PROJECT N. 037033

EXIOPOL

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

TECHNICAL REPORT: INVENTORY OF TRADE DATA AND OPTIONS FOR CREATING LINKAGES

Report of the EXIOPOL project

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1 Introduction

The objective of the EXIOPOL project is to enable the estimation of environmental impacts and external costs of different economic activities, consumption activities and resource use for countries in the European Union. To realize this, a toolbox will be developed for full cost accounting and full impact assessment of different activities, which in turn supports cost-effectiveness and cost-benefit analysis of technologies and policies. More specifically, the toolbox will consist of a detailed environmentally extended input-output framework with links to other socio-economic models in which as many external cost estimates as possible are included (FEEM and TNO, 2006, p.4).

Cluster III in the EXIOPOL project is responsible for the development of the detailed environmentally extended input-output table. Next to the EU-27 countries additional countries will be included to reach 80% of world GDP coverage. Each country will be individually represented in the table with a sector detail of approximately one hundred industries or products. Work package III.4.a is responsible for the trade linkages between the countries in the input-output table, which will result in a trade linked global system. This scoping report discusses the availability of trade data and options for linking the national input-output tables.

The database to be compiled in the EXIOPOL project will be based on the European Systems of Accounts 1995 (ESA 95) supply and use tables (SUTs) and/or input-output tables (IOTs).[1] All these tables are compiled from national data on (intermediate) production, value added, final outputs, imports, and exports. The drawback of these national tables resides in the fact that the bilateral trade connections between industries in different countries are not included. This implies that the national tables only enable the estimation of direct spillovers - the import requirements from other regions. A setup that includes multiple countries and their linkages also enables the estimation of indirect spillovers. These indirect spillovers are the output requirements to produce the direct spillovers, including the feedbacks on the region itself (Van der Linden & Oosterhaven, 1995). Analyses based on a table with intercountry linkages account for all the direct and indirect effects of a change in final demand.

In a national table the value of inputs imported by an industry is known, but the source – by country and industry – is not recorded. Due to the unknown source the imports can only be assumed to be produced with domestic production technology. In models with environmental extensions this may lead to a biased estimation of the environmental impacts. Lenzen (2004) and Peters and Hertwich (2006), for example, show that it is important to use international tables to correctly account for cumulative emissions of CO_2. Consider the case in which domestic industries use clean technologies to produce energy, while many products are imported from countries with high emissions of CO_2. In that case it is clear that the estimated cumulative emissions are underestimated when a national approach is followed.

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[1] These tables are maintained by EUROSTAT.

The international integration of two or more national IOTs or SUTs involves linking the national tables with bilateral trade data. In section 2 the availability of trade data is discussed, both the bilateral trade data that will be used for linking and the trade data already present in the SUTs and IOTs. The trade data in the national tables is to be reconciled with the bilateral trade data in order to reach consistency between the two sources.

In section 3 the problems related to the use of trade data are presented followed by a discussion of the harmonization methods that might be used to remedy these problems. Some relative simple alignment issues of currency denomination and classification are first discussed. Trade data classifications include very detailed subheadings with much more detail than needed for EXIOPOL. In addition many classifications exist; for different purposes but also for the same purpose, which in turn may include several revisions per classification. Trade data is in general classified by product. The goods in these product classifications might need to be reclassified as economic activity or to be assigned to a producing sector for the construction of IOTs on an industry-by-industry basis.

In addition, there are some fundamental sources of discrepancies between import and export data in SUTs and IOTs and in trade statistics. The most important is the fact that the same goods at different measurement points (inter alia in different geographical locations) are valued at different prices. The extra pricing layers added to the goods that cause the valuation differences include trade and transport margins, and taxes and subsidies. These discrepancies will need specific consideration and a thorough discussion is given of the methods available to harmonize the data.

Next, section 4 gives an overview of the accounting frameworks and accompanying models for multiple regions or nations. Two general types of multiple-region models exist, which are referred to as the 'inter-regional' model (Isard, 1951) and the 'multi-regional' model (Chenery, 1953; Moses 1955). The choice of either model depends on the acceptance of the assumptions that are implicit in their construction. Their accompanying tables are constructed following a top-down approach with a national table as the starting point. For tables that comprise multiple countries the construction method slightly differs, the starting point is once again the national table, but now a bottom-up approach is applied to arrive at a multi-country or an intercountry table.

Based on the discussion of the specific construction methods and the corresponding assumptions the methods most suitable for the EXIOPOL project are discussed in further detail in section 5. Specific issues and possible pitfalls are analyzed in relation to the availability of SUTs, IOTs and bilateral trade data. As many specifics are not yet decided upon, this report cannot spell out an EXIOPOL tailored methodology, even though all the ingredients are discussed in this report.

The last section will recapitulate and conclude this scoping report.

2 Trade data availability

In this chapter a description will be given of the availability of trade data. First, bilateral trade data from trade statistics will be discussed. Next, the trade data already present in the SUTs and IOTs is discussed. As the latter data are recorded without a specific origin in case of imports and without destination in case of exports, the bilateral trade data are needed to assign this spatial dimension to the data in the SUTs and IOTs. The availability and specific characteristics of these data together with the encountered discrepancies determine which methods will be used to construct the international accounting framework for EXIOPOL.

Over the years trade data has been classified according to many international classification schemes. Within the large group of international classification schemes, different families of classifications can be distinguished of which the product and activity (or industry) classifications are important for EXIOPOL. In this report several classification schemes are referred to. They are succinctly presented in Annex I: Table 1.

2.1 Bilateral trade databases

In general, national statistical offices are the primary collectors of trade data. International organizations that collect and disseminate databases that comprise trade data of multiple countries collect their data from the national offices through specific surveys. Eurostat, the OECD and the United Nations all develop and maintain large databases of international trade statistics. The UN have a database that covers the whole world, Eurostat focuses on European countries, and the OECD on countries that are a member of the organization. The Global Trade Analysis Project (GTAP) has over the years also collected a large dataset of bilateral trade data.[2]

The advantage of using data from these sources is the time saved in collecting the data from national sources. Data will have been checked, aligned and will be denominated in the same currency. The downside is the fact that these international organizations might have been correcting the data in ways that might not be clear afterwards. Obtaining the data from an original source would ensure that a minimum of data manipulation has been carried out.

Bilateral trade databases in general are split up into international commodity trade and international services trade. Commodities trade data is available in different product classifications, such as the ‘Harmonized Commodity Description and Coding System’ (HS), the ‘Standard International Trade Classification’ (SITC), and the ‘Classification by Broad Economic Categories’ (BEC). Most classifications schemes have gone through several revisions that continue to co-exist. The classification used for services trade is

[2] GTAP is a global network of researchers and policy makers conducting quantitative analysis of international policy issues. It maintains its own global model and database. See: https://www.gtap.agecon.purdue.edu, last accessed: 21.6.2007.

the 'Extended Balance of Payments Services Classification' (EBOPS), which is consistent with, but more detailed than the Balance of Payments Manual (5^{th} ed.) classification of services trade.

One of the characteristics distinguishing services trade statistics from commodity trade statistics is the availability of data. Trade in goods is easier to define and hence to record than trade in services. Work on definitions and measurement methods fro services trade is rather recent. It took a flight after the General Agreement on Trade in Services (GATS), which was drafted in 1994 and entered into force in 1995. A manual on services trade has been jointly developed and published in 2002 by EU, IMF, OECD, UN, UNCTAD, and WTO. Four modalities through which services may be delivered are identified in the GATS: (1) cross border supply, (2) consumption abroad, (3) commercial presence, and (4) the presence of natural persons. For many services the buyer and supplier need to be in the same location. Demand from a country that induces supply by another country will then involve relocation of a company, the opening of a new affiliate abroad, or a short term visit by an employee of the company (e.g. in international consultancy work).

The availability of data will be discussed according to the international organization that maintains the databases and whether it pertains to commodity or services trade. The focus is on the three main international data sources on international trade statistics; Eurostat, UN and OECD. As GTAP is a reference model and database for the EXIOPOL database its contents are also shortly discussed. Each international database makes a distinction between the countries that supply the data (the reporters) and the countries these reporters trade with (the partners). For each of these data sources the metadata on number of reporters and partners, the type of classification, and detail incorporated will be discussed.

Only Eurostat denominates its data in euros. The other three sources contain data denominated in U.S. dollars. Export values are always given in free on board (f.o.b.) prices, which means that the cost of international transport is not included. Imports are given in cost-insurance-freight (c.i.f.) prices, which do include the costs of international transport. GTAP also includes trade in market prices of both countries.

The EXIOPOL database will at first contain data for only one year. Which particular year still needs to be decided upon although earlier years than 2000 are not considered. All trade databases contain data for 2000, years after 2003 are not always covered in all databases. In Table 1 an overview of the specifics of different trade data sources is given for quick reference.

2.2 Inventory of international sources of bilateral trade data

2.2.1 Eurostat

The online database maintained by Eurostat[3], called **Comext**, only covers trade in goods. The currency denomination is euros. Data can be retrieved in five

[3] Directly accessible at: http://fd.comext.eurostat.cec.eu.int/xtweb, last accessed 15.06. 2007.

different classification schemes: the ‘Combined Nomenclature’ (CN) (9842 products), two versions of the HS (5224 products), the SITC classification (3118 products) and the BEC classification (19 types of products). The reporters that can be selected are the members of the European Union and several aggregations of EU reporters (like the EU-15 and the EU-27). In total 263 partners are represented in the database. Both value and quantity data of exports and imports are available.

2.2.2 United Nations

The international goods trade database of the United Nations, called **Comtrade**, is accessible online, but in order to download a substantial amount of data paid subscriber access is required.[4] It provides trade data for all available countries and areas, which total to 249 reporting identities, and includes aggregates of regions. The classification schemes incorporated are three versions of the SITC (Rev. 1, 2, and 3), three versions of the HS (1992, 1996, and 2002) and the BEC.

The United Nations is also in the process of setting up a service trade database. This database combines data from the OECD and IMF complemented with some data from the Caribbean Community (CARICOM) and national sources. Services are classified according to the Extended Balance of Payments Services Classification (EBOPS). Data will cover 27 reporting countries and more than 200 partners.[5]

2.2.3 OECD

The OECD international trade database by commodity (called **ITCS**) contains data for SITC Revision 2, SITC Revision 3, HS 1988, and HS 1996.[6] The SITC Revision 2 features by far the longest time series but has less detail and is somewhat outdated. Most series of the SITC Revision 3 data cover data from 1988 to 2005. The HS 1988 covers data from 1990 to 2000 and the HS 1996 from 1996 to 2004/2005. The SITC classifications have respectively 2582 and 4346 different product reporting categories. The HS systems include respectively 6873 and 6784 different product reporting categories. However, these categories all have a main coding with several levels of subcategories so there is overlap in the data. Each classification has about 33 reporting countries and 264 different trading partners.

The OECD also maintains an industrial data base (called **STAN**), which includes a bilateral trade database.[7] It is classified according to 42 (not all independent) economic activities following the ISIC Rev. 3 classification. In total 30 countries are covered and 61 partner countries and geographical zones. This database is derived from the ITCS database by applying a standard conversion

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[4] Access to the database and related resources at: http://comtrade.un.org, last accessed: 06.06.2007.

[5] See: http://unstats.un.org/unsd/servicetrade/default.aspx, last accessed 11.06.2007.

[6] See: http://www.oecd.org/document/18/0,3343,en_2825_495663_1906706_1_1_1_1,00.html, last accessed: 22.6.2007.

[7] See: http://www.oecd.org/document/52/0,3343,en_2825_495649_36274100_1_1_1_1,00.html, last accessed: 22.06.2007.

scheme from product to industry classification. The time period covered is 1988 to 2004.

Next to the industry and commodity trade database, the OECD also facilitates a very limited online services trade database. Data can be retrieved either by partner country or by type of service.[8] In the first case no breakdown by type of service is available, in the second case all partners are aggregated into one 'world' partner. When the data are retrieved by partner country, 35 reporting identities are included and 269 partners. The data by type of service covers 35 reporting identities and 13 different services. Data submitted by non-EU OECD members are published without changes. Data for the EU OECD members are supplied by Eurostat, which may have adjusted or estimated some of the data. Via the OECD's online library a more detailed data set of international service trade data can be retrieved.[9] However, there is still a division between tables by service, and tables by partner. In the tables by service, the world or the EU can be selected as partner. There are 121 services, which consists of 19 main headings and 2 levels of subcategories. For the tables by partner, there are five categories; total services and four subcategories. The statistics give data for 269 partners.

2.2.4 GTAP

The GTAP database is a global database that represents the world economy. Each of the versions has its own reference year, which in case of the latest update, GTAP 6, is 2001. The database consists of 87 countries and regions, and 57 sectors, which are delimitated according to their own classification scheme 'GTAP Sectoral Classification (GSC2).[10] The GTAP agricultural and food processing industries are classified by reference to the 'Central Product Classification' (CPC). The other sectors are defined by reference to the 'International Standard Industry Classification' (ISIC). Ten of these sectors are service sectors.

McDougall (2006a) describes the construction of the trade data sets in GTAP. Four bilateral trade arrays give data in market prices in exporting countries, f.o.b., c.i.f., and market prices in importing countries. The source for the bilateral merchandise trade is the UN Comtrade database. Services trade data are obtained from the IMF balance of payments statistics. The data extracted from the IMF includes 185 countries, but does not include bilateral information. Two additional arrays contain data on international trade margins: a *margin supply array* indexed by type of margin and country of origin of the margin, and a *margin use array* indexed by type of margin, and by country of origin and destination, and type of commodity to which the margin at hand applies.

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[8] For this limited database go to: http://stats.oecd.org/wbos/default.aspx?DatasetCode =TISP, last accessed 14.06.2007.

[9] www.sourceoecd.org, last accessed 14.06.2007.

[10] The 87 countries and regions (and the regional composition) are listed in this file: https://www.gtap.agecon.purdue.edu/databases/v6/v6_tab8_2.xls, last accessed at 06.06.2007. A detailed overview of the sector breakdown is given at: https://www. gtap.agecon.purdue.edu/databases/v6/v6_sectors.asp, last accessed 06.06.2007.

Table 1: Trade data availability by international organization

	EUROSTAT	UN[1)]	OECD	GTAP[2)]
Commodity trade data – overview only for HS 1996 classification				
Classification scheme	HS 1996	HS 1996	HS 1996	GSC2
Reporters	EU-27	All countries	OECD members	Countries + regions
# of country reporters	27	249	33	87 (+/-200 gathered)
# of partners	263	279	264	87 (+/-200 gathered)
Product detail	5224	5113 subheadings	5500 different products	57 (gathered in more detail)
Indicators	Value/ quantity	Value	Value/quantity/ unit of quantity	Value
Service trade data				
# of country reporters	No online data[3)]	27	By partner: 35 By service: 35	87
# of partners	No online data	200+	By partner: 269 By service: 1	87
Service detail	No online data	unknown	By partner: 1 By service: 13	10 in final dataset (27 are gathered including overlapping levels)

* All numbers are on basis of the possibility of selecting a country, a partner, a product, or a service category. Whether data is actually available for each of these categories is not investigated. Actual data availability may therefore be (substantially) lower.

[1)] The UN Service Trade Database is not been made available online yet.

[2)] As there is no direct online access to the data the numbers given in this table have not been checked. CD-ROMS with the data can be purchased via the site: https://www.gtap.agecon.purdue.edu/default.asp, last accessed 22.06.2007.

[3)] As indicated in the section on the OECD Services trade databases, Eurostat provides bilateral data for the EU countries. However, to my knowledge it is not available online.

2.3 Trade data in SUTs and IOTs

The Eurostat ESA 95 IOTs and SUTs all feature the 'Statistical Classification of Products by Activity in the European Economic Community' (CPA) product classification and the 'Statistical Classification of Economic Activities in the European Community' (NACE) industry classification.[11] In SUTs and IOTs data on imports and exports are part of the tables. Of the EU-27, 24 countries have supplied SUTs or IOTs to Eurostat within the ESA95 framework. Three of these

[11] The tables can be obtained from: http://epp.eurostat.ec.europa.eu/portal/page?_pageid=2474,54156821,2474_54764840&_dad=portal&_schema=PORTAL, last accessed: 22.06.2007

countries only supply SUTs, 21 also supply IOTs.[12] Norway is excluded from this account as it is not part of the EU-27, it has, however, supplied SUTs and IOTs to Eurostat for the years 2001 and 2002.

When IOTs are available, they are also broken down in a domestic and import table.[13] The reporters, on a voluntary basis, can give a breakdown in each of the tables of the import row and/or the export column between intra-EU and extra-EU trade. The import tables all give imports from the rest of the world, in contrast to earlier Eurostat input-output tables that included two import tables; one with imports from other member states, and one with imports from non-EU countries. Each import table includes a column (or two when the split between EU and non-EU is available) with re-exports, alternatively named transit trade. Each table is in the national currency and all Euro-countries in euros. All IOTs, including the import tables, are supplied in basic prices.

Each SUT features the product (CPA) classification on its rows and the industry (NACE) classification on its columns. The dimensions for the IOTs (the total, domestic, and import table) cannot be deduced from the tables as each of them features the product classification on its rows and so-called homogeneous branches as its column classification. However, the availability overview of the Eurostat ESA 95 tables indicates for most of the tables their dimensions.[14] The product-by-product set-up is used in 14 cases, and the industry-by-industry set-up is used in 4 cases. Hungary is the only country that supplies both set-ups. See Table 2 for an overview of trade in the ESA95 SUTs and IOTs.

The OECD IOTs are all industry-by-industry symmetric IOTs, and each of them includes a breakdown between a domestic and an import table.[15] Thirty-five countries are represented, all in their national currency (the Euro-countries are all reported in euros) and in basic prices. Due to the use of a common format, each table has an export column and an import column, which only contain data when appropriate. The total (domestic plus import) table has an export and import column, and a non-comparable import row. The domestic table only has the export column and the non-comparable import row filled. For some countries transit trade is recorded in the import table for others it is not.

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[12] For more information on the availability of SUT and IOT see the technical report on checks on economic data sources for SUT/IO tables for EU25 and RoW included in this document.

[13] Only Greece does not give this break down.

[14] See: http://epp.eurostat.ec.europa.eu/pls/portal/docs/PAGE/PGP_DS_ESA_IOT/PGE_DS_ESA_01/TAB54764839/0_AVAILABILITY_20070615.XLS, last accessed 22.06.2007.

[15] The data can be obtained via: http://www.oecd.org/document/3//0,2340,en_2649_34445_38071427_1_1_1_1,00.html, last accessed: 22.06.2007.

Table 2: Overview of trade in the Eurostat ESA95 SUTs and IOTs.

Table	Supply Table	Use Table	IOT		Domestic IOT		Import IOT
Price type	Basic prices[1]	Purchasers' prices [2]	Basic prices		Basic prices		Basic prices
Total # of countries	24	24	21		20		20
Industry-by-ind./ product-by-prod.			4/11 for 2000		4/11 for 2000		4/11 for 2000
Table not for 2000, # of countries	2	2	5		4		4
Import/export	Import column c.i.f.	Export column f.o.b.	Import row c.i.f.	Export column f.o.b.	Import row c.i.f.	Export column f.o.b.	Re-export column f.o.b.
Breakdown between intra- and extra-EU trade included, # of countries	13	13	11 [3]	12 [3]	n/a	10	8

1) Each Supply Table is in basic prices, but a column of trade and transport margins, and a column of taxes and subsidies are added resulting in a transformation of the total supply column into purchasers' prices.

2) Belgium, Denmark, Spain, and Finland also provide a valuation matrix of trade and transport margins, a valuation matrix for taxes less subsidies on products, and a use table at basic prices. Belgium and Denmark for the year 2000, Spain for 2000 and 2001, and Finland for 2002.

3) Ten of the 21 countries have both a breakdown in the import row as well as the export column. France only has a breakdown of the import row, Spain and Slovenia only have a breakdown in the export column.

3 Trade data harmonization and integration

In bilateral trade data any flow of goods is in general recorded at least twice; once by the seller and once by the purchaser. Although these data apply to the same goods, the values recorded as exports in general do not match the corresponding import data. There are several sources for these discrepancies that will be discussed in this section.

3.1 Consistency issues and sources of discrepancies in trade data

For the integration of trade data in one international table important consistency issues have to be addressed. As different countries denominate their data in their own currency, these currencies will have to be converted to one single currency for comparability. In case of EXIOPOL the currency of denomination will be euros. This implies that when data from the UN, OECD or GTAP are used, values will have to be converted from US dollars to euros. When obtaining data from national offices, each corresponding currency will need to be converted to euros. In most cases the international organizations have already converted the values to a common currency by applying standard exchange rates.

As indicated before, trade statistics are published according to several classification schemes. There are three levels at which classification schemes can differ; the conceptual level (for example; the difference between a product and an industry classification), the specific type of classification (for example; HS and SITC are both product classifications), and the revision number (for example; SITC Rev. 2 and SITC Rev. 3) Different revisions of classifications are often not compatible. In general, it is rather easy to go back to an older revision, whereas converting data into a newer revision is quite difficult.[16] More challenging is the conversion of data into different types of classifications. Conceptually different classification schemes, like product and industry classifications are even more difficult to align.

The documentation of the OECD-STAN database (2005) gives an overview of the reasons for inconsistencies in trade data. The most obvious problem is the fact that mirror statistics (trade from A to B recorded by country A as exports and by country B as imports) in general do not match. The reasons for inconsistencies are: (1) valuation is based on CIF prices for imports and on FOB prices for exports, (2) transit trade might not be recorded as originating from the country of production or as being designated for the country of consumption, (3) the accuracy of customs declarations may vary over countries and time, (4) minimum values and cut-off points are different in different countries, (5) some exported goods may be recorded in one year, while the importing country might record them in the next year, (6) there are differences in treatment of confidential data, which may lead to different values at different

[16] See the comments about SITC Rev. 2 and SITC Rev. 3 on the information page of the ITCS database: http://www.oecd.org/document/18/0,2340,en_2649_34235_1906706_1_1_1_1,00.html, last accessed 14.06.2007

levels of aggregation, (7) only newly produced products, products that add or subtract resources from a country by their movement should be included in trade statistics and trade in second-hand products should not be included.

In the GTAP documentation the largest contributors to the trade data incompatibility are identified to be the failure of countries to properly classify detailed commodities, and the failure to properly identify their trading partners.[17] This is mainly because of the possibility to report commodities as unclassified and partners as unspecified. Also the growth in re-export trade has become more important in determining reporting variation in particular for the Netherlands and Hong Kong.[18] From the testing of four non-survey methods on the Asian-Pacific IOT it appeared that failure to geographically classify transit trade according to the location of the final user produced significant errors (see Oosterhaven et al. 2007). This was specifically the case for trade involving Singapore.

Van Leeuwen & Schout (1987) and Van der Linden (1999) additionally discuss the discrepancies between the trade data in the input-output tables and in international trade databases. In physical terms these four flows should be equal. Their values, however, seldom match. Several reasons have been identified that lead to this discrepancy. Each flow can be divided into a price and a volume component. The largest discrepancies are related to the prices. Several pricing layers are added to the producers' price in between the point a good leaves the factory or warehouse and its arrival at an international customer (see Table 3). Other pricing discrepancies might arise due to exchange rate changes and due to errors made when the prices are recorded.

With regards to the volume of trade several discrepancies exist due to the differences in definitions used by countries to identify the countries of origin and destination, destination changes, different aggregation to the classification, time lags between registering the good, confidentiality, and statistical recording thresholds.

[17] See Gehlhar, M (2006a). Reconciling Merchandise Trade Data. Chapter 15.B in: Dimaranan, B.V. Ed. (2006)

[18] See Gehlhar, M (2006b). Re-Export Trade for Hong Kong and the Netherlands. Chapter 15.C in: Dimaranan, B.V. Ed. (2006)

Table 3: Price definitions used in valuating international trade flows[19]

Price definitions used in valuating international trade flows.	
Basic price (production cost) in country *r* + Indirect taxes in country *r* =	(Supply tables and IOTs)
Producers' price in country *r* + Trade and transport margins within country *r* =	→ Export value in IOTs
Free on board (f.o.b.) price leaving country *r* + Trade and transport margins between *r* and *s* =	→ Export value in trade statistics
Cost, insurance and freight (c.i.f.) price for country *s* + Indirect taxes in country *s* =	→ Import value in trade statistics
Ex customs' price for country *s* + Trade and transport margins within country *s* =	→ Import value in IOTs
Purchasers' price	(Use tables)

3.2 Harmonization methods

The previous section has indicated the alignment issues that arise and the discrepancies that exist in bilateral trade data and in SUTs and IOTs between exports and imports. The objective of the harmonization methods is to achieve consistency between the data originating from these different sources. It is possible to tackle the inconsistency issues on a case by case basis for each country and each sector. Additional information from national statistical offices or other trusted sources may provide directions as to how to solve inconsistencies. However, these ad hoc methods can be very time consuming and untraceable, making future updating complicated. As an alternative the generalized and automated reconciliation method called RAS is described below. It (re)estimates values on basis of the limited information already available.

Converting the data to one standard currency can straightforwardly be done by applying the related exchange rate series. To make comparisons of differences in real welfare and real productivity, purchasing power parity (PPP) series can need to be used to compare values among different currencies. To integrate transaction values in different currencies into one international IOT or SUT, however, using exchange rates is the standard choice.

Trade data are in general available in a (very detailed) product classification different from the product classification used in SUTs and IOTs. In addition, in the SUT the columns are classified according to the type of industry, while an IOT can be constructed to represent the sales and purchases of industries. This implies that the bilateral trade data will at least need to be converted to the product classification and possibly also the industry classification used in the SUTs or IOTs. General correspondence tables are

[19] Source: Van der Linden (1999), p. 83, slightly adjusted. The original table is published in Van der Linden and Oosterhaven (1995)

available from the international organizations, which give mappings from different revisions of the same classification and between different product classifications.[20] These can be consulted as guideline to construct the correspondence table that matches the specific classifications and sector detail used in EXIOPOL. For example, the conversion tables for the OECD STAN database relating the HS with the ISIC Rev. 3 classification is available online.[21]

The most general method to reconcile inconsistencies in data that should match or sum up to the same amount is called RAS. It is a biproportional adjustment algorithm that balances matrices in a mechanical way. Its origins are discussed in Lahr and de Mesnard (2004) in the special issue of *Economic Systems Research* on Biproportional Techniques in Input-Output Analysis. It has been widely used to update input-output tables given new row and column totals of intermediate inputs (Miller and Blair, 1985). In IOTs it can be used to re-price matrixes to other prices, when the row and column totals are known in the desired price. In addition, it can be used to balance the derived import and export data matrices with the original total import and export data from the IOT (Van der Linden and Oosterhaven, 1995).

After applying the import ratios from the bilateral trade data to the individual import matrices of the countries at hand, the resulting matrices may be combined into one large matrix. The diagonal matrices of this large import matrix are zero as these represent domestic transactions. In general RAS may be applied to this large import matrix using the combined export columns and import rows of the original input-output tables as constraints. Additional information from export ratios from the bilateral trade data may be used in this process. Boomsma and Oosterhaven (1992) indicate that sellers have a better idea of their buyers than the other way around. This would make the spatial dimension of sales data obtained from company surveys more reliable. Bilateral trade data, on the other hand, is recorded at customs' offices at the border of the importing countries. These data are thought to be more reliable when they concern imports, because countries better record what they import due to subsequent tariffs and taxes that can be imposed.

GTAP reconciles trade flows based on a selection process that measures each country's reliability based on its record of matching its trade with its partners. However, it is deemed that overriding this automated selection process can be desirable when additional industry-specific knowledge is available. When reconciled sector totals are not consistent with the available industry statistics corrective measure can be taken on a case-by-case basis.[22]

In case of services trade data conflicts with merchandise trade, GTAP adjusts the former to agree with the latter as merchandise trade data is believed

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[20] An overview of correspondence tables of the United Nations is available at: http://unstats.un.org/unsd/cr/registry/regot.asp?Lg=1, last accessed 07.06.2007. The Eurostat – RAMON correspondence tables are available at: http://ec.europa.eu/eurostat/ramon/relations/index.cfm?TargetUrl=LST_REL, last accessed 07.06.2007.

[21] The HS to ISIC Rev. 3 correspondence scheme: http://oecd-stats.ingenta.com/tables/7EBTD_H1toI3.xls, last accessed 14.06.2007.

[22] See also Chapter 15B by M. Gehlhar (2006a) of the GTAP Documentation in; Dimaranan, B.V. Ed. (2006).

to be more firmly based[23]. Each service dataset is extended to cover the complete list of GTAP standard countries. In order to reconcile services exports and imports first a world trade target is set for each category, calculated as the geometric mean of the estimates for world exports and world imports. Then the export and import estimates for individual countries are rescaled to match the common world target. A bilateral trade matrix is constructed for each service by mutually redistributing the rescaled exports and imports estimates. In this matrix the diagonal entries are set to zero so as to impose zero intra-country trade after which it is rebalanced against the export and import estimates using the RAS procedure.[24] To make the complete input-output tables consistent with the international data sets, a specific program is used, which applies entropy-theoretic methods, a specific version of RAS.[25]

[23] In section 2.2.4 the data sources used by GTAP were indicated to be the UN Comtrade database for the merchandise trade data and the IMF Balance of Payments statistics for the service trade data.

[24] See also Chapter 15E by R.A. McDougall and J. Hagemejer (2006) of the GTAP Documentation; Dimaranan, B.V. Ed. (2006).

[25] See also Chapter 19 by R.A. McDougall (2006b) of the GTAP Documentation; Dimaranan, B.V. Ed. (2006).

4 Accounting frameworks and models for linking SUTs and IOTs

Most IOTs represent a single national or regional economy. In order to analyze the structure of multiple regions within the national economy or a combination of multiple nations, the linkages between the regions or nations need to be explicitly incorporated.

In case of an input-output table of multiple regions in one country a *top-down* approach may be followed where the national table is split up mostly column-by-column in its regional parts while trade linkages between the regions are added (see Boomsma & Oosterhaven, 1992; Eding et al. 1999). In case of an input-output table that comprises multiple nations, the starting point is again the national table. Now a *bottom-up* approach is applied where all national tables are linked with data on international trade (see Oosterhaven et al. 2007).

In the top-down interregional case the major problems are the accuracy of the non-survey assumptions involved in splitting the national IO table and linking the regional tables with lacking interregional trade data. In the bottom-up intercountry case the major problems are the initial split of the national table into a domestic and an import table, and the further split of the import table according to the country of origin of the imports. Additional issues are related to the consistency of classifications and definitions among countries and among trade statistics, as discussed in section 3.

In general, two different types of multiple-region models can be distinguished. The *interregional* IO model conceived by Isard (1951) considers the intermediate inputs z from industry i from each different region r by industry j in region s as a unique input, and therefore assumes the interregional input coefficients per unit of output x to be the product of domestic technical coefficients ($a_{ij}^{\bullet s} = z_{ij}^{\bullet s} / x_j^s$) and *cell level* trade coefficients ($t_{ij}^{rs} = z_{ij}^{rs} / z_{ij}^{\bullet s}$) (where $\bullet$ is a summation over the index concerned). Hence, this model requires data from an interregional IOT with full information on the sectoral and spatial origin and destination of all intermediate and final deliveries within the covered area, as shown in Figure 1. In contrast, the *multi-regional* model originating from Chenery (1953) and Moses (1955) combines the domestic technical coefficients with *aggregate* trade coefficients ($t_{i\bullet}^{rs} = z_{i\bullet}^{rs} / z_{i\bullet}^{\bullet s}$). Hence, it requires data from a multi-regional IOT with only aggregate information on intra-regional and interregional trade flows. Polenske (1980) has made an important contribution to the field by empirically applying the multi-regional model to the United States.

As discussed in Oosterhaven (1984) a whole family of square and rectangular interregional accounting frameworks and models exists. The construction of the square and rectangular interregional tables from a national table is discussed, covering both the type of data needed and the assumptions being made in the process. For both the IOT and the SUT, splitting up the national table can take place along the columns with purchase data or along the rows with sales data. Both types of tables feature limited information that does not allow for a consistent IO model. In the *columns-only* IOT or SUT there is no split-up by spatial origin along the rows of the (use) table that remain nationwide, and in the *rows-only* SUT or IOT there is no split-up by spatial destination along the columns of the (supply) table. A consistent IO model can only be formulated if the national IOT or SUT is split-up according to both spatial origin and destination. [26]

Figure 1: Intercountry input-output table

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

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

The *multi-regional IOT* is then a combination of limited information columns-only regional tables with a matrix of aggregate interregional trade flows. The *multi-regional SUT* combines regional use and regional supply tables also with a matrix of aggregated trade flows (of course by product). In case of the multi-regional IOT or SUT each industry *j* in region *s* buys the same percentage of products from industry *i* in region *r*. With cell level interregional trade data (the destination industry is also recorded) the interregional IO model can be constructed. This model does not feature constant import percentages per origin industry *i*. The *interregional IOTs*, whether columns-only, rows-only or reconciled, all serve as base for the interregional IO model. The *interregional SUTs*, whether use-only, supply-only, and full-information, all have their own corresponding model with different implied assumptions. Figure 2 shows the accounting framework of a full information interregional SUT.

In case of tables that consist of multiple countries the distinction between multi-country tables and intercountry tables is also present, only the construction method will be bottom-up instead of top-down and some of the multiple region variants become irrelevant in the multi country case. Multi-country tables combine national tables with aggregate international trade flows, whereas intercountry tables have cell level information on all trade flows. Due to the extensive data needs of intercountry tables these are never constructed by means of survey methods. In (semi-survey) intercountry tables the domestic origin IOTs of nations can be directly inserted on the diagonal. The off-diagonal

[26] Note that the distinction between full and limited information in Oosterhaven (1984) is different from the distinction between multi-regional and inter-regional IO models.

blocks need to be filled by redistributing the values of the import IOTs using trade data to derive the origin country of the imports. Here the assumption of row-wise constant input percentages is made again, but only applies to the off-diagonal matrices. Due to inconsistencies, the tables need to be harmonized in order to be able to represent the table in a full-information layout. Such intercountry tables should therefore be typified as *hybrid tables*, as they actually combines the informational features of the multi-regional and the interregional table.

Figure 2: Intercountry supply and use table

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

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

Van der Linden (1999) indicates three methods that can be used to arrive at such a hybrid intercountry table. First, the gravity approach can be adopted in which the bilateral trade flows are estimated as a function of the geographic distance between each pair of countries and the total intra-EU trade flows. Although data requirements are low, the gravity approach disregards a large amount of information embodied in international trade data. Second, the import matrices of intra-EU trade can be disaggregated by import coefficients derived from international trade statistics. Third, the same methods as in two can be followed but the data is now augmented by information from large exporting and importing firms. This last approach will result in a table that most closely resembles the real world, but requires an extensive amount of field work.

Van der Linden and Oosterhaven (1995) apply the second method to construct a time series of intercountry tables for the EU for 1965-1985. The bilateral trade flows are estimated from the aggregate import and export flows present in the national input-output tables. The intra-EU imports are disaggregated with the aggregate imports shares that are derived from international trade statistics. The resulting matrices are then inserted as the off-diagonal matrices in the intercountry tables. Summing the elements from these matrices represents total exports and total imports by all countries. In general these totals do not match the total exports and imports from the domestic IOTs, which can be obtained by summing over the export columns and import rows of the individual country's domestic IOT. The RAS method is used to equalize these two, or actually four, totals and balance the international trade matrices of their intercountry IOTs. In this way, the ex customs import matrices are implicitly re-priced to the producer prices of the exports in old EU IOTs.

The GTAP project has build a global database that represents the world economy. It is based on an input-output core. Their national IOTs are delivered by individual users of the GTAP databases, who may be affiliates of statistical agencies, universities, or other research institutes. These tables are first checked and adjusted to incorporate the required level of detail. The internationalization method closely resembles the Van der Linden and Oosterhaven (1995) approach. The specific data harmonization methods are discussed in the previous section.

In Oosterhaven et al. (2007) four non-survey methods are described to link national tables to arrive at an international table. Each of the methods uses an increasing degree of information. The methods are applied and tested with the ten countries Asian-Pacific international IOT of 2000 constructed by IDE/JETRO (Inomata et al. 2006). In their first method, the national IOTs with world-wide inputs are first split-up into a domestic origin IOT and an import IOT by means of the aggregate sectoral self-sufficiency ratios that may be derived from any national IOT. Most national IO accounting frameworks, however, already incorporate this split-up, including the ten Asian-Pacific countries.

Their next step is to partition the national import tables according to the country of origin by applying the bilateral import ratios from import trade statistics. As the services import ratios are lacking the import ratio of the total of the commodity sectors is used as proxy. The national IO export columns are split up by country of destination by export ratios derived from export trade statistics. Destinations of IO services exports are estimated by using the total commodity export ratio. For the first and second method the export columns of the Asian-Pacific countries are all aggregated into one export column for the rest of the Asian-Pacific area. This export column is then re-scaled to match the total of the intercountry import matrix constructed by applying the import data. The difference between the original and the re-scaled column in put in an extra column. The re-scaled export column is used as a row constraint for the intercountry import matrix in the GRAS method (Junius and Oosterhaven, 2003).[27]

The third method uses the individual country export columns as row constraints for the block-column matrix that consists of the import sub-matrices per purchasing country. In this fashion ten re-scaling columns are obtained, each with an accompanying re-scaling factor. These are then used as constraints in the GRAS method. The fourth method uses the spatial information from the import trade statistics as these are assumed to contain more reliable information. The import block-column matrices are re-priced from ex-customs

[27] GRAS is a generalized RAS method that also handles negative cells and negative row and column totals, such as for changes in stocks, net exports and subsidies.

prices to producer's prices. The bilateral export columns are re-scaled to their corresponding value in the bilateral import block-column sub-matrices. Again there are ten re-scaling columns, but now there are different re-scaling sub-factors. The re-scaling columns are combined into a single column and used in the GRAS method for balancing.

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

In Lenzen et al (2004) national SUTs are used to construct a table with multidirectional trade analogous to the international IOT discussed above.[28] The use tables are split-up according to country of origin of the imports. Trade coefficients are used to accomplish the split-up of the use tables. No explicit balancing other than re-pricing from f.o.b. prices to c.i.f. is carried out. It is mentioned that the diagonal elements in the international table are the original intra-country direct requirement matrices. The off-diagonal elements remain to contain incomplete and uncertain information.

[28] The supply and use coefficient tables are rectangular but the overall table is square (with both dimensions = # of industries x # of commodities x # of countries) and can thus be inverted.

5 Proposed EXIOPOL methodology

For the European countries the main data source will be the ESA95 collection of SUTs and IOTs. These tables will be the starting point for the international input-output tables to be built for EXIOPOL. For the EU-27, 17 countries have both domestic and import matrices of which 14 have product-to-product matrices and four have industry-to-industry matrices (Hungary features both). The rest has supplied a SUT or no tables at all. As there is a mixed availability of both SUTs and IOTs and both have their merits, both will probably be included in the database.

5.1 Key choice: national SUTs or national IOTs?

First of all, from a software and an updating point of view, it is not practically possible to link a mix of national SUTs and IOTs into an international table. Before linking the national tables all tables have to be restructured into one common format. The choice, inter alia, depend upon the following considerations.

When SUTs are to be transformed to industry-by-industry IOTs, information on secondary products is lost as secondary product need to be allocated to a producing industry. Transforming SUTs into IOTs can be done using an *industry-technology* assumption (the secondary products are produced with the same technology as the primary products of the industry) or using a *product-technology* assumption (equal products are produced with the same technology independent of the producing industry). The first assumption may lead to unrealistic inputs in the production of secondary products and requires that the number of products equals the number of industries. The second assumption has the undesirable effect that negative coefficients can be obtained due to the often incomplete information on the production of secondary products. Moreover, in the second case the interpretation of the table as a demand-driven economic system does not hold (De Mesnard, 2004). Kop Jansen and ten Raa (1990) have established four invariance and balance axioms for selecting the construction technology assumption. They single out the commodity-technology assumption as it fulfils all four, whereas the industry-technology assumption fulfils only one. One way out of this dilemma is using an *activity-technology* assumption (Konijn, 1994), but this can practically only be done in national statistical offices as it requires access to survey data.

Deconstructing an IOT to the unpublished underlying SUT is possible, but it will be different from the original SUT due to the missing information on secondary products in IOTs.

The ESA 95 IOTs are supplied in basic prices. Retaining basic prices as the pricing standard in the EXIOPOL database will prevent biased estimation of environmental effects due to inclusion of other cost next to production costs in, for example, purchasers' prices. However, the exclusion of trade and transport margins has as negative effect that there is no basis to derive estimates of the production by the transport and trade services sectors. Especially the first induces relatively large environmental effects and it is very desirable to include a well-underpinned estimate of services provided by the transport sector.

The supply tables are also in basic prices, but each one includes a transformation to purchaser's prices by the presence of a taxes and subsidies column and a trade and transport column in the table. The use tables are given in purchaser's prices. These two tables include information that can be used to arrive at a well-underpinned estimate of the trade and transport services.

5.2 Methodology

The choice of the most appropriate methodology depends to a large extent on the data (SUTs or IOTs, including classification, detail, prices, and number of countries) that will be supplied to this work package. However, the process of linking IOTs or SUTs follows the same general methods, and both, at the very least, apply the import ratios obtained from bilateral trade data. According to Oosterhaven et al. (2007) additional use of already available information in the export statistics (method three and four) improves the overall performance of the complete international table, but the effect is not consistent on an individual country basis. A clear answer whether to use export data in the linking process is not available. Most papers that link regions or nations use only import statistics as this contains enough information to build a consistent table and accompanying model.

With currency conversion, the convention is to use exchange rates. This will be fine for conversions between developed nations. Using PPP series is important when welfare and productivity changes effects of changes are studies over time, especially in case of developing countries. In the construction of the EXIOPOL database, however, nominal values of flows in different currencies need to be made consistent and this can only de done by applying exchange rates. In comparative studies that employ data of the EXIOPOL project PPP rates can be applied afterwards to investigate the welfare effects.

Due to the discrepancies in trade data discussed in section 3.1 there will be inconsistencies in the international import matrix constructed from the national import matrices and the import trade ratios. A RAS method can be used to make the table consistent. RAS methods can be customized to incorporate more information than the necessary new row and column totals when this information is available.[29]

The re-pricing of import tables is in general done using some form of RAS or GRAS in order to obtain a consistent table. The use of additional data on export ratios in this process may be included when they are deemed to provide superior information on the spatial dimension.

5.3 Data needed to apply proposed methodology

The classification of the bilateral trade data should be at least one level more detailed than the classification that will be used in the EXIOPOL project. This

[29] In theory it is also possible to include probability or reliance percentages as weights that reflect data quality.

additional detail will facilitate the conversion between different classification schemes as aggregated levels of different classification may include different products.

Trade data will be needed for all the individual countries included in the EXIOPOL project. The difference between the total value of these flows and total world trade (available in most trade databases) can be used to estimate the trade flows from, to and among the RoW (rest of the world) countries.

Due to the development of services trade database it will be possible to obtain direct data on services trade instead of having to use the total commodity trade ratio assumption as used in Oosterhaven et al. (2007). However, the measurement of trade in services will remain inherently difficult, which has to be kept in mind when deriving implications or making statements directly related to the services industries.

6 Conclusion and perspectives

Specific details of the methods that will be used cannot be given until it is known what the input from the other work packages will be. Each of the international trade databases contains enough product classification detail. Eurostat's Comext and OECD ITCS database might be combined in case the OECD cannot supply trade data on all of the countries that are in the EU-27.

Provided detailed trade information on both commodities and services will be available the most important step that will be undertaken is the split-up of the national import matrices according to the country of origin of the imports. After the construction of the overall international import matrix there is a host of different balancing methods that can be used to obtain a consistent table including the use of additional information on exports.

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Annex I: Classification schemes

Annex I: Table 1: Classification schemes alphabetically ordered[1]

Abbreviation	Full name	Used by	Used in/for
BEC	Broad Economic Classification	Eurostat UN	Comext Comtrade
CN	Combined Nomenclature	Eurostat	Comext
CPA	Statistical Classification of Products by Activity in the European Economic Community	Eurostat	ESA95 SUTs & IOTs
CPC	Central Product Classification	GTAP	IOTs
EBOPS	Extended Balance of Payments Services Classification	UN	Services trade database
GSC	GTAP Sectoral Classification	GTAP	IOTs and trade vectors
HS	Harmonized System	Eurostat OECD UN	Comext ITCS Comtrade
ISIC	International Standard Industrial Classification	OECD	STAN
NACE	Statistical Classification of Economic Activities in the European Community	Eurostat	ESA95 SUTs & IOTs
SITC	Standard International Trade Classification	Eurostat OECD UN	Comext ITCS Comtrade

[1] For a more elaborate overview; both the United Nations and Eurostat have a list of (international) classifications on their website. The internet addresses are: UN Classifications Registry; http://unstats.un.org/unsd/cr/family1.asp, last accessed 06.06.2007, and Eurostat – Ramon; http://ec.europa.eu/eurostat/ramon/nomenclatures/index.cfm?TargetUrl=LST_NOM&StrGroupCode=CLASSIFIC&StrLanguageCode=EN, last accessed 06.06.2007.