PROJECT N. 037033

EXIOPOL

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

METHOD FOR TRADE LINKING DESCRIBED

Report of the EXIOPOL project

Title	Method for trade linking described
Purpose	Deliverable of WP III.4.a
Filename	DIII.4.a-2_TradeLinking_June08_MCB_JO.doc
Authors	Maaike C. Bouwmeester & Jan Oosterhaven
Document history	-
Current version.	Final
Changes to previous version.	-
Date	15.06.2008
Status	Final
Target readership	EXIOPOL project group
General readership	-
Dissemination level	Internal document

Maaike C. Bouwmeester & Jan Oosterhaven
Rijksuniversiteit Groningen (RuG) – University of Groningen

June 2008

Deliverable title: Method for trade linking described
Deliverable no. : DIII.4.a-2
Due date of deliverable: Month 14
Period covered: from 1st March 2007 to 1st May 2008
Actual submission date: 15.06.2008
Start of the project: 01.03.2007
Duration: 4 years
Start date of project: 01.03.2007
Project coordinator: Arnold Tukker
Project coordinator organisation: FEEM

Executive summary

The EU-funded EXIOPOL project has as main objective to create an environmentally extended input-output database. Instead of focusing on symmetric input-output tables, the core of the database will be formed by trade-linked national supply and use tables (SUTs). SUTs have not yet been used as framework in international databases even though they are superior for statistical reasons. To provide a methodological basis, this paper describes two methods to construct an international supply-use table. The initial requirements are specified, accompanied by an indication of the non-survey methods that can be used to link the national SUTs by means of international trade data. The trade-linking process consists of three main steps. The first step is the split-up of either the import use table or the export supply table into bilateral use or supply tables, using the relevant ratios derived from trade statistics. The choice to disaggregate either the import use table or the export supply table depends on which trade data are assumed to contain the most realistic information regarding international trade flows. For either choice, the second step is to reconcile international commodity trade flows contained in the import use tables by applying a generalized RAS method. This method results in a revaluation of the import trade flows, separating international trade and transport margins from the products values and assigning them to the sector that supplies these services. In the last step, the companion table that has not been disaggregated is split up using the implied trade ratios from the tables to which generalized RAS has been applied. The paper thus develops a methodology for dealing with the valuation layers of taxes, subsidies, and trade and transport margins that are added to products when they are traded internationally, and produces two international SUTs that can be compared to gauge the estimation errors involved.

Table of contents

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 of the project 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 tables (industry-by-product) and 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 in the EU, due to the economic integration, 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 distribute 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 is to assign the production of goods to the correct countries and industries, according to the technologies actually used.

Databases designed for this kind of purposes often have a core of input-output tables. The SUT framework has as advantage that it is closer to the data recording process and that more information can be incorporated in these tables. Also, international trade data is not registered by industry but by product classifications. 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 setup over the Global Trade Analysis Project (GTAP) database (Dimaranan, 2006), which uses input-output tables as its base. In other respects the two databases are quite close, for example in coverage and possible applications[1]. 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 SUTs requires an explicit assumption regarding the production technology of secondary and/or by-products of industries, instead of the 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 that are imported. The national supply table represents the supply by domestic industries of products to both the domestic market as well as 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.

---

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

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. As the SUT are the most important building blocks of the ISUT, the trade data of the trade databases 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 the available tables that are used as basis of the international tables are briefly discussed. In addition, an overview of the valuation layers present in international trade is given. These valuation layers are largely responsible for the complexity of the problem of trade-linking.

In section 3 the preparatory stages are described that cover the transition from the basic tables (for example the ESA-95 tables) to the tables that can be used in the international trade-linking procedure. The use of additional information is preferred in these transitions, although in case of lack of data non-survey assumptions can be made to arrive at the required tables. As the availability of additional data per country is unknown to us, fully mechanical methods are provided.

Section 4 covers the construction of the ISUT. Two alternatives are presented. Depending on the perceived reliability of the trade data, the import statistics may be used to split up the import use tables, or the 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 5 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.

Finally, the last section concludes and stresses some of the important assumptions that have been made in the construction of the ISUT.

2 Starting point

The EXIOPOL project will encompass 43 individual countries and an additional 'Rest of the World' region. The classification used distinguishes between 131 industries and 131 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 131 industries and products. Additionally, the national SUTs will be split up in a domestic and an export supply table, and in a domestic 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 lay-out 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).

(†) 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

(†) 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 ($\cdot$) indicates a summation over all countries of the world including country S, while an open dot ($\circ$) indicates all countries except country S. The matrix $\mathbf{V}$ indicates the make table, with row totals $\mathbf{x}$ representing industry output. The vector $\mathbf{m}$ represents imports by commodity. The vectors $\mathbf{d}$ en $\mathbf{t}$ are the valuation vectors of domestic trade and transport margins, and domestic taxes and subsidies, respectively. The column totals $\mathbf{q}$ 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 subscripts are placed to the right of the country they refer to. For example, the superscript $Sb\cdot$ 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	Purchaser prices R	= Exports f.o.b. R
International		+ Valuation layer: international trade and transport margins
S	Basic prices S	= Imports c.i.f. S
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

3   Preparatory work

In section 4 it is assumed that some preparatory work has been undertaken. The tables will have to be harmonized in terms of classification and the number of sectors and products included has to be extended to 131 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. The preparatory work is described separately for the use and make table.

3.1 Use table

As a first step the use table has to be transformed to basic prices. Taxes and subsidies on domestic production and tariffs and taxes on imported products have to be deducted from each element of intermediate and final demand. This will result in a domestic tax and subsidy matrix:

$$\mathbf{T}^{\bullet S} = \left[\mathbf{T}_{\mathbf{U}}^{\bullet S} \vdots \mathbf{T}_{\mathbf{F}}^{\bullet S} \vdots \mathbf{t}_{\mathbf{e}}^{S \circ} \right] \qquad \forall S \tag{1}$$

Note that $\mathbf{t}_{\mathbf{e}}^{S \circ}$ represents taxes levied by country S on goods and services that are exported.

Trade and transport margins also have to be deducted from each element of intermediate and final demand in which they are included and have to be ascribed to the trade and transport sectors. This results in a margins table that has positive entries in all cells where trade and transport margins are to be deducted and negative values in the rows that denote the trade and transport sectors:

$$\mathbf{D}^{\bullet S} = \left[\mathbf{D}_{\mathbf{U}}^{\bullet S} \vdots \mathbf{D}_{\mathbf{F}}^{\bullet S} \vdots \mathbf{d}_{\mathbf{e}}^{S \circ} \right] \qquad \forall S \tag{2}$$

Note that $\mathbf{D}^{\bullet S}$ applies to all products domestically produced, imported and exported, but only contains the trade and transport margins incurred *inside* country S.

The use table in basic prices then shows which products are used by which industries:

$$\left[\mathbf{U}^{\bullet Sb} \vdots \mathbf{F}^{\bullet Sb} \vdots \mathbf{e}^{Sb\bullet}\right] = \left[\mathbf{U}^{\bullet Sp} \vdots \mathbf{F}^{\bullet Sp} \vdots \mathbf{e}^{Sp\bullet}\right] - \mathbf{T}^{\bullet S} - \mathbf{D}^{\bullet S} \qquad \forall S \qquad (3)$$

These products can be domestically produced, in which case they are in basic prices, or they can be imported, in which case they are in c.i.f. prices. These two prices are equivalent in the country S where the products are used.

Most ESA-95 use tables are in purchaser prices. Four countries (Belgium, Denmark, Finland and Spain) also present a use table in basic prices, and the first three countries include valuation matrices; the tax and subsidies matrix and the trade and transport margins matrix. In order to arrive at the use table in basic prices for the other countries 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 least data intensive method is using the structure of the intermediate and final demand tables to proportionally distribute the valuation vectors. In this case $\mathbf{T}^{\bullet S}$ and $\mathbf{D}^{\bullet S}$ are calculated using:

$$\mathbf{T}^{\bullet S} = \hat{\mathbf{t}}^{\bullet S} \left(\hat{\mathbf{q}}^{Sp}\right)^{-1} \left[\mathbf{U}^{\bullet Sp} \vdots \mathbf{F}^{\bullet Sp} \vdots \mathbf{e}^{Sp\bullet}\right] \qquad \forall S \qquad (4)$$

$$\mathbf{D}^{\bullet S} = \hat{\mathbf{d}}^{\bullet S} \left(\hat{\mathbf{q}}^{Sp}\right)^{-1} \left[\mathbf{U}^{\bullet Sp} \vdots \mathbf{F}^{\bullet Sp} \vdots \mathbf{e}^{Sp\bullet}\right] \qquad \forall S \qquad (5)$$

The vectors $\mathbf{t}^{\bullet S}$ and $\mathbf{d}^{\bullet S}$ are the valuation vectors that are given in the make table. The hats (^) over the vectors indicate that they have been transformed into a diagonal matrix. The preferred method is the one closer to the full information table, assuming that the additional information is reliable.

The next step in the preparatory phase is to split the use table in basic prices into a domestic use table, which contains the products domestically produced, and an import use table, which contains the products that are imported:

$$\left[\mathbf{U}^{\bullet Sb} \vdots \mathbf{F}^{\bullet Sb} \vdots \mathbf{e}^{Sb\bullet}\right] = \left[\mathbf{U}^{SSb} \vdots \mathbf{F}^{SSb} \vdots \mathbf{e}^{Sb\circ}\right] + \left[\mathbf{U}^{\circ Sb} \vdots \mathbf{F}^{\circ Sb} \vdots \mathbf{e}^{SbS}\right] \qquad \forall S \qquad (6)$$

The matrix $\left[\mathbf{U}^{\circ Sb} \vdots \mathbf{F}^{\circ Sb} \vdots \mathbf{e}^{SbS}\right]$ incorporates all products imported into S in c.i.f. prices which are equivalent to basic prices in country S. It is often assumed that all exports are domestically produced and that transit trade is zero ($\mathbf{e}^{SbS} = 0$). Including positive transit trade complicates several matters, most importantly

4

the estimation of bilateral flows. Therefore the export vector in this matrix is set to zero: $\left[\mathbf{U}^{\circ Sb} \vdots \mathbf{F}^{\circ Sb} \vdots \mathbf{0}\right]$. This assumption is maintained in the rest of the paper.

$$\left[\mathbf{U}^{\bullet Sb} \vdots \mathbf{F}^{\bullet Sb} \vdots \mathbf{e}^{Sb\circ}\right] = \left[\mathbf{U}^{SSb} \vdots \mathbf{F}^{SSb} \vdots \mathbf{e}^{Sb\circ}\right] + \left[\mathbf{U}^{\circ Sb} \vdots \mathbf{F}^{\circ Sb} \vdots \mathbf{0}\right] \quad \forall S \tag{7}$$

Note that in this case the export vector with transit trade $\mathbf{e}^{Sb\bullet}$ is replaced by one without transit trade $\mathbf{e}^{Sb\circ}$. This vector is directly associated with the domestic use table and will therefore not be part of the internationalization methodology.

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 structure may be used in combination with the import vector in the make table.

In case a proportional disaggregation is preferred, (8) can be applied.

$$\left[\mathbf{U}^{\circ Sb} \vdots \mathbf{F}^{\circ Sb}\right] = \hat{\mathbf{m}}_{\mathbf{c}}^{\circ Sb} \left(\hat{\mathbf{q}}^{Sb} - \hat{\mathbf{e}}^{Sb\circ}\right)^{-1} \left[\mathbf{U}^{\bullet Sb} \vdots \mathbf{F}^{\bullet Sb}\right] \quad \forall S \tag{8}$$

Here the subscript c is used to denote commodities. This is done to differentiate from the import vector by industries which will be denoted by a subscript i. Note that the export vector in basic prices is deducted from the vector of total use of commodities. The export vector is also left out the total use table in order to find the import to total domestic use ratio, because we assume that transit trade is absent.

The resulting row totals of the import use table will of course be equal to the import vector used in disaggregating the tables, as is shown in (9).

$$
\begin{aligned}
\left[\mathbf{U}^{\circ Sb} \vdots \mathbf{F}^{\circ Sb}\right] &= \hat{\mathbf{m}}_{\mathbf{c}}^{\circ Sb} \left(\hat{\mathbf{q}}^{Sb} - \hat{\mathbf{e}}^{Sb\circ}\right)^{-1} \left[\mathbf{U}^{\bullet Sb} \vdots \mathbf{F}^{\bullet Sb}\right] &\Rightarrow \\
\left[\mathbf{U}^{\circ Sb} \vdots \mathbf{F}^{\circ Sb}\right]\mathbf{i} &= \hat{\mathbf{m}}_{\mathbf{c}}^{\circ Sb} \left(\hat{\mathbf{q}}^{Sb} - \hat{\mathbf{e}}^{Sb\circ}\right)^{-1} \left[\mathbf{U}^{\bullet Sb} \vdots \mathbf{F}^{\bullet Sb}\right]\mathbf{i} &\Rightarrow \\
\left[\mathbf{U}^{\circ Sb} \vdots \mathbf{F}^{\circ Sb}\right]\mathbf{i} &= \hat{\mathbf{m}}_{\mathbf{c}}^{\circ Sb} \left(\hat{\mathbf{q}}^{Sb} - \hat{\mathbf{e}}^{Sb\circ}\right)^{-1} \left(\mathbf{q}^{Sb} - \mathbf{e}^{Sb\circ}\right) &\Rightarrow \\
\left[\mathbf{U}^{\circ Sb} \vdots \mathbf{F}^{\circ Sb}\right]\mathbf{i} &= \hat{\mathbf{m}}_{\mathbf{c}}^{\circ Sb}\mathbf{i} = \mathbf{m}_{\mathbf{c}}^{\circ Sb}
\end{aligned}
\tag{9}
$$

where $\mathbf{i}$ is a unity column vector of the appropriate dimensions. Note that exports are not included in the matrix $\left[\mathbf{U}^{\bullet Sb} \vdots \mathbf{F}^{\bullet Sb}\right]$. If the import ratios would be calculated using the total make vector $\hat{\mathbf{q}}^{Sb}$ (including the export values) the row

totals of the matrix $\left[\mathbf{U}^{\circ Sb} \vdots \mathbf{F}^{\circ Sb} \right]$ would not equal $\mathbf{m}_\mathbf{c}^{\circ Sb}$. The column totals of the import use matrix give the imports of all commodities by industry i ($\mathbf{m}_\mathbf{i}^{\circ Sb}$) and by final demand category k ($\mathbf{m}_\mathbf{k}^{\circ Sb}$). [2]

In case some of the elements of the import use matrix are obtained from additional information sources, (8) may be used for the unknown cells after the total import value obtained from additional sources is deducted from the import vector. In any case it would be desirable to have an estimation of the transit trade flows when these flows are sizeable. Using $\left[\mathbf{U}^{\bullet Sb} \vdots \mathbf{F}^{\bullet Sb} \vdots \mathbf{e}^{Sp\bullet} \right]$ in (8) to obtain $\left[\mathbf{U}^{\circ Sb} \vdots \mathbf{F}^{\circ Sb} \vdots \mathbf{e}^{SpS} \right]$ is flawed, because it is very unlikely that the same share of exports is re-imported as the ratio of imports to total use. However, the assumption of zero transit trade may not resemble reality close enough. For example, in Oosterhaven *et al.* (2007) it was shown for the Asian-Pacific international input-output table that the proportionally constructed import table was to a large extent different from the import table constructed using survey information. This indicates that the proportionality assumption will lead to import values that may deviate considerably from the real world data.

After calculating (8), the domestic use table can be obtained by subtracting the import use table from the original use table in basic prices:

$$\left[\mathbf{U}^{SSb} \vdots \mathbf{F}^{SSb} \vdots \mathbf{e}^{Sb\circ} \right] = \left[\mathbf{U}^{\bullet Sb} \vdots \mathbf{F}^{\bullet Sb} \vdots \mathbf{e}^{Sb\circ} \right] - \left[\mathbf{U}^{\circ Sb} \vdots \mathbf{F}^{\circ Sb} \vdots \mathbf{0} \right] \qquad \forall S \qquad (10)$$

Note that the above described method to construct a use table in basic prices is a pure non-survey method in the sense that no additional survey data are added. Instead only proportionality assumptions are used. If this would be done for all countries, due to a total lack of survey data, then constructing a separate use table in basic prices becomes redundant. In this case each use table in purchaser prices can be expressed in a use table in basic prices by pre-multiplying with the diagonalized commodity output vector in basic prices cell-wise divide by output in purchaser prices (see Appendix I).[3]

---

[2] In an industry-by-industry input-output table these are normally presented as a single row in the primary input block of the IOT.

[3] Combining the information from the use and supply tables as constructed above with a production technology assumption produces a national input-output model which is able to answer all kind of impact questions, but at a low level of quality

3.2   Make table

All make tables are already expressed in basic prices and only need to be split up in a domestic table and an export table. This can be undertaken at the commodity level in the same way as the split of the use table in case there is no industry specific information on exports. Again it is assumed that there is no transit trade.

$$\mathbf{V}^{Sb\circ} = \mathbf{V}^{Sb\bullet}\left(\hat{\mathbf{q}}^{Sb} - \hat{\mathbf{m}}_{\mathbf{c}}^{\circ Sb}\right)^{-1}\hat{\mathbf{e}}^{Sb\circ} \qquad \forall S \tag{11}$$

The column sums of the calculated export make table $\mathbf{V}^{Sb\circ}$ will of course be equal to the transpose of the export vector $\left(\mathbf{e}^{Sb\circ}\right)'$, as is shown in (11):

$$
\begin{aligned}
\mathbf{V}^{Sb\circ} &= \mathbf{V}^{Sb\bullet}\left(\hat{\mathbf{q}}^{Sb} - \hat{\mathbf{m}}_{\mathbf{c}}^{\circ Sb}\right)^{-1}\hat{\mathbf{e}}_{\mathbf{c}}^{Sb\circ} & \Rightarrow \\
\mathbf{i}'\mathbf{V}^{Sb\circ} &= \mathbf{i}'\mathbf{V}^{Sb\bullet}\left(\hat{\mathbf{q}}^{Sb} - \hat{\mathbf{m}}_{\mathbf{c}}^{\circ Sb}\right)^{-1}\hat{\mathbf{e}}_{\mathbf{c}}^{Sb\circ} & \Rightarrow \\
\mathbf{i}'\mathbf{V}^{Sb\circ} &= \left(\hat{\mathbf{q}}^{Sb} - \hat{\mathbf{m}}_{\mathbf{c}}^{\circ Sb}\right)\left(\hat{\mathbf{q}}^{Sb} - \hat{\mathbf{m}}_{\mathbf{c}}^{\circ Sb}\right)^{-1}\hat{\mathbf{e}}_{\mathbf{c}}^{Sb\circ} & \Rightarrow \\
\mathbf{i}'\mathbf{V}^{Sb\circ} &= \mathbf{i}'\hat{\mathbf{e}}_{\mathbf{c}}^{Sb\circ} = \left(\mathbf{e}_{\mathbf{c}}^{Sb\circ}\right)'
\end{aligned}
\tag{12}
$$

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

$$\mathbf{V}^{SbS} = \mathbf{V}^{Sb\bullet} - \mathbf{V}^{Sb\circ} \qquad \forall S \tag{13}$$

The domestic make table in basic prices does not require any additional transformation.

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. The export make table in purchaser prices is obtained by adding the two valuation matrices to the export make table in basic prices.

$$\mathbf{V}^{Sp\circ} = \mathbf{V}^{Sb\circ} + \mathbf{T}_{\mathbf{e}}^{S\circ} + \mathbf{D}_{\mathbf{e}}^{S\circ} \qquad \forall S \tag{14}$$

The valuation matrices only add information if they are obtained using additional information. Using a proportionality assumption as applied in (4) and (5) will not add information. If no extra information is available the export make table in basic prices can be used equally well.

To summarize, in order to apply the linking methodology discussed below, it is assumed that for all countries that are to be included in the ISUT, at least a domestic use and an import use table in basic prices, and a domestic make and export make table in basic prices are available. In addition the availability of both domestic valuation matrices (taxes and trade & transport) for the export make table would be preferred over the use of the export make table in basic prices in case additional information on these valuation matrices is available.

4 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 contraints 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 is

(very) 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 related 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 means that using GRAS 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, the 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.

4.1 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 $\left[\mathbf{U}^{\circ Sb} \vdots \mathbf{F}^{\circ Sb}\right]$ 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:

$$r_{c\bullet}^{RS} = m_{c\bullet}^{RS} / m_{c\bullet}^{\circ S} \quad \forall R \neq S \quad \forall S \tag{15}$$

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:

$$\left[\mathbf{U}^{RSb} \vdots \mathbf{F}^{RSb}\right] = \hat{\mathbf{r}}^{RSb}\left[\mathbf{U}^{\circ Sb} \vdots \mathbf{F}^{\circ Sb}\right] \quad \forall R \neq S \quad \forall S \tag{16}$$

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.

$$\left[\mathbf{U}^{WSb} \vdots \mathbf{F}^{WSb}\right] = \left[\mathbf{U}^{\circ Sb} \vdots \mathbf{F}^{\circ Sb}\right] - \sum_{R \neq S \neq W}\left[\mathbf{U}^{RSb} \vdots \mathbf{F}^{RSb}\right] \quad \forall S \tag{17}$$

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 $\overline{\mathbf{e}}_{c}^{R\otimes}$.

$$\overline{\mathbf{e}}_{c}^{R\otimes} = \sum_{S \neq R \neq W}\left[\mathbf{U}^{RSb} \vdots \mathbf{F}^{RSb}\right]\mathbf{i} \quad \forall R \tag{18}$$

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.

$$\mathbf{m}_{ik}^{\otimes S} = \mathbf{i} \left[\mathbf{U}^{\otimes Sb} \vdots \mathbf{F}^{\otimes Sb} \right] = \mathbf{i} \sum_{R \neq S \neq W} \left[\mathbf{U}^{RSb} \vdots \mathbf{F}^{RSb} \right] \quad \forall S \tag{19}$$

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 $\overline{\mathbf{e}}_{\mathbf{c}}^{R\otimes}$, 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.

$$s_{i\bullet}^{RS} = e_{i\bullet}^{RS} / e_{i\bullet}^{R\circ} \quad \forall S \neq R \tag{20}$$

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.

$$\mathbf{e}_{\mathbf{c}}^{R\otimes} = \sum_{S \neq R \neq W} \mathbf{e}_{\mathbf{c}}^{RS} = \sum_{S \neq R \neq W} \left(\hat{\mathbf{s}}^{RS} \mathbf{e}_{\mathbf{c}}^{R\circ} \right) \quad \forall R \tag{21}$$

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

$$\tilde{\mathbf{e}}_{\mathbf{c}}^{R\otimes} = \mathbf{e}_{\mathbf{c}}^{R\otimes} \mathbf{i}' \overline{\mathbf{e}}_{\mathbf{c}}^{R\otimes} \left(\mathbf{i}' \mathbf{e}_{\mathbf{c}}^{R\otimes} \right)^{-1} \quad \forall R \tag{22}$$

The difference between the implicit exports column $\overline{\mathbf{e}}_{\mathbf{c}}^{R\otimes}$ in c.i.f. prices, and the export column $\mathbf{e}_{\mathbf{c}}^{R\otimes}$ 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 $\overline{\mathbf{e}}_{\mathbf{c}}^{R\otimes}$ and the export vector used as constraint $\tilde{\mathbf{e}}_{\mathbf{c}}^{R\otimes}$, which contains information about the valuation layer of international trade and transport. The difference between the constraint $\tilde{\mathbf{e}}_{\mathbf{c}}^{RS}$ and the export column $\mathbf{e}_{\mathbf{c}}^{R\otimes}$ is the statistical discrepancy between the vectors. This column is included in de framework as an extra column to account for the difference between the total value of the RASed use tables and the export column $\mathbf{e}_{\mathbf{c}}^{R\otimes}$. This statistical discrepancy vector contains, next to recording errors in the trade statistics, taxes levied in R on its exports.[4] 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

---

[4] 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.

from each of the different industries that produce it with the same ratio (= market share of industry *i* in the exports of commodity *c*).

4.2 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 revaluate 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:

$$\mathbf{V}^{RbS} = \mathbf{V}^{Rb\circ}\hat{\mathbf{s}}^{RS} \qquad \forall R \qquad \forall S \neq R \tag{23}$$

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

$$\mathbf{V}^{RbW} = \mathbf{V}^{Rb\circ} - \sum_{S \neq R \neq W} \mathbf{V}^{RbS} \qquad \forall R \tag{24}$$

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.
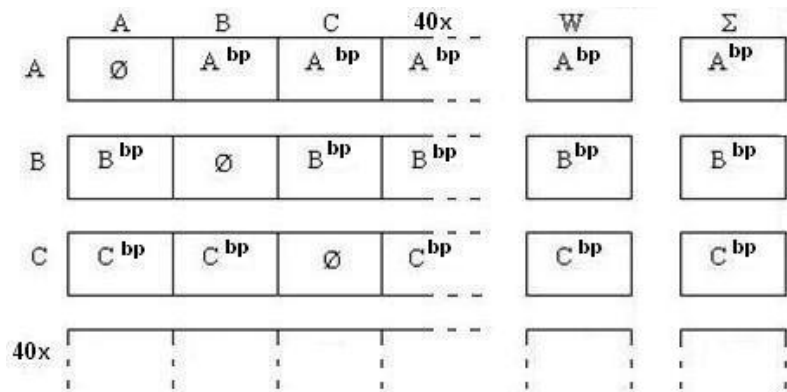

Figure 4: International export make table

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

14

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, $\mathbf{m}_{\mathbf{c}}^{\otimes S}{}' = \mathbf{i}' \sum_{R \neq S \neq W} \mathbf{V}^{RbS}$, 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.

$$\bar{\mathbf{m}}_{\mathbf{c}}^{\otimes S} = \left[\mathbf{U}^{\otimes Sb} \vdots \mathbf{F}^{\otimes Sb} \right] \mathbf{i} \quad \forall S \tag{25}$$

Using the structure of the import vector $\mathbf{m}_{\mathbf{c}}^{\otimes S}$, 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:

$$\tilde{\mathbf{m}}_{\mathbf{c}}^{\otimes S} = \mathbf{m}_{\mathbf{c}}^{\otimes S} \mathbf{i}' \bar{\mathbf{m}}_{\mathbf{c}}^{\otimes S} \left(\mathbf{i}' \mathbf{m}_{\mathbf{c}}^{\otimes S} \right)^{-1} \quad \forall S \tag{26}$$

Analogue to the first method, the difference between the import vector $\bar{\mathbf{m}}_{\mathbf{c}}^{\otimes S}$ in c.i.f. prices, and the import vector $\mathbf{m}_{\mathbf{c}}^{\otimes S}$ 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 $\bar{\mathbf{m}}_{\mathbf{c}}^{\otimes S}$, and the row totals of the RASed use table, $\tilde{\mathbf{m}}_{\mathbf{c}}^{\otimes S}$, contains information about the trade and transport margins related to all imports of country S. The difference between the vector used as constraint $\tilde{\mathbf{m}}_{\mathbf{c}}^{\otimes S}$ and the actual values $\mathbf{m}_{\mathbf{c}}^{\otimes S}$ 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.
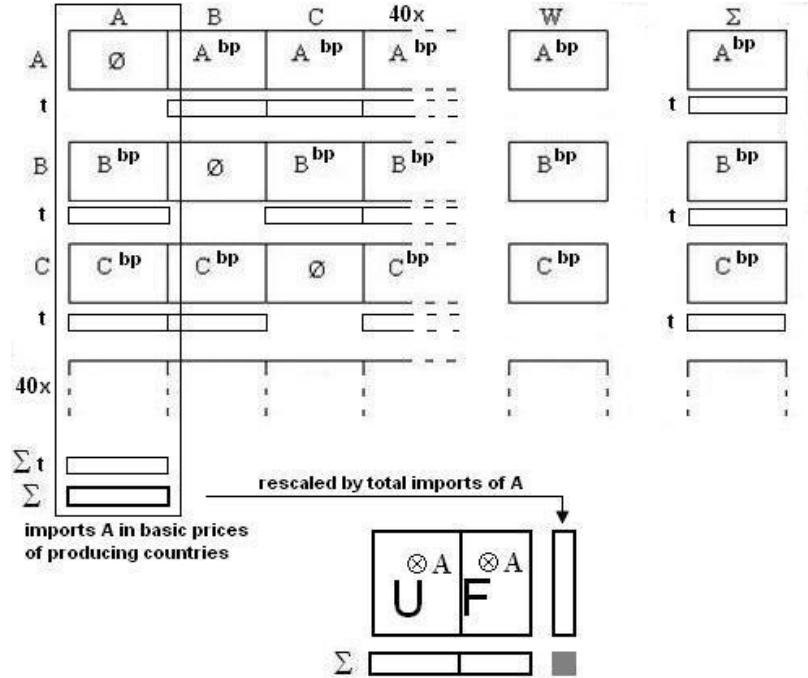

Figure 5: International export make table and revaluation of use matrix

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 peal 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).

5   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. Fort 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 (27) 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)

$\mathbf{U}$ is com * ind – $\mathbf{V}$ is ind * com

Commodity technology

com * com $\qquad \mathbf{U}\left(\hat{\mathbf{x}}\right)^{-1}\hat{\mathbf{x}}\left(\mathbf{V}'\right)^{-1}$ $\hfill$ **(27a)**

ind * ind $\qquad \hat{\mathbf{x}}\left(\mathbf{V}'\right)^{-1}\mathbf{U}\left(\hat{\mathbf{x}}\right)^{-1}$ $\hfill$ **(27b)**

Industry technology

com * com $\qquad \mathbf{U}\left(\hat{\mathbf{x}}\right)^{-1}\mathbf{V}\left(\hat{\mathbf{q}}\right)^{-1}$ $\hfill$ **(27c)**

ind * ind $\qquad \mathbf{V}\left(\hat{\mathbf{q}}\right)^{-1}\mathbf{U}\left(\hat{\mathbf{x}}\right)^{-1}$ $\hfill$ **(27d)**

6   Conclusion

This paper presents the methodology of the construction of an international make and use table. 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. The proportionality assumption is in general 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 in 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 actual construction of the ISUT will most probably uncover computational problems that cannot be foreseen yet. As a next step a four-country table will be constructed to test the basic algorithms that are implied by the equations in this paper.

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.

List of references

Bacharach, M. (1970) *Biproportional Matrices and Input-Output Change*. Cambridge University Press, Cambridge, England.

De Mesnard, L. (2004) Understanding the shortcomings of commodity-based technology in input-output models: an economic-circuit approach. *Journal of Regional Science*, 44(1), 125–141.

Dimaranan, B.V. (ed.) (2006) *Global Trade, Assistance, and Production: The GTAP 6 Data Base*. Center for Global Trade Analysis, Purdue University. Individual chapters of the GTAP (2006) Documentation accessible through: https://www.gtap.agecon.purdue.edu, last accessed: 28.01.2007

FEEM and TNO (2006) *EXIOPOL – Annex I: Description of Work*. FEEM, Milan/Venice, Italy. Version of 16.11.2006

Inomata, S. and N. Okamoto (eds.) (2006) *How to make Asian input-output tables*. IDE-JETRO, Chiba, Japan.

Jensen, R.C. (1980) The concept of accuracy in regional input-output models. *International Regional Science Review* 5, 139-154.

Junius, T. & Oosterhaven, J. (2003) The Solution of Updating or Regionalizing a Matrix with both Positive and Negative Entries, *Economic System Research*, 15, 87-96

Kop Jansen, P.S.M. and Th. ten Raa (1990) The Choice of Model in the Construction of Input-Output Coefficients Matrices. *International Economic Review* 31(1), 213–227

Linden, J.A. van der and J. Oosterhaven (1995) European Community Intercountry Input-Output Relations: Construction Method and Main Results for 1965-1985. *Economic Systems Research* 7(3), 249–269.

Miller R.E. and P.D. Blair (1985) *Input-output analysis, foundations and extensions*. Prentice-Hall, New Jersey, U.S.A.

Oosterhaven J., T.M. Stelder and S. Inomata (2007) *Evaluation of Non-Survey International IO Construction Methods with the Asian-Pacific Input-Output Table*. Working paper IDE-JETRO, Chiba, Japan.

Parniczky, G. (1980) On the Inconsistency of World Trade Statistics. *International Statistical Review* 48, 43-48.

Stone, R.A. (1961) *Input-Output Accounts and National Accounts* (Paris, Organization for European Economic Cooperation).

United Nations (2004) *International Merchandise Trade Statistics, Compilers Manual*. Department of Economic and Social Affairs Statistics Division. New York.

Annex I

In case proportionality assumptions are used to obtain $\mathbf{T}$ and $\mathbf{D}$, $\mathbf{U}^p$ can be expressed in terms of $\mathbf{U}^b$.

By definition:

$$\mathbf{U}^b \equiv \mathbf{U}^p - \mathbf{T}^u - \mathbf{D}^u$$

$$\mathbf{q}^b \equiv \mathbf{q}^p - \mathbf{t} - \mathbf{d} \tag{28}$$

Where $\mathbf{T}^u$ and $\mathbf{D}^u$ are calculated using the following formulas:

$$\mathbf{T}^u = \hat{\mathbf{t}} \left(\hat{\mathbf{q}}^p \right)^{-1} \mathbf{U}^p$$

$$\mathbf{D}^u = \hat{\mathbf{d}} \left(\hat{\mathbf{q}}^p \right)^{-1} \mathbf{U}^p \tag{29}$$

In each of the equations of Box 1, page 17 $\mathbf{U} \left(\hat{\mathbf{x}} \right)^{-1}$ is part of the calculation of the input-output coefficient matrix. To obtain input-output matrices the $\mathbf{U}$ matrix should be in basic prices: $\mathbf{U}^b \left(\hat{\mathbf{x}} \right)^{-1}$.

It can be seen, using the equations of 36 and 37 that:

$$
\begin{aligned}
\mathbf{U}^b \left(\hat{\mathbf{x}} \right)^{-1} &= \left[\mathbf{U}^p - \mathbf{T}^u - \mathbf{D}^u \right] \left(\hat{\mathbf{x}} \right)^{-1} \\
&= \left[\mathbf{U}^p - \hat{\mathbf{t}} \left(\hat{\mathbf{q}}^p \right)^{-1} \mathbf{U}^p - \hat{\mathbf{d}} \left(\hat{\mathbf{q}}^p \right)^{-1} \mathbf{U}^p \right] \left(\hat{\mathbf{x}} \right)^{-1} \\
&= \left[\mathbf{I} - \hat{\mathbf{t}} \left(\hat{\mathbf{q}}^p \right)^{-1} - \hat{\mathbf{d}} \left(\hat{\mathbf{q}}^p \right)^{-1} \right] \mathbf{U}^p \left(\hat{\mathbf{x}} \right)^{-1} \\
&= \left[\mathbf{I} - \left(\hat{\mathbf{t}} + \hat{\mathbf{d}} \right) \left(\hat{\mathbf{q}}^p \right)^{-1} \right] \mathbf{U}^p \left(\hat{\mathbf{x}} \right)^{-1}
\end{aligned}
\tag{30}
$$

Using now the second identity:

$$
\begin{aligned}
\mathbf{q}^b &\equiv \mathbf{q}^p - \mathbf{t} - \mathbf{d} &\Rightarrow \\
\hat{\mathbf{q}}^b &= \hat{\mathbf{q}}^p - \left(\hat{\mathbf{t}} + \hat{\mathbf{d}} \right) &\Rightarrow
\end{aligned}
\tag{31}
$$

$$\hat{\mathbf{q}}^b \left(\hat{\mathbf{q}}^p \right)^{-1} = \mathbf{I} - \left(\hat{\mathbf{t}} + \hat{\mathbf{d}} \right) \left(\hat{\mathbf{q}}^p \right)^{-1}$$

Which can be substituted in the last equation of equation 38:

$$\mathbf{U}^b \left(\hat{\mathbf{x}} \right)^{-1} = \hat{\mathbf{q}}^b \left(\hat{\mathbf{q}}^p \right)^{-1} \mathbf{U}^p \left(\hat{\mathbf{x}} \right)^{-1} \tag{32}$$

In case of the industry technology assumption, it can be seen that:

$$\mathbf{A}_i^b = \mathbf{V} \left(\hat{\mathbf{q}}^b \right)^{-1} \mathbf{U}^b \left(\hat{\mathbf{x}} \right)^{-1} = \mathbf{V} \left(\hat{\mathbf{q}}^b \right)^{-1} \hat{\mathbf{q}}^b \left(\hat{\mathbf{q}}^p \right)^{-1} \mathbf{U}^p \left(\hat{\mathbf{x}} \right)^{-1} = \mathbf{V} \left(\hat{\mathbf{q}}^p \right)^{-1} \mathbf{U}^p \left(\hat{\mathbf{x}} \right)^{-1} = \mathbf{A}_i^p \tag{33}$$