in another country and charges the same price, and it is difficult to determine this from the data alone. That said, in heterogeneous industry groupings, such as 'other metal products, machinery and equipment' (ISIC28-32), it seems unlikely that these conditions will be satisfied. For example steel industry products are extremely varied, ranging from pig-iron products to specialised stainless steel say (see Paragraphs B21-33); moreover a tonne of steel produced in Russia is cheaper than a tonne of equivalent steel produced in the United Kingdom, say."

The problem is compounded by two issues. First, it is more pollution intensive to produce pig-iron compared to processing pig-iron into stainless steel. Second, the cost of the pig-iron is less than that of stainless steel. Thus if a developing country exports pig-iron to the EU and the EU produces stainless steel it appears that the EU is significantly cleaner when in fact it may not be.

The ideal approach to deal with this situation is to use physical units with a suitable aggregation (say a pig-iron sector and a stainless steel sector). This will be unlikely primarily due to time constraints sourcing the necessary data. Another approach is to use regional prices for each sector (section 5.3.2). As an example, the export price of unwrought aluminum in 2000 varied considerably across regions[11] (in kg/US$); Norway 1.73, Sweden 1.70, United Kingdom 1.61, United States 1.44, Germany 1.67, Denmark 1.42, Japan 2.55, and China 1.45 (Peters and Hertwich 2004). The regional prices can be used to construct "proxy" physical units. However, the example of the steel also highlights an aggregation problem – pig-iron and stainless steel in one sector – which will also bias the results.

While product mix variations within a sector will affect the results, there is probably little that can be done about it, particularly given the aggregation levels in EXIOPOL. If a sector is environmentally important, then consideration should be given to further detailing (see section 5.4).

[11] These data are for a different study and only includes the countries for that study. It did not calculate the price in, for example, Russia and Australia.

6.4 Inconsistencies between SNA and NAMEA

There are several issues with the reporting of SNA and NAMEA data. NAMEA data is often drawn initially from energy statistics which has a territorial system boundary, while SNA has an economic system boundary (Pedersen and de Haan 2006). This primarily presents issues with international activities such as transportation and tourism. Since different agencies or departments collect NAMEA and SNA data, there may be variations in definitions and estimation methods. In addition, energy statistics are usually collected in a different classification system compared to the SNA. The main motivation of this section is to discuss consistency between the SNA and NAMEA. It should be noted that inconsistencies also arise due to variations in product mixes, product quality, definitions, secondary production, allocation, etc. While NAMEA and SNA inconsistencies may arise in many sectors, these section focuses on pulp and paper production in Scandinavia and international transportation.

6.4.1 Pulp and paper in Scandinavia

Pulp and paper is, at the aggregate, the second most polluting industry in Finland, Sweden, and Norway (electricity is first). Pulp and paper represents 16% of CO_2 emissions in the three countries (Finland 31%, Sweden 10%, and Norway 1%). A comparison of the NAMEA and SNA data for these three countries in 2000 is shown in Table 11.

Table 11: A comparison of the direct emissions in the pulp and paper industry in Finland, Sweden and Norway.

	Finland	Sweden	Norway
CO_2 (1000t)	23,650	5,452	340
Output (MEUR)	15,889	13,543	2,509
Direct Intensity (kg/EUR)	1.49	0.40	0.14
Indirect Intensity (kg/EUR)	2.4	0.66	

According to Table 11 Finland was the most polluting pulp and paper industry in the year 2000 producing 3.7 times more CO_2/EUR than Sweden and 11 times more than Norway (direct emissions only). Similar numbers are found for the indirect emissions. While the energy mix of the individual countries will be reflected in the indirect emissions, it is not as crucial in the direct emissions particularly if the pulp and paper industry purchases electricity (see below). In terms of output Finland and Sweden produce the same, but the emissions are considerably different. This could represent realistic issues such as differences in product mix, production technology, and so on. However, it is generally agreed that Finnish and Swedish pulp and paper production is comparable. It is claimed that the inconsistency in the SNA and NAMEA data is due to secondary production of electricity: “Finland’s relatively lower emissions efficiency can possibly be explained by the fact that the Finnish paper and pulp industry often own and operate their own power plants instead of purchasing power from others. The emissions from these power plants are therefore included in the emissions for NACE 21 [Pulp and paper] in Finland whereas in the other Nordic countries these emissions are found elsewhere. This can be one explanation for the high levels of emissions from Finland” (Hass 2000).

If the high Finnish emissions are due to secondary production then this should be reflected in the SUT. According to Eurostat's SUT, 3% of Finnish pulp and paper output is in the electricity sector, while for Sweden it is 1%. In addition, if Finnish mills produced their own electricity, then they would presumably use less electricity. According to the SUT Finland uses more electricity as a fraction of total product use: 6.3% of total use, 6.1% for Norway, and 4.3% for Sweden. Further emphasizing this point is that the indirect emissions would be expected to pick up differences in who produces electricity (for instance, if the IOT purchases electricity then the first tier in a power series expansion will show the emissions for electricity use). At least in the SUT, it does not seem that secondary production is the key issue, unless it has been manually adjusted.

Another possible explanation is different methods of allocation for energy use in the pulp and paper industry in the SNA and NAMEA. For instance, the NAMEA data may show the total emissions from the pulp and paper industry (regardless of the product they produce), while the SUT has been pre-adjusted.

Investigating pulp and paper was just one relevant sector which had been discussed in the past as showing counter-intuitive results (Hass 2000). It is worth investigating the degree to which these inconsistencies exist in other sectors and if they are problematic. Applying entropy methods as discussed earlier across both the SNA and NAMEA is one possibility worth investigating.

6.4.2 International transportation

International shipping is a known problem when comparing SNA, IPCC, and NAMEA data (Pedersen and de Haan 2006). The SNA allocates international shipping according to residential institutions. Thus if a Norwegian company provides shipping services between Singapore and the US, the economic activity is allocated to the Norwegian shipping company (hence Norway's national accounts). Energy data is constructed using different definitions. Historically, energy balances have been constructed on a territorial basis (IEA 2005). Sales of fuel for international transportation – bunker fuels – are allocated to the country that sells the bunker fuel (bunker sales). The buyer of the fuel is not reported. In the IPCC emission inventory, bunker sales are reported by the country selling the bunker fuel but they are not allocated to any country. For NAMEA reporting it is requested that countries report the bunker use by residential institutions as in the SNA. Table 12 shows the IPCC to NAMEA bridge table for Norway.

Table 12: The bridge table between the Norwegian NAMEA and IPCC data.

	CO_2 (Mt)	Addition	Comment
IPCC without land-use	40.8	(1)	Reported to UNFCCC (territorial)
Bunker Sales	3.6	(2)	Reported to UNFCCC, but not allocated
Bunker Use: International transportation	13.9	(3)	Not reported to UNFCCC, allocated for NAMEA
NAMEA total	54.7	(4)=(1)+(3)	Correct NAMEA total

As seen in Table 12 the difference between the IPCC and NAMEA definitions can be substantial. In the case of Norway, 25% of the NAMEA emissions are from international transportation (primarily international shipping). Unfortunately, some countries do not report the correct NAMEA data. For instance, a country might report the IPCC total instead of the NAMEA total. The difference between the IPCC and NAMEA data will be significant for countries with either large bunker sales (eg, the Netherlands) or countries with large international shipping activities (eg, Norway).

Table 13: A comparison of NAMEA and SNA data for water transport.

Country	NAMEA Mt CO_2	Output MEUR	Intensity kg/EUR	Estimated Mt CO2
Belgium	424	2,244	0.19	3,117
Denmark	19,874	12,533	1.59	17,409
Germany	949	11,356	0.08	15,775
Spain	1,997			
Italy	16,738	15,075	1.11	20,941
Netherlands	9,159	4,688	1.95	6,512
Finland	302	1,622	0.19	2,253
Sweden	4,913	3,599	1.36	4,993
Austria	55	108	0.51	150
Norway	14,985	11,442	1.31	15,894

Table 13 shows a comparison of the NAMEA emissions data and the SNA output data for Water Transport (NACE 61). From other data sources and personal communication we know that Norway and Denmark report international transportation, the Netherlands matches with other sources[12], Sweden seems to report (Hass 2000), and Finland states that it does *not* report international transportation in NAMEA communications. Finland should report approximately 1,500 Mt CO_2 (Hass 2000). Based on the magnitude of the value for Italy, it appears that international transport is also reported.

One method to deal with the lack of reporting of international transportation is to estimate it using the emission intensity based on reported data. Using the countries that report international shipping – Denmark, Italy, Netherlands, Norway, and Sweden – the emission intensity would be 1.39 kg/EUR. This emission intensity can then be applied to the output to estimate the emissions from the countries not reporting (last column in Table 13). For example, Germany would be allocated 16 Mt CO_2.

There two key problems with this approach. First, it assumes that each country has approximately the same technology and product mix for international transportation. This assumption seems reasonable, particularly given that the costs of shipping a dominated by fuel costs, and hence technology which is relatively uniform. Second, the water transport sector also includes domestic water transport which may be significant for some countries. In effect this makes the domestic water transport more pollution intensive and international shipping less pollution intensive. This same aggregation problem arises in other sectors – for example, pig-iron and stainless steel. The only way to avoid this problem is to disaggregate the sector.

[12] Table 1 in http://www.esri.go.jp/jp/archive/hou/hou020/hou20-2b-1.pdf

6.5 Reporting inconsistencies between NAMEA and SNA

Various reporting inconsistencies may exist between the NAMEA and SNA data sets. These inconsistencies may arise due to different reporting conventions between energy and the SNA. Further, different departments may construct different data sets. Depending on the communication between the two agencies, inconsistencies may arise.

6.5.1 Electricity data

For a variety of reasons, different users of electricity pay different prices[13]. Table 14 shows statistics from the Norwegian IOT and NAMEA data from 1990 to 2002. The average price is obtained by dividing the total electricity in basic prices by the total electricity consumed (excluding households). These prices are comparable to the wholesale price. The mean, standard deviation, and coefficient of variance[14] are based on sectoral prices in the 64 industry sectors considered. A large coefficient of variance (greater than one) shows that the standard deviation is greater than mean! That is, there is considerable variation in the price paid by different users of electricity. This violates a key assumption of IOA – namely, sectoral prices are constant (Weisz and Duchin 2006).

Table 14: Statistics on electricity prices inferred from the Norwegian IO and NAMEA data (Øre/kWh).

	Average Price	Mean	Standard Deviation	Coefficient of Variance
1990	10.3	21.7	37.4	1.7
1991	11.4	20.8	29.1	1.4
1992	10.5	21.9	30.7	1.4
1993	10.2	19.7	30.4	1.5
1994	9.9	17.0	15.6	0.9
1995	12.4	18.5	15.9	0.9
1996	15.2	25.2	28.6	1.1
1997	16.7	25.7	25.3	1.0
1998	15.7	23.8	26.8	1.1
1999	15.6	23.7	24.6	1.0
2000	16.8	26.4	31.1	1.2
2001	25.0	51.0	88.9	1.7
2002	26.5	48.2	69.7	1.4

The only real way to circumvent this problem is to use physical units. Energy consumption data, hopefully by different energy types, should be available for EXIOPOL, at least for EU countries. This gives the opportunity to convert the relevant sectors to physical units and this in turn makes the SNA and NAMEA data consistent.

As an aside, it is worth noting the approach taken by GTAP. They take preference for the IEA energy data and overwrite the IOT energy sectors by converting the IEA energy data to monetary units using energy price data. The

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13 http://www.ssb.no/english/subjects/10/08/10/elektrisitetaar_en/tab-2007-05-24-20-en.html

14 The coefficient of variance is the ratio of the standard deviation to the mean.

goal of this process is to obtain consistency between the IOT and energy statistics (Dimaranan 2006).

6.5.2 Reporting inconsistencies

While making comparisons between Scandinavian countries a few inconsistencies in the Finnish data were noted. The Finnish NAMEA data shows no CO_2 emissions for the sector "Manufacture of radio, television and communication equipment and apparatus", but according to the IOT Finland produced 18,790 MEUR of output in that sector (making it the second biggest sector in Finland). While the emissions may be captured indirectly through the IO multipliers, it may represent reporting errors or differences in methodology between Finland and other countries.

7 Overall conclusions and recommendations

7.1 Introduction

A main conclusion is that we should not get overly focussed on the issue of availability. It is not *the* key issue that poses the risk to EXIOPOL. As other studies have shown, the GTAP and the OECD database in particular, is that data *is* available. It is just that the data is in different formats, based on different definitions, classifications, prices, resolution, base-years, etc, etc. The main task for EXIOPOL is harmonizing all these issues – which is at least technically possible. In this, three issues are of key importance that we now will discuss further in this concluding section

1. To use SUT or IOT as the core of the database
2. The countries to include in the database, and primary data sets to be used
3. How to deal with the key transformation and harmonization issues.

7.2 Choosing SUT or IOT

The format of the ESA data places constraints on the choice between SUT or IOT for the EU27. Similar issues arise in the RoW data. The Eurostat Use Table is in purchaser prices, while the remainder is in basic prices. Thus, to convert the use table into basic prices, or to construct IOT from the Eurostat SUT, one needs to:

- Take trade and transport margins out of the Use Table
- Take taxes and subsides out of the Use Table
- Split the Use Table into domestic and import components
- Decide on a method of allocating secondary production

On the other hand, the Eurostat IOT are already in basic prices implying that no additional manipulations are needed. Further, most NSI use additional information and more disaggregation when converting the SUT to IOT. Thus, it is unlikely that a data user can construct an IOT better than a NSI based on the published ESA SUT.

Given the uneven distribution of availability of SUT and IOT from ESA (SUT are published more frequently) there may be advantages to using the SUT instead of the IOT. The advantages of using the SUT to construct our own IOT is that we know the assumptions used and have greater flexibility in the years. However, due to the ESA valuation of the use table (purchaser prices) we need to estimate margins, taxes, and import shares. If using the IOT directly from ESA we have the advantage that the NSI have constructed the data using additional in-house data unavailable to the general user. The disadvantages are that less IOT data is available and we do not know the assumptions that the NSI may have used to construct the data.

In the interests of data quality, preferences should be given to using the NSI constructed IOT where available. However, given this is not available for all countries and years, some method of transformation between SUT and IOT is required. A likely option is that given the incomplete SUT and IOT availability, the SUT and IOT data will be made complete in EXIOPOL by using various transformations between SUT to IOT and IOT to SUT.

7.3 Selection of countries and data sets to be used

For the EU27, we propose to take the Eurostat ESA95 SUT (rather than national tables) as a basis, due to the harmonisation already performed by the respective NSI.

For the Rest of the World, on the basis of criteria like GDP and trade with Europe we propose to include at least 15 other countries in the database (US, Japan, China, Canada, Korea, Brazil, India, Russia, Australia, Switzerland, Turkey, Taiwan, Norway, Indonesia and South Africa). In principle, we will aim to source SUT and IOT directly from NSI rather than using secondary (if even harmonized) sources like OECD or GTAP. The main advantages are a better level of transparency, less problems in realising a good sector or product detail for some countries that already have detailed tables, etc.

A danger of this approach is that we will miss industries in other countries with low added value, high volume processes that generate a high environmental pressure. Yet, from our inventory it became clear that many other countries with significant trade with Europe or GDP in fact are resource producing countries. Rather than inventorying and harmonizing full SUT or IOT, we may model the most relevant sectors in such countries as a true Rest of World. This will also ensure that many impact-intensive processes are covered in our database.

7.4 Transformation and harmonization of data and quality control

The process of bringing the primary data into the harmonized EXIOPOL format requires various transformation and harmonization steps, for instance dealing with confidential data, harmonizing sector and product classifications and monetary units, scaling up or down to a common base year, ensuring that all data are in the same price type (basic prices), etc. Chapter 5 lists over a dozen of such harmonization issues, and does a first proposal for an approach of dealing with them. We usually opted for pragmatic, time-lean, and robust approaches that probably can be easily automated. We refer to Chapter 5 rather than duplicating the main conclusions drawn there. It is likely that in practice the method may be adjusted or adapted to the experience with the factual data situation once the harmonization work has started.

Finally, the report pays attention to data verification and cross checking methods. The whole idea behind discerning different countries is that they may have different technology structures. Cross country comparisons of SUT and SIOT are proposed to identify the most significant differences, and to see if there is a logical explanation for them other than statistical artefacts and other anomalies

List of references

Ahmad, N. and A. Wyckoff (2003). Carbon dioxide emissions embodied in international trade of goods, Organisation for Economic Co-operation and Development (OECD).

Dimaranan, B. V., Ed. (2006). Global Trade, Assistance, and Production: The GTAP 6 Data Base, Center for Global Trade Analysis, Purdue University.

European Communities (1996). European System of National Accounts (ESA 95).

Eurostat (2002). The ESA 95 Input-Output Manual – Compilation and Analysis European Commission.

FEEM and TNO (2006). EXIOPOL. A New Environmental Accounting Framework Using Externality Data And Input-Output Tools For Policy Analysis. Description of Work., FEEM: Italy, TNO: Netherlands,.

Hass, J. (2000). Nordic Environment-Economic Indicators: Nordic Natural Resources and Environment Accounts -- Part III, TemaNord 2000:515.

IEA (2005). Energy Statistics Manual, Organisation for Economic Co-Operation and Development and International Energy Agency.

Lenzen, M., L.-L. Pade, et al. (2004). "CO_2 multipliers in multi-region input-output models." Economic Systems Research **16**(4): 391-412.

Lenzen, M., L.-L. Pade, et al. (2004). "CO$_2$ multipliers in multi-region input-output models." Economic Systems Research **16**(4): 391--412.

Meyer, B., C. Lutz, et al. (2007). "The Global Multisector/Multicountry 3E-Model GINFORS. A Description of the Model and a Baseline Forecast for Global Energy Demand and CO_2-Emissions." International Journal of Global Environmental Issues **Forthcoming**.

Miller, R. and P. D. Blair (1985). Input-output analysis: Foundations and extensions, Englewood Cliffs, NJ, Prentice-Hall.

Neuwahl, F., F. Duchin, et al. (2007). Technical Report On Specifications Of The Database In View Of The Desire To Link It With Existing Models. Seville, Spain, IPTS.

Nijdam, D. S., H. C. Wilting, et al. (2005). "Environmental load from Dutch private consumption: How much pollution is exported?" Journal of Industrial Ecology **9**(1-2): 147--168.

Pedersen, G. O. and M. de Haan (2006). "The System of Environmental and Economic Accounts--2003 and the Economic Relevance of Physical Flow Accounting." Journal of Industrial Ecology **10**(1--2): 19--42.

Peters, G. P. (2007). Opportunities and challenges for environmental MRIO modelling: Illustrations with the GTAP database. 16th International Input-Output Conference, Istanbul, Turkey.

Peters, G. P. and E. G. Hertwich (2004). Production factors and pollution embodied in trade: Theoretical development, Industrial Ecology Programme, Norwegian University of Science and Technology.

Peters, G. P. and E. G. Hertwich (2006). "Pollution embodied in trade: The Norwegian case." Global Environmental Change **16**: 379--389.

Peters, G. P. and E. G. Hertwich (2006). "Structural analysis of international trade: Environmental impacts of Norway." Economic Systems Research **18**(2): 155--181.

Peters, G. P. and E. G. Hertwich (2006). Trade and the Environment: Implications for Climate Change Policy. Ninth Biennial Conference of the International Society for Ecological Economics on Ecological Sustainability and Human Well-Being, New Delhi, India.

Peters, G. P. and E. G. Hertwich (2007). The Application of Multi-Regional Input-Output Analysis to Industrial Ecology: Evaluating trans-boundary environmental impacts. Handbook of Input-Output Analysis for Industrial Ecology. S. Suh. Dordrecht, Springer: Forthcoming.

Rueda-Cantuche, J. M., J. Beutel, et al. (2007). A Symmetric Input-Output Table for EU27: Latest Progress 16th International Input-Output Conference, Istanbul, Turkey.

Suh, S. (2004). Materials and energy flows in industry and ecosystem networks: Life Cycle Assessment, Input-Output Analysis, Material Flow Analysis, Ecologicol Network Flow Analysis and their combinations for Industrial Ecology, Institute of Environmental Sciences (CML), Leiden University.

ten Raa, T. and J. M. Rueda-Cantuche (2003). "The Construction of Input–Output Coefficients Matrices in an Axiomatic Context: Some Further Considerations." Economic Systems Research **15**(4): 439-455.

ten Raa, T. and J. M. Rueda-Cantuche (2007). "A Generalized Expression for the Commodity and the Industry Technology Models in Input-Output Analysis." Economic Systems Research **19**(1): 99-104.

Timmer, M., T. van Moergastel, et al. (2007). EU KLEMSs Growth And Productivity Accounts Version 1.0: Part I, Methodology. Groningen, Netherlands, Rijksuniversiteit, Groningen Growth and Development Centre.

Tukker, A., G. Huppes, et al. (2006). Environmental Impact of Products (EIPRO): Analysis of the life cycle environmental impacts related to the final consumption of the EU-25. Seville, IPTS/ESTO Project.

United Nations (1993). System of National Accounts 1993, United Nations.

United Nations (1999). Handbook of input-output table compilation and analysis. Studies in Methods Series F, No 74. Handbook of National Accounting, United Nations.

Walmsley, T. L. and R. McDougall (2007). Using Entropy to compare IO tables. GTAP Research Memorandum No. 9.

Weber, C. and H. S. Matthews (2007). "Embodied Environmental Emissions in U.S. International Trade, 1997-2004." Environmental Science and Technology(To appear).

Weidema, B. P., A. M. Nielsen, et al. (2005). Prioritisation within the Integrated Product Policy, Danish Environmental Protection Agency.

Weisz, H. and F. Duchin (2006). "Physical and monetary input-output analysis: What makes the difference?" Ecological Economics **57**(3): 534--541.

Wiedmann, T., M. Lenzen, et al. (2007). "Examining the Global Environmental Impact of Regional Consumption Activities - Part 2: Review of input-output models for the assessment of environmental impacts embodied in trade." Ecological Economics **61**: 15--26.

Yamano, N. and N. Ahmad (2006). The OECD input-output database: 2006 edition, Statistical Analysis of Science, Technology and Industry (OECD).

Yamano, N. and N. Ahmad (2006). The OECD input-output database: 2006 edition. STI Working Paper 2006/8, Organisation for Economic Co-operation and Development.