

Methodology for the Construction of an International Supply-Use Table*

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Abstract

The EU-funded EXIOPOL project has as its main objective to create an international environmentally extended input-output database. Instead of focusing on symmetric input-output tables, the core of the database will be formed by trade-linked rectangular supply and use tables. Supply-Use Tables (SUTs) have not yet been used as framework in international databases even though they are superior for statistical reasons. Trade-linking the SUTs is essential for obtaining a correct estimate of the actual environmental impacts of international production and consumption. Analyses based on an international SUT will attribute both direct and indirect environmental impacts to an internationally traded product or service, irrespective of its stage in the production chain in which they are created.

To provide an economically sound database, this paper describes a non-survey method to construct, alternatively, an international supply table or an international use table. Due to the valuation layers of taxes, subsidies, and trade and transport margins that are added to products when they are traded internationally, import-use tables and export-supply tables cannot be trade-linked simultaneously. Both alternative trade-linking processes consist of two main steps. The first step is the split-up of the import-use table (or export-supply table) into bilateral use (or supply) tables, using trade ratios derived from an import (or export) trade database. The second step is to reconcile the international commodity trade flows obtained from trade-linking with information in the national SUTs by applying a generalized RAS method.

This methodology is tested on a limited set of countries, resulting in the first trade-linked international supply tables and international use tables. The two alternative international tables obtained by trade-linking the import-use tables and the export-supply tables are analyzed to interpret any differences.

Keywords: supply-use table, international trade, input-output analysis, RAS

JEL codes: B41, C67, F10

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1. Introduction

The construction method of an international supply-use table (ISUT) described in this paper is part of the EU-funded EXIOPOL project. The full title of the project is 'A new environmental accounting framework using externality data and input-output tools for policy analysis'. The objective is to enable the estimation of environmental impacts and external costs of different business activities, consumption activities and resource use of countries in the European Union. To realize this, a toolbox is developed to facilitate full cost accounting and full impact assessment of different activities, which in turn supports cost-effectiveness analysis and cost-benefit analysis of technologies and policies (FEEM and TNO, 2006, p.4). The ISUT will form the core of this toolbox.

In general, the construction of national supply (industry-by-product) tables, national use (product-by-industry) tables and input-output tables is undertaken by statistical offices, primarily on account of their role in the calculation of (gross) domestic product. Subsequent economic analysis can be undertaken by means of the input-output model, after computing the input coefficient matrix. A strong assumption in this analysis is that the input coefficients do not change regardless of output, final demand, or other relevant changes. The structure of the economy is taken to be constant, at least in the short term. This use means that it is important to have accounting schemes and construction methods that result in economically sensible input coefficients.

Most of these tables are constructed at the national level. Researchers interested in the impacts of a regional demand shock can use the input coefficient matrix derived from the national table and regional import coefficients under the assumption that the structure of the national and the regional economy is alike. A regionalized final demand vector can then be used to analyze the output changes due to the regional final demand shock. Over the years regionalization of input-output tables has received much attention. It was, and is felt that in order to do regional or interregional analysis, more sophisticated tables were needed that represented the different structures of the regional economies. The assumption that regional structures are equal to the national structure was discarded.

In the international arena this assumption is still employed. Over the years, international trade has increased tremendously, and within the EU trade has increased even more. Notwithstanding these international linkages, many policy analyses are still based on national input-output tables, assuming that the national structure may also be applied to the international spillovers of national measures. Over the years, this practice has been changing by the

construction of several trade-linked input-output databases that at least include the main partners of the countries incorporated. Examples are the GTAP database (Dimaranan, 2006), the European Union intercountry input-output tables (Van der Linden and Oosterhaven, 1995), and the Asian-Pacific international input-output tables (Inomata & Okamoto, 2006).

The purpose of the ISUT in the EXIOPOL project is to calculate and allocate the environmental effects caused by the production and consumption of goods and services. In terms of policy, in addition to knowing the environmental impact of the products, information about which industry produces them is also needed. The Leontief-inverse is instrumental in the analysis as it can be used to see how much extra production is needed in each industry to fulfill one extra unit of final demand for a certain product. This extra production can be translated into increased environmental impacts. Therefore, it is important to assign the production of goods to the correct countries and industries that actually produce these goods.

Databases designed for this kind of purposes often have a core of input-output tables (IOTs). The SUT framework has the advantage that it is closer to the data recording process and that more information can be incorporated than in IOTs. Also, international trade data is not registered by industry but by product. These are more easily linked into a SUT framework, as compared to an industry-by-industry input-output table. Moreover, some of the environmental data are directly linked to products and not to industries.

The SUT framework offers an important advantage of the EXIOPOL database setup over the Global Trade Analysis Project (GTAP) database (Dimaranan, 2006), which uses input-output tables. In other respects the two databases are quite close, for example in coverage and possible applications¹. The GTAP database consists of IO tables that are supplied by users, implying that uniformity has to be established afterwards, while the quality of the tables may vary. The documentation related to the adaptation process that these tables undergo is not very detailed. In addition, the documentation related to the trade data also lacks transparency, and a growing need for overriding automated processes on a case-by-case basis is noted. The EXIOPOL database aims at a higher level of automation and a higher level of transparency. Besides, the EXIOPOL database will be publicly available.

The derivation of an input-output model from a SUT requires an explicit assumption regarding the production technology of secondary and/or by-products of industries, instead of the

¹ For more details on the GTAP database see the GTAP website: www.gtap.agecon.purdue.edu, last accessed 21.4.2008.

implicit assumptions hiding in input-output tables. Different assumptions can be made and there is no definite answer to the question which of these is conceptually and practically the best. The choice for SUT as core of the database leaves the choice of the technology assumption to the user of the data. After the choice has been made, the construction of an input-output model is then straightforward.

The national SUTs are supplemented by trade data in order to link the tables through bilateral trade flows. Each national SUT includes aggregate international trade flows. The national use table shows which products industries use, both domestically as well as foreign produced goods, which are imported. The national supply table represents the supply by domestic industries of products to both the domestic market and the international market. The international trade flows can be split from the domestic flows, which results in four tables; a domestic use table, an import use table, a domestic supply table, and an export supply table. The import use table is still aggregated over all countries of origin. Using international import statistics the import use table can be disaggregated into bilateral import use tables. Equivalently, the export supply table represents the supply to all foreign countries. In this case international export statistics can be used to disaggregate the export supply table into bilateral export supply tables.

However, several problems arise when using international trade statistics. First of all, the international trade data as represented in the SUT and in the trade statistics will not be (fully) consistent. Since the SUT are the most important building blocks of the ISUT and because SUTs harmonize their production, demand and trade data internally, the trade data of the international trade statistics will only be used as ratios. Second, in trade statistics the value of bilateral exports does not equal the value of bilateral imports that corresponds to the same trade flow (see Parniczky, 1980). There are several reasons for the discrepancy between these values; in order of systematic occurrence, these are differences in valuation (prices), transit trade, and differences in recording practices, and measurement errors. These discrepancies influence the data in the final tables in two ways. First, a choice has to be made whether international import data or export data is assumed to provide the most relevant information about the trade flows. This implies that only the import use table, or the export supply table, is disaggregated into bilateral trade flows, or both. Second, the inconsistencies that arise in the table that is disaggregated have to be resolved using a mechanical adjustment method.

In the rest of this paper the feasible construction methods of an ISUT are discussed in detail. In section 2 a description is given of the tables and data required for both of our trade-linking alternatives. The available tables that are used as basis of the international tables are briefly discussed. In addition, an overview of the valuation layers in international trade data is

given. These valuation layers are largely responsible for the complexity of the problem of trade-linking.

Section 3 covers the construction of the ISUT. Two alternatives are presented. Depending on the perceived reliability of the trade data, the foreign import statistics may be used to split up the import use tables, or the foreign export statistics may be used to split up the export supply tables. Both alternatives consist of three main stages. In the first stage the relevant trade ratios are applied in order to incorporate information on the origin or the destination of internationally traded products. The splitting up of the tables introduces inconsistencies with the information given in the import and export data in the SUT. In the second stage these inconsistencies are resolved using the generalized RAS method. In the last stage, the table that has not been disaggregated is split up using the implied trade ratios from the tables to which the generalized RAS has been applied.

In section 4 the assumptions regarding the production technology of the secondary and/or by-products are briefly discussed. After making a choice in this matter, an international input-output table can be constructed from the ISUT. This choice will not be made within the database, but will be left to final users.

In section 5 the actual process of the construction of the ISUT will be dealt with, using a sample set of European countries to obtain the first results of our trade-linking methodology. In this process several assumptions have been made that are described in this section complemented by a discussion of their implications. Our experiences indicate that the quality of the data obtained after trade-linking depends crucially on the tables started with.

Finally, the last section takes a forward view and indicates what still needs to be done and where improvements can be expected.

2. Starting point

The complete EXIOPOL database will encompass 43 individual countries and an additional 'Rest of the World' region. The classification used distinguishes between 129 industries and 129 products, leading to a squared set-up of the tables. However, the methodology described in this paper can be applied to rectangular SUTs as well.

The supply and use tables maintained by Eurostat (referred to as the ESA-95 tables) will be used as basis for the supply and use tables of the European Union countries. These tables will be disaggregated in industry and commodity classification from 59 to 129 industries and products. Additionally, the national SUTs will be split up in a domestic supply and an export supply table, and in a domestic use and an import use table. The standard format of the ESA-95

tables consists of national tables, with the use table in purchaser prices and the supply table in basic prices.

In Figure 1 a make table is depicted, which is just the transposed supply table. This layout is chosen as it better represents the conceptual idea of the supply table with industry origins on the rows and product destinations in the columns. The dimensions of our make table are therefore industry-by-commodity. In the national make table of country S all domestically used and exported products supplied by industries in country S are incorporated. In the national use table of country S , as depicted in Figure 2, all domestic and imported products that are used by industries in country S are incorporated. The international products first have to be separated from the domestic products, after which they can be assigned to a country of origin (for the used products) or a country of destination (for the supplied products).

	●	Σ
S	$V^{Sb\bullet}$	x^{Sb}
	m^{Sb} (=cif) (†)	
Σ	q^{Sb}	
	d^{SS}	
	t^{S}	
Σ	q^{Sp}	

(†) Imports in the make table can include re-exports, which may be negligible for many countries but will be sizeable for some countries (like the Netherlands)

Figure 1: Make table

	S			Σ
●	U^{Sp}	F^{Sp}	$e^{Sp\bullet}$ (=fob) (†)	q^{Sp}
	w^S			
Σ	x^{Sb}			

(†) Exports in the use table can include re-imports, which may be negligible for many countries but may be sizeable for some countries

Figure 2: Use table

The *notation* is the following. Both tables are for country S . A black dot (●) indicates a summation over all countries of the world including country S , while an open dot (°) indicates all countries except country S . The matrix V indicates the make table, with row totals x representing industry output. The vector m represents imports by commodity. The vectors d en t are the valuation vectors of domestic trade and transport margins, and domestic taxes and subsidies, respectively. The column totals q of the make table thus represent total supply of products. The superscripts b and p denote the valuation level of the respective part of the tables, with b referring to basic

prices and p referring to purchaser prices. These superscripts are placed to the right of the country they refer to. For example, the superscript Sb^{\bullet} represents the trade flows from country S to all countries in basic prices of country S . The matrix \mathbf{U} refers to the intermediate part of the use table. The matrix \mathbf{F} indicates the domestic final demand part of the use table and the vector \mathbf{e} denotes exports. The row vector \mathbf{w} denotes value added. The row totals \mathbf{q} of the use table represent total commodity demand and its column totals \mathbf{x} represent total industry input. The \mathbf{x} and the \mathbf{q} in the use table are equal to the \mathbf{x} and \mathbf{q} in the make table. These form the basic accounting identities in the SUT framework.

As indicated in the introduction, a discrepancy between international trade data exists due to a different valuation of the flows. In addition, the make table is valued in basic prices, while the use table is in general valued in purchaser prices. The valuation layers in domestic trade and in international trade are given in Table 1. In international trade five valuation layers are added to a product before it reaches the buyer in another country. To the basic price, that includes production costs and producer margins, taxes and subsidies, and domestic trade and transport margins are added to arrive at purchaser prices of the country of origin. This price equals the price that in international trade is referred to as ‘free on board’ (f.o.b.). During international transport, international trade and transport margins are added to this price, which is referred to as the ‘cost-insurance-freight’ (c.i.f.) price in the country of arrival (UN, 2004, par. 116). To get the products to the buyer another two valuation layers are added. These valuation layers have to be explicitly taken into account to solve the inconsistencies between trade data.

Table 1: Valuation scheme

Country	Domestic valuation	International trade (exports by R/imports by S)
R	Basic prices R	Basic prices R
R	+ Valuation layer: taxes and subsidies	+ Valuation layer: taxes and subsidies
R	+ Valuation layer: trade and transport	+ Valuation layer: trade and transport
R	<i>Purchaser prices R</i>	<i>= Exports f.o.b. R</i>
International		+ Valuation layer: international trade and transport margins
S	<i>Basic prices S</i>	<i>= Imports c.i.f. S</i>
S	+ Valuation layer: taxes and subsidies	+ Valuation layer: taxes and subsidies
S	+ Valuation layer: trade and transport	+ Valuation layer: trade and transport
S	Purchaser prices S	Purchaser prices S

The SUTs have to be harmonized in terms of classification, while the number of sectors, and products included has to be extended to 129 individual sectors and products. Most SUTs are made available with the make table in basic prices and the use table in purchaser prices. For modeling purposes it is essential that all ISUT sub-tables are denoted in basic prices, for only this valuation enables to allocate environmental impacts to the industries that actually are producing them. Using purchaser prices, for example, would allocate output related to transport and trade unjustly to the industries that produce the goods and services that are being transported and traded.

Partners in the project will undertake the detailing of the tables and the split of the use table in a domestic use table and an import use table – which will both be expressed in basic prices of the country using the products. This implies that the import use table will be in c.i.f. prices of the importing country, which is still several valuation layers apart from basic prices in the country of production.

In order to arrive at the use table in basic prices for each country included several methods can be used. Preferably, additional information about taxes and subsidies, and trade and transport margins of specific industries may be obtained from statistical offices or from other national data agencies. However, obtaining full information to construct these matrices is unlikely. Alternatively, the structure of the valuation matrices of the countries that do provide one, can be used in combination with the valuation vectors of taxes and subsidies and trade and transport vectors in the make table.

The only ESA-95 country that offers a split of the use matrix in basic prices into a domestic part and an import part is Spain. Here the same applies as for the valuation matrices; if additional information is available which will improve the split of the use table it should definitely be incorporated. For countries that are expected to have a similar import structure as Spain, the Spanish intermediate and final demand structure of import use may be applied in combination with the import vector by product from the make table.

All make tables are already expressed in basic prices, but no additional information regarding the domestic and export flows incorporated in the make table is available. The export make tables, required for trade-linking, are obtained by assuming that each industry exporting a certain product exports that product at the ratio given by aggregate export ratio of that product.

$$\mathbf{V}^{Sb^o} = \mathbf{V}^{Sb^*} \left(\hat{\mathbf{q}}^{Sb} - \hat{\mathbf{m}}_c^{oSb} \right)^{-1} \hat{\mathbf{e}}^{Sb^o} \quad \forall S \quad (1)$$

The domestic make table is obtained by deducting the export make table from the total make table.

$$\mathbf{V}^{SbS} = \mathbf{V}^{Sb\bullet} - \mathbf{V}^{Sb\circ} \quad \forall S \quad (2)$$

For international trade linking, the availability of valuation matrices of domestic trade and transport margins and of taxes on exports would enhance the information contained in the trade-linked tables. If no extra information is available the export make table in basic prices can be used equally well. Summarizing; to undertake the trade-linking methodology, for all countries included in the ISUT, there needs to be available at least a domestic use and an import use table in basic prices, and a make table in basic prices.

3. ISUT methodology

The aim of including international trade linkages in the supply-use framework is to be able to analyze international dependencies in production and the effects of final demand changes, both economically and environmentally, that cross national borders. The import use table and the export make table of a country show all international trade flows of a country with the rest of the world. The import use table shows products imported from all other countries by domestic industry of use and by domestic category of final demand, and the export supply table shows the products exported to all other countries by domestic industry of production. To trade link these tables information on the country origin of the products is needed to disaggregate the import use table, or the country destination of products is needed to disaggregate the export make table. This information can be obtained from international trade statistics, which records the type of product traded and the country of origin and destination of trade flows.

However, applying the trade data to disaggregate the import use and the export supply table introduces inconsistencies that arise from several sources. First of all, the SUT and the trade data are taken from different data sources that are in general not (entirely) consistent. Second, the imports and exports recorded in the SUT and the trade data are in different prices; imports include the international trade and transport margins, whereas exports exclude these margins (see Table 1). Third, there is a host of other sources of statistical discrepancies between import and export data that include, among others, misclassification, recording errors and lacking information.

To regain consistency within the framework of the ISUT the generalized RAS method (GRAS, Junius and Oosterhaven, 2003) can be used. RAS was originally used to update old input-output tables given new row and column totals (Stone, 1961). It is a bi-proportional

adjustment algorithm that balances matrices in a mechanical way. Its solution is equivalent to adding minimum information to the old table such that it just satisfies the new totals (see Bacharach, 1970, for an extensive treatment). Alternative objective functions may be used and the set of linear accounting constraints may be extended, leaving the main ingredients of the method the same. More advanced mathematical programming can be applied, but this will add in complexity and will go beyond a bi-proportional adjustment of the initial matrix. GRAS can be applied to any table (with positive and negative cells) for which an initial structure is given (or assumed), and new row and column totals are supplied, provided that the sum of the row totals and the sum of the column totals are equal.

In case of inconsistent bilateral export make and import use tables, import vectors may be used as column constraints for the bilateral make table and export vectors may be used as row constraints for the bilateral use matrix. Exports are in general valued in f.o.b. prices and import in c.i.f. prices. The fact that the sum of the column constraints over all countries combined has to equal the sum of the row constraints over all countries combined does not introduce a major problem, because the total value of products traded in f.o.b. prices should be close to the total value of products traded in c.i.f. prices. The difference in principle only consists of international trade and transport margins. However, these margins are recorded as exports of the trade and transport service industries of those countries that specialize in the production of these services, whereas they are recorded as part of the import value of each and every traded commodity by importing country.

The basic idea is to use the export f.o.b. values to redistribute the transport and trade margins included in the import c.i.f. values to the countries and sectors that really produce these services. To complicate matters, the export of trade and transport margins by country R does not only relate to the exports of its own products, but also includes services supplied by country R for the import of commodities into R and services supplied to the trade of commodities between third countries. These two complications mean that using GRAS to re-price the imports of country S from c.i.f. prices to f.o.b. prices may lead to overestimation of the bilateral trade and transport margins related to the export of commodities by R to S . However, trade and transport services related to the imports of S can also be provided by S itself or by any third country, leading to an underestimation of the margins on the exports of R to S . The over- and underestimation of the trade and transport margins on the exports of R to S will at least partially cancel out.

In case of the disaggregated use tables, imposing an export constraint in f.o.b. prices results in a reduction in the product prices and an increase in the exports of trade and transport

services. The fact that the total of products imported is still valued in c.i.f. prices is consistent with the redistribution of the trade and transport margins.

Turning to the disaggregated export make table, applying GRAS to this table would imply using a commodity import vector as a column constraint. However, in that case imposing an import vector in c.i.f. prices along with the total export vector (by industries) in f.o.b. prices by means of GRAS would result in a revaluation of the bilateral export make table to c.i.f. prices. This pricing layer is further away from basic prices and would contaminate the information on the product export flows with trade and transport margins. As this is highly undesirable, and since there is no information to obtain import vectors in f.o.b. prices, the bilateral export make matrices cannot be subjected to GRAS.

Due to the lack of information on international trade and transport margins, and the resulting implication that GRAS can only be applied to the disaggregated import use table, a choice has to be made whether import statistics are used to disaggregate the import use table, or export statistics are used to disaggregate the export make table. The subsequent steps taken after a choice is made to either disaggregate the import use table or the export make table are described in the next sections. In fact, applying both methods separately will give a good indication of size the errors instead of hiding them from the user.

International import use table

If the choice is made to use import statistics, the import use table is disaggregated using the import ratios. First, if any duties and import commodity taxes levied in country S are included in the $\left[\mathbf{U}^{\circ Sb} ; \mathbf{F}^{\circ Sb} \right]$ table these are to be removed and aggregated in a row (or matrix for transparency) that will be added to the primary input block of the international use table. To disaggregate the import use tables the import ratios from the import statistics are used:

$$r_{c\bullet}^{RS} = m_{c\bullet}^{RS} / m_{c\bullet}^{\circ S} \quad \forall R \neq S \quad \forall S \quad (3)$$

For each country S there will be in 42 vectors \mathbf{r}^{RSb} , one for each trading partner R . These vectors are based on the EXIOPOL product classification. The bilateral import use matrices are calculated by applying the import ratios to the rows of the import use tables:

$$\left[\mathbf{U}^{RSb} ; \mathbf{F}^{RSb} \right] = \hat{\mathbf{r}}^{RSb} \left[\mathbf{U}^{\circ Sb} ; \mathbf{F}^{\circ Sb} \right] \quad \forall R \neq S \quad \forall S \quad (4)$$

The proportionality assumption made here is that each industry and each final demand category in country S imports the same share of product i from country R . Each of the import use matrices is in basic prices (c.i.f. prices as it concerns imports) of country S .

The import use table of the rest of the world W is obtained by deducting all bilateral import use tables from the aggregate import use table of country S .

$$\left[\mathbf{U}^{WSb} : \mathbf{F}^{WSb} \right] = \left[\mathbf{U}^{\circ Sb} : \mathbf{F}^{\circ Sb} \right] - \sum_{R \neq S \neq W} \left[\mathbf{U}^{RSb} : \mathbf{F}^{RSb} \right] \quad \forall S \quad (5)$$

Splitting up the import use tables using the import ratios and combining the disaggregated import tables of the different countries results the disaggregated table import use table \mathbf{U}^* shown in Figure 3. Again, the letters A , B , and C , denote individual countries, while W represents the rest of the world. The vertical summation of tables produces the original import use tables.

The import use tables are split up vertically. However, the table can also be interpreted horizontally. The first row of tables all indicate the use of products produced by A in the 42 countries included in the EXIOPOL project. The row totals of the bilateral import use table can therefore be interpreted as the exports of country A per product to the included countries. The implied export vector as derived from the disaggregated import use tables is denoted by $\bar{\mathbf{e}}_c^{R\otimes}$.

$$\bar{\mathbf{e}}_c^{R\otimes} = \sum_{S \neq R \neq W} \left[\mathbf{U}^{RSb} : \mathbf{F}^{RSb} \right] \mathbf{i} \quad \forall R \quad (6)$$

This aggregated value will not be equal the exports of country A to the included countries that may be derived from the national use table. To regain consistency and to re-price the imports from c.i.f. values to f.o.b. values, GRAS will be applied to the bilateral import use table for the included countries in Figure 3.

First, its column total will be equal to the total use of imports by industries (i) and final demand categories (k , both used as subscripts) from all included countries of origin and all products.

$$\mathbf{m}_{ik}^{\otimes S} = \mathbf{i} \left[\mathbf{U}^{\otimes Sb} : \mathbf{F}^{\otimes Sb} \right] = \mathbf{i} \sum_{R \neq S \neq W} \left[\mathbf{U}^{RSb} : \mathbf{F}^{RSb} \right] \quad \forall S \quad (7)$$

	A	B	C	40x
A	O	B cif	C cif	
B	A cif	O	C cif	
C	A cif	B cif	O	
40x	A cif	B cif	C cif	
W	A cif	B cif	C cif	cif
Σ	A cif	B cif	C cif	cif

Figure 3: International import use table

The total of the use of products by all included countries produced by R , which are the implicit exports $\bar{\mathbf{e}}_c^{R\otimes}$, should be equal to the exports of R to all included countries. The national use table of each country R includes, next to the final demand categories, a vector with total exports from R to the world. (See Figure 3). Using export trade ratios the bilateral export vectors to all included countries are obtained and then summed to arrive at the export vector of R to all included countries. First the export trade ratios are obtained from the export statistics.

$$s_{i\bullet}^{RS} = e_{i\bullet}^{RS} / e_{i\bullet}^{R\circ} \quad \forall S \neq R \quad (8)$$

There will be in total 42 vectors \mathbf{s}^{RS} , one for each trading partner of county R , with export ratio data for each country R . Pre-multiplying the total export vector by the (diagonal) export ratios vector results in the bilateral export vectors that are summed into the export vector of R to all included countries.

$$\mathbf{e}_c^{R\otimes} = \sum_{S \neq R \neq W} \mathbf{e}_c^{RS} = \sum_{S \neq R \neq W} (\hat{\mathbf{s}}^{RS} \mathbf{e}_c^{R\circ}) \quad \forall R \quad (9)$$

The structure of this vector is used to re-price the bilateral import use table of the included countries. The rescaled vector $\tilde{\mathbf{e}}_c^{R\otimes}$ is used as row constraint in the RAS procedure:

$$\tilde{\mathbf{e}}_c^{R\otimes} = \mathbf{e}_c^{R\otimes} \mathbf{i}' \bar{\mathbf{e}}_c^{R\otimes} (\mathbf{i}' \mathbf{e}_c^{R\otimes})^{-1} \quad \forall R \quad (10)$$

The difference between the implicit exports column $\bar{\mathbf{e}}_c^{R\otimes}$ in c.i.f. prices, and the export column $\mathbf{e}_c^{R\otimes}$ in basic prices, indicates the overall discrepancy between the two export vectors. This overall discrepancy consists of two parts. The first part is the difference between the implicit export column $\bar{\mathbf{e}}_c^{R\otimes}$ and the export vector used as constraint $\tilde{\mathbf{e}}_c^{R\otimes}$, which contains information about the valuation layer of international trade and transport. The difference between the constraint $\tilde{\mathbf{e}}_c^{RS}$ and the export column $\mathbf{e}_c^{R\otimes}$ is the statistical discrepancy between the vectors. This column is included in the framework as an extra column to account for the difference between the total value of the RASed use tables and the export column $\mathbf{e}_c^{R\otimes}$. This statistical discrepancy vector contains, next to recording errors in the trade statistics, taxes levied in R on its exports.²

The international use table obtained after GRAS has been applied contains consistent export shares of goods to industries in other countries. These implicit export shares can be applied to the export make table of a country in order to split it up in bilateral export make tables. However, it is important to note that the implicit export shares from the international use table represent the shares of domestic goods supplied to foreign industries (without reference to the industry of origin). In a bilateral make table the export shares represent the goods exported by domestic industries (without reference to the industry and final demand of destination). Using these implicit export ratios to disaggregate the export make table, implies making the assumption that each country imports a commodity from each of the different industries that produce it with the same ratio (= market share of industry i in the exports of commodity c).

² In case information on taxing of exports in county R is known, the taxes can be deducted from the use tables and added as a row vector underneath the use tables. In this case the taxes are kept outside of the RAS procedure. As a result the statistical discrepancy vector should contain smaller values.

International export make table

If the choice is made to use the export data, the first step in the trade-linking process is to disaggregate the export make table. Information in this table can then be used to reevaluate the aggregate import use matrices of the countries into f.o.b. prices, reallocating the international trade and transport margins to the sectors that supply these services.

The export make table can be split up in bilateral export make tables using the export shares derived from export statistics as calculated in (20). To obtain the bilateral export make matrices the export ratios are applied to the columns of the export supply tables:

$$\mathbf{V}^{RbS} = \mathbf{V}^{Rb\circ} \hat{\mathbf{S}}^{RS} \quad \forall R \quad \forall S \neq R \quad (11)$$

The ‘Rest of the World’ can be calculated by taking the difference between the original table and the summation of all included country tables.

$$\mathbf{V}^{RbW} = \mathbf{V}^{Rb\circ} - \sum_{S \neq R \neq W} \mathbf{V}^{RbS} \quad \forall R \quad (12)$$

Each of the bilateral export matrices are concatenated horizontally into the matrix \mathbf{V}^* , of which each country block row has as dimensions 131 by 44 x 131, with an empty block on the diagonal. Each of these country row blocks are in basic prices of the country of origin.

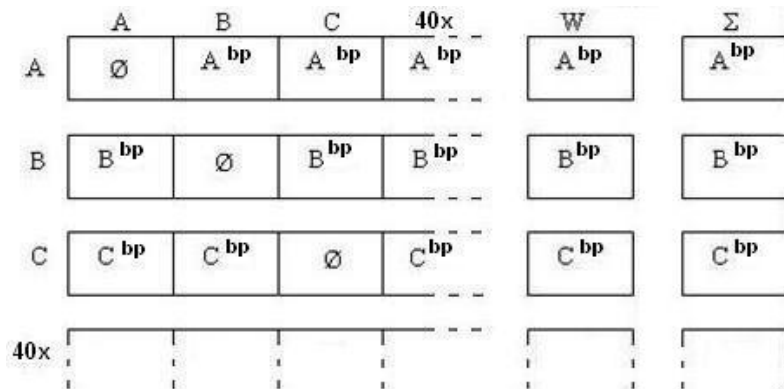


Figure 4: International export make table

The international export make table is represented in Figure 4. In this figure the letters A, B, and C, denote individual countries, while W represents the rest of the world. The horizontal

summation of the tables over the included countries and the rest of the world equates the original export make table per country.

Summing the matrices vertically, per country of destination, results in a row with the total of the imports from the included countries, i.e. excluding the imports from W, $\mathbf{m}_c^{\otimes S} = \mathbf{i}' \sum_{R \neq S \neq W} \mathbf{V}^{RbS}$, in basic prices of the exporting countries. This vector contains information about the structure of import of country A valued in basic prices.

The row totals of the aggregate import use table of country S , give the import vector in c.i.f. prices.

$$\bar{\mathbf{m}}_c^{\otimes S} = [\mathbf{U}^{\otimes Sb} : \mathbf{F}^{\otimes Sb}] \mathbf{i} \quad \forall S \quad (13)$$

Using the structure of the import vector $\mathbf{m}_c^{\otimes S}$, derived from the disaggregated export supply tables in combination with the overall total value of the use table, the column with row constraints for the aggregate import use table is found:

$$\tilde{\mathbf{m}}_c^{\otimes S} = \mathbf{m}_c^{\otimes S} \mathbf{i}' \bar{\mathbf{m}}_c^{\otimes S} (\mathbf{i}' \mathbf{m}_c^{\otimes S})^{-1} \quad \forall S \quad (14)$$

Analogue to the first method, the difference between the import vector $\bar{\mathbf{m}}_c^{\otimes S}$ in c.i.f. prices, and the import vector $\mathbf{m}_c^{\otimes S}$ in f.o.b. prices gives the overall discrepancy. This overall discrepancy is sum of the revaluation column and a statistical discrepancy column. The difference between the row totals of the original use table $\bar{\mathbf{m}}_c^{\otimes S}$, and the row totals of the RASed use table, $\tilde{\mathbf{m}}_c^{\otimes S}$, contains information about the trade and transport margins related to all imports of country S . The difference between the vector used as constraint $\tilde{\mathbf{m}}_c^{\otimes S}$ and the actual values $\mathbf{m}_c^{\otimes S}$ is stored in the final use table as a statistical discrepancy column.

The reason for rescaling the export column in the use table and not the import row in the make table is due to the fact that the inclusion of a rescaling row to the make table would distort the market coefficient part of the input coefficients in the input-output model. After these preparatory steps the GRAS algorithm can be applied.

The use of the structure of the vector of imports of country A in basic prices results in a revaluation of the import use matrix after the GRAS method has been applied. During GRAS the

values of the products are lowered by the amount of trade and transport margins needed to transport the product from the producer to the border of country A. The entries for the trade and transport service sectors are increased by the trade and transport margins deducted from the products. See Figure 5. Each import use table of all 43 countries needs to be revalued so GRAS has to be undertaken 43 times. Leaving the ‘rest of the world’ out of the GRAS procedure assumes that the trade between the countries included in the ISUT is balanced. In our case we include all large countries, and most of world trade takes place among these countries.

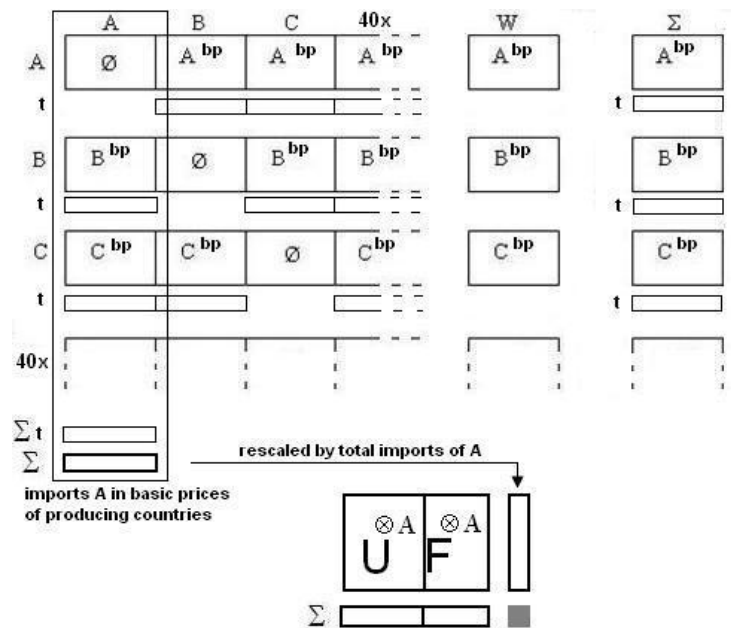


Figure 5: International export make table and revaluation of use matrix

Using the total of the import use table to rescale the import vector obtained from the export make matrices in basic prices, see (26), will increase the value of the imports as the taxes do not balance out. Alternatively, if information on the taxes levied on the exports of the countries is known, these can also be split up into bilateral vectors using the export ratios. Adding these bilateral vectors vertically a row vector of taxes is obtained, which represents the taxes levied in all included countries that a country imports from. See also Figure 5. The information in this column can be used to rescale the use table, i.e. to peel off the valuation layer of taxes. This matrix will be inserting underneath the table, and the new overall total of the use table will be used to rescale the vector with import row constraints as given in (26). This procedure will result in a final import use table in basic prices.

As a last step, analogous to the case of the bilateral import use table, the implied import ratios of the export make table may be applied to the above calculated aggregate import table to come to a second estimate of a bilateral import table.

To evaluate the *partitive* accuracy of the two estimation procedures it is best to compare the bilateral commodity totals of the trade between each pair of included countries in the two bilateral export make tables and the two bilateral import use tables, calculated with the two different procedures (see for the distinction between partitive and holistic accuracy, Jensen, 1980).

4. International input-output model

Transforming make tables and use tables into an input-output model requires the assumption of a production technology for the secondary products and by-products. This production technology can be the *commodity technology*, which holds that all commodities that are alike are produced using the same technology irrespective of the industry where this production takes place. Alternatively the *industry technology* can be assumed which results in the assumption that all secondary products are produced with the technology of the industry that produces them, which is especially in case of by-products a plausible assumption. There is quite some literature on the preferred and acceptable assumption regarding the production technology (see for example Kop Jansen and ten Raa, 1990; De Mesnard, 2004). Theoretically, the commodity technology assumption is the preferred one. However, it requires the make table to be square in order for it to be inverted to arrive at the input-output model. Also it often results in negative values, which is undesirable as negative inputs do not exist. The industry technology assumption does not require a square table and does not result in negative values. Therefore this technology is often applied even though it is theoretically inferior.

Using either one of these technology assumptions, there are two different input-output tables that can be constructed; the commodity-by-commodity table, and the industry-by-industry table. For each for of these cases the matrix with technical coefficients is derived using a different calculation. See Box 1. The full international use table and the full international make table, both in basic prices of the country of origin, can be used alternatively in each of these calculations, in which case they have to be combined with, respectively, the aggregate export make table and the aggregated import use table. For the domestic part of the international input-output table, in both cases the domestic use table has to be combined with the domestic make table.

To evaluate the *holistic* accuracy of the two estimation procedures the outcomes of the national multipliers and international spillover effects from (15) calculated with respectively the bilateral import use table and with the bilateral export make table can be compared.

Box 1: Technical coefficient matrices in four different input-output models

Input-output model – technical coefficient matrices (Miller and Blair, 1985)			
U = use table (com * ind), and V = make table (ind * com)			
<i>Commodity technology assumption</i>			
com * com	=	$\mathbf{U}(\hat{\mathbf{x}})^{-1} \hat{\mathbf{x}}(\mathbf{V}')^{-1}$	(15)a
ind * ind	=	$\hat{\mathbf{x}}(\mathbf{V}')^{-1} \mathbf{U}(\hat{\mathbf{x}})^{-1}$	(15)b
<i>Industry technology assumption</i>			
com * com	=	$\mathbf{U}(\hat{\mathbf{x}})^{-1} \mathbf{V}(\hat{\mathbf{q}})^{-1}$	(15)c
ind * ind	=	$\mathbf{V}(\hat{\mathbf{q}})^{-1} \mathbf{U}(\hat{\mathbf{x}})^{-1}$	(15)d

5. Data construction process

– first preliminary results: do not quote –

In this section a description is given of the necessary steps in order to undertake trade-linking and an overview is given of the first preliminary results of the actual trade-linking and the assumptions made to arrive at these results.

In order to undertake trade-linking, first suitable trade data have to be gathered and reclassified. The specific data used is from the ‘NBER-United Nations Trade Data, 1962–2000’ database (Feenstra, 2005).³ A bridge matrix between the classification of the data; the Standard International Trade Classification (SITC) Revision 2, and the classification of the EXIOPOL tables has been made. The product classification used in the EXIOPOL tables is the Classification

³ Accessible at <http://cid.econ.ucdavis.edu/data/undata/undata.html>, last accessed 1st of June 2009.

of Products by Activity (CPA) 2002, in which some extra codes are introduced to cater for more detail in environmentally important products and sectors. This bridge matrix has been constructed by comparing the detailed classifications as well as using several bridge matrices that map the SITC Rev. 2 to the CPA 2002 classification. Both results have been merged into the final bridge matrix **B**:

$$m_{EXIOPOL}^{rs} = B m_{SITC}^{rs}, \forall r \neq s \quad (16)$$

With $b_{EXIOPOL,SITC} = 1$ if a certain SITC-subsector belongs to the aggregate EXIOPOL-sector and $b_{EXIOPOL,SITC} = 0$ if that subsector does not belong to the aggregate EXIOPOL-sector at hand. **B** has been used to reclassify the foreign trade data into the desired classification

The database specified in the previous paragraph only contains trade data for goods. The UN Service trade database⁴ is the most encompassing database of trade in services. However, due to large variance in the data present and the less obvious link to the services as included in the EXIOPOL supply and use tables, these data are not ready to be integrated in the trade-link procedure yet. Instead a very general and extensively applied assumption is used for the moment; for each of the services industries it is assumed that the trade ratios of the services correspond to the ratios of all goods taken together. Especially in case of trade and transport services this assumption is quite reasonable. In due time the ratios obtained by this assumption will be replaced by ratios derived from the data available in the UN Service trade database to the extent the required information is present.

As described in section 2, the SUTs required for trade-linking are the import use table, and the export supply table, both in basic prices. Some of these tables include a transit trade column (in case it was recorded in the original table). No specific attention is given to this column as it represents goods that are only passing through a country. These trade flows are exported from a country, where they are also recorded, and after transit they are recorded in another country as imports that have reached their final destination. To include this column would lead to double-counting of the flow. In case this transit trade column is present, instead of using the column with total exports, total exports minus transit trade is used in the trade-linking procedure.

In the process of trade-linking two sources of trade data are combined. First, trade data is included in the SUTs, although aggregated regarding geographical origin (in case of imports) and

⁴ See <http://unstats.un.org/unsd/ServiceTrade/default.aspx>, last accessed on 1st of June, 2009.

destination (in case of exports). Second, trade data are used to obtain information about the geographical origin and destination of the trade flows in the supply and use tables. These two sources of data contain discrepancies that are most notable in case one source indicates a flow taking place while the other source does not contain any information regarding this flow. This type of problem will be referred to as *zero-inconsistency*.

These zero-inconsistencies arise at both stages of the trade linking. First, when splitting up the tables using trade ratios, the trade value from the supply or use table may be zero while the trade ratios indicate trade flows. Alternatively, the trade ratios may be zero for each partner country included in the dataset, while the supply or use table does report a trade value. In the first case, the zero trade flow in the supply or use table is given priority and the trade ratio is effectively set to zero. In the second case, the value reported in the supply or use table is not assigned to any of the partner countries in the database, but to the ‘rest of the world’ that is computed as the residual. After each of the bilateral use or supply tables is computed the ‘rest of the world table’ is obtained by taking the complete import use, or export supply table and subtracting all bilateral tables obtained after applying the trade ratios.

Zero-inconsistencies can also arise at the balancing stage of trade-linking. First, it may be that a row in the table to be balanced contains trade values while the constraint used for this row is zero. Second, a specific row in the table may contain only zeros while the constraint used for this row is not equal to zero. In the first case, the GRAS algorithm automatically sets all values in the row equal to zero as result of the zero constraint. In the second case, the value of the constraint can be set to zero, which implies that it is assumed that the value actually corresponds to a trade flow with ‘the rest of the world’.

Each of these solutions at both stages requires least effort as most of them do not require specific action. Only in case a constraint has a value unequal to zero, while the supply or use tables only contain zeros trade values for this specific product, the constraint has to be actively set to zero. As the database construction is still in progress, these solutions will be reconsidered and any arising zero-inconsistencies will be communicated to the partners that have constructed the supply and use tables in order to arrive at more deliberate solutions.

The constraints used in trade-linking have to be rescaled as the overall total of the table to be balanced and the total value of the constraint do not match exactly. A necessary condition for convergence of the GRAS procedure is the match between these two values. For both the trade-linking of the use tables as well as the trade linking of the supply tables, the constraint of the rows (of the use table) is rescaled. The rescaling factors applied contain information regarding the quality of the data. Table 2 shows that the rescaling factors for the second method (of

disaggregation of the export supply tables) tend to be lower than the single rescaling factor for the first method (of disaggregation on the import use tables). In the case of Ireland, however, the value of imports according to the other country's export supply tables is far larger than the imports in Ireland's total import use table. This calls for further investigation. The same holds to a lesser extend for the reverse case of Germany. Here the relative down scaling of other country's exports to Germany with 0.78 is smaller, but in view of the size of the German economy this problem is equally serious as that for Ireland.

Table 2: Rescaling factors

Country	Rescaling factor
All countries – GRAS of all bilateral import use tables simultaneously	0.88
GRAS of the total import use tables (using import information from the bilateral supply tables):	
Austria	1.02
Estonia	1.02
Germany	0.78
Hungary	1.02
Ireland	1.54
Italy	1.00
Lithuania	0.89
Netherlands	0.82
Poland	1.09
Slovak Republic	1.01

In Table 3 the first results of a comparison of both methods are given. The overall trade value of exports originating from all A imported by all B as found in the bilateral use table and the bilateral supply table after rescaling and applying GRAS is recorded. For each country the third column gives the value of the correlation coefficient of the two vectors with traded products that represent the same bilateral trade flow. In a lot of the cases the difference between the two methods seems to be relatively small, i.e. smaller than 10%. In case of the largest bilateral flow from the Netherlands to Germany, however, we observe a quite large difference of 31%. More reassuring is the fact that the two methods produce product-by-product distributions that are quite close in R^2 in case of the bilateral trade relations of the larger countries.

Table 3: Comparison of bilateral results of the two trade-linking methods

	Austria			Estonia			Germany			Hungary			Ireland		
	use	supply	corr	use	supply	corr	use	supply	corr	use	supply	corr	use	supply	corr
Austria	-	-	-	50	43	0.97	25924	33456	0.99	4049	3746	0.96	344	183	0.71
Estonia	28	25	0.96	-	-	-	322	417	0.99	27	27	0.96	24	17	0.83
Germany	29328	31074	0.99	403	448	0.95	-	-	-	7853	9428	0.97	3864	3263	0.74
Hungary	2746	2351	0.98	20	20	0.99	8840	11440	1.00	-	-	-	362	318	0.99
Ireland	760	551	0.98	41	31	0.94	10406	12518	1.00	365	365	0.92	-	-	-
Italy	7472	6053	0.98	155	127	0.96	31436	42260	0.99	3156	2986	0.95	2820	1572	0.52
Lithuania	48	38	0.98	0	0	-	642	835	0.99	9	10	0.81	47	34	0.70
Netherlands	2878	2670	0.98	122	113	0.89	45553	59550	0.97	825	880	0.87	3325	1777	0.70
Poland	1788	1460	0.94	142	153	0.86	18435	23588	0.97	1174	1394	0.83	283	218	0.58
Slovak_Re	1223	1190	0.93	3	4	0.91	3099	4261	0.99	759	808	0.94	29	21	0.66
	Italy			Lithuania			Netherlands			Poland			Slovak Republic		
	use	supply	corr	use	supply	corr	use	supply	corr	use	supply	corr	use	supply	corr
Austria	10101	9512	0.90	46	53	0.93	1534	1687	0.90	1865	1521	0.93	815	756	0.91
Estonia	55	53	0.90	0	0	-	171	206	0.97	68	48	0.93	6	6	0.97
Germany	45271	49021	0.98	728	923	0.92	23146	31844	0.95	12467	14029	0.94	3082	3675	0.98
Hungary	2021	1909	0.97	46	45	0.98	968	1413	0.94	1069	903	0.97	304	277	0.95
Ireland	4585	4220	0.93	15	12	0.96	2689	4004	0.92	497	361	0.97	55	53	0.96
Italy	-	-	-	198	245	0.96	4475	5122	0.93	5960	5304	0.95	1055	966	0.93
Lithuania	176	152	0.76	-	-	-	102	135	0.80	250	249	0.74	4	5	0.94
Netherlands	18103	16450	0.91	206	163	0.78	-	-	-	2461	2322	0.88	426	261	0.43
Poland	5327	4742	0.94	808	1029	0.83	2577	2600	0.64	-	-	-	1042	788	0.70
Slovak_Re	1498	1398	0.93	18	21	0.91	203	229	0.56	996	991	0.91	-	-	-

6. Conclusion

This paper presents the methodology of the construction of an international supply and use table (ISUT). As the ISUT forms the core of the EXIOPOL database, this paper's main goal is to enhance transparency in the construction of the database. Important elements in this exposition concern the assumptions made in this construction process and the issue of valuation layers. Several information sources are combined to construct full international make or use tables although these full tables do not represent full information. In general, the proportionality assumption is needed to complement the limited information available.

As a first step, some of the possible assumptions are presented that can be used to prepare the national make and use tables such that they can be internationally linked. The actual linking methodology consists of two steps. In the first step trade ratios are applied to the tables in order to add the missing geographical dimension. Each country's import use table or export make table are split into 42 different individual countries and a 'rest of the world' region. In the second step the consistency of the international trade flows is regained by adjusting the total import use table (in case export ratios are used to split up the export make table) or adjusting the bilateral import use tables (in case import ratios are used to split up the import use table).

This project is very ambitious, especially in terms of the amount of data incorporated. The basic algorithms given in this paper have been programmed and tested on a set of preliminary country tables of 10 European countries. The actual construction of the 10-country ISUT uncovered data problems that were only not, or only partly, foreseen. Some of these problems are due to the preliminary status of the tables that were used in the trade-linking process and will be handled in due time through communicating discrepancies in SUT data and trade data to partners and through improvement of the tables by partners. In the construction process assumptions have been used that need further thought regarding implications and possible improvements.

At this point the methodology is based on choosing either the export data or the import data to disaggregate the corresponding tables. It is important to note that the disaggregated import use tables will imply different import and export ratios than the export make tables that are disaggregated using export data. Further attempts will be made to integrate all data sources to arrive at consistently disaggregated import use tables and export make tables at the same time. However, using both import and export data is only considered to add value if there is additional information contained in the added trade data that can be reconciled with primary trade data used.

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