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Publication date:
2014

university of groningen / faculty of economics and business

14004-EEF

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Measuring the EU value added embodied in EU foreign exports by consolidating 27 national supply and use tables for 2000-2007[‡]

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Abstract

This paper develops a method to consolidate national supply-use tables (SUTs) into a single supra-regional SUT. The method deals with mirror trade statistics problems, such as the different valuation of imports and exports, and it corrects for the double-counting of re-exports. To test the contribution of the various construction steps, the paper decomposes the EU value added that is embodied in the EU exports to third countries into seven components. When the national SUTs for the period 2000-2007 are used, neglecting intra-EU spillover and feedback effects between the 27 EU-members results in an underestimation of the embodied value added of 12-15%. Not consolidating the national tables leads to a further under-estimation of 11-16%. Both types of errors are substantial. With these underestimations removed, the exports to third countries still only explain around 11% of the EU27 GDP.

Keywords: supply-use tables, mirror trade problems, re-exports, intra-EU spillovers effects, value added in trade

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[‡] An extended version of this working paper is forthcoming in *Economic Systems Research* under a different title. The extended version includes a discussion of the differences between consolidating national SUTs and aggregating a partly non-survey international SUT. It also includes a decomposition of embodied CO_2 emissions, as additional test of our method, and a comparison of the CO_2 results with the value added results discussed in this working paper.

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1. Introduction

The European Union (EU) acknowledges openness to trade as a core component of the renewed strategy for economic growth and job creation (Council of the EU 2009, European Commission 2010a). Increasing the competitiveness of the EU in global markets is considered to be of key importance to a trade policy that fits EU's 2020 strategy (European Commission 2010b). The size and importance of the external market are emphasized by the European Commission (2010b, p. 4): 'Our economy is the largest in the world. It is also the biggest exporter. Our firms exported € 1.6 trillion of goods and services in 2009, which is about 13 % of our GDP.'

Although the volume of EU's external trade is sizeable, assessing its importance as percentage of GDP produces an overstatement. The comparison goes awry by relating trade flows, which are gross flows, to the value added of an economy, which is a net flow (Brahmbhatt, 1998). Trade flows include flows of intermediate goods and services, whereas GDP explicitly excludes these. Intermediate goods and services account for as much as 61% to 63% of EU external imports over the years 2000 to 2007.[1] However, in policy analysis the use of trade/GDP ratios as measure of openness to trade (Roca Zamora, 2009) or as market integration indicator (Ilkovic, 2007) is still commonplace.

Recent literature has focused on measuring trade as a net flow by computing the value added content of trade (Belke and Wang 2006; Daudin *et al.* 2011).[2] Johnson and Noguera (2012) show the value added content of exports is about 73% of gross exports with substantial variation between countries. The variation in these value added content to gross trade (VAX) ratios is largely attributed to the variation in sector composition of exports. Countries that primarily export manufacturing products tend to have lower VAX ratios, which should have consequences for their score on openness to trade. We will not calculate VAX ratios, but directly concentrate on the methodology to measure the value added content of trade at the supra-regional level.

The increasing importance of decision making at this level, like the European Union and the Euro-zone, underlines the need for model building at that same level. To enable such model building, consistent time series of consolidated national accounts are a *conditio sine qua non*. These times series need to be derived from supply and use tables (SUTs) in order to increase their empirical reliability, to secure their internal consistency, and to estimate interindustry models, such as input-output and general equilibrium models. The required set of supply, use and input-output tables covering a series of years and all EU Member States has been incomplete until recently.

[1] Derived from the input-output tables used in this paper, available via (last accessed 06-03-2012): http://epp.eurostat.ec.europa.eu/portal/page/portal/esa95_supply_use_input_tables/data/workbooks

[2] Recent working papers are: Koopman *et al*, 2008; Koopman *et al*, 2010, Foster *et al*, 2011.

Within this context, the first contribution of this paper is to develop a method for the consolidation of national SUTs into a single consolidated supra-regional SUT. The method will include a solution to a series of methodological problems, such as the different valuation of national domestic use at basic prices and of imports at c.i.f. prices, and the double-counting of re-exports.[3] The second contribution of this paper is an evaluation of the extent to which the use of existing national SUTs instead of the new consolidated EU27 SUT will misestimate the EU27 value added embodied in the EU27 exports to third countries.

The description of the consolidation process starts from a harmonized set of national SUTs in Section 3.[4] Before that, Section 2 discusses related research and earlier attempts to construct supra-regional SUTs and supra-regional input-output tables (IOTs), in order to indicate what our methodology adds to the existing literature. A crucial element in our method is the re-pricing of the sum of the national import tables from the basic prices of the importing country into the basic prices of the exporting country (i.e. exclusive of all taxes, subsidies, and trade and transport margins). If this is not done properly, impact analyses of policy measures and scenario analyses will attribute all kinds of indirect effects to the wrong industries (i.e. to commodity producing industries instead of to the government and to trade and transport industries). In addition, double-counting of re-exports and statistical discrepancies also play a role in miscalculating indirect effects, particularly with respect to intra-European trade. At the end of Section 3 it is indicated how the consolidated SUTs are transformed into consolidated IOTs, which are needed to formulate the input-output models used the next section.

Section 4 shows how the correct estimation of the impact of EU27 exports to third countries on EU27 value added may be decomposed into: domestic impacts, first round intra-EU spillover effects, higher round intra-EU spillover and feedback effects, and four types of measurement errors of these effects that occur when national IOTs are used instead of the consolidated EU27 IOT. Section 5 then shows the actual empirical size of these three impacts and the four measurement errors for the period 2000-2007, both at the level of the 59 homogenous EU-branches and for the EU27 as a whole. It appears that not including the intra-EU spillovers and feedbacks leads to an aggregate underestimation of the embodied EU27 value added of 12-15%, while the four measurement errors together lead to an additional aggregate underestimation of the intra-EU spillover and feedback effects of 11-16% over this period. Even with these underestimations removed, EU27 exports to third countries still explain only a little more than 11% of EU27 gross value added or GDP. Section 6 concludes, inter alia, that our results show that it may be more important to strengthen the EU’s internal competitiveness than the EU´s external competitiveness.

[3] The result of the method is a set of annual consolidated supply, use and input-output tables for the EU27 for 2000-2007, published on the Eurostat website last May 2011. Technical documentation related to the dataset (Eurostat, 2011) is available at: http://epp.eurostat.ec.europa.eu/portal/pls/portal/!portal.wwpob_page.show?_docname=2530266.pdf

[4] To derive that set for the EU27, lacking SUT data needed to be estimated. See Rueda-Cantuche et al. (2009) for an early account, and see Eurostat (2011) for the final details.

2. Data sources and literature overview

2.1 Data sources

For a correct consolidation of national SUTs into a single supra-regional SUT and IOT, a full set of national SUTs at basic prices is required.[5] These national SUTs need to include a distinction between intra-European and extra-European exports and imports. Such a database did not exist until recently. The annual national SUT and IOT database, generated jointly by Eurostat and the European Commission's Joint Research Centre (JRC) finds its first use in this paper. This database allows us to estimate both a consolidated EU27 and a consolidated Euro-area time series of SUTs and IOTs for the period 2000-2007. The authors participated actively and collaborated with Eurostat and the JRC, not only in estimating the missing national SUTs and IOTs, but also in developing the consolidation method described in this paper. The final database and the method of consolidation have been endorsed by a technical group of European National Statistical Offices and the European Central Bank for future internal use by Eurostat (see further Eurostat, 2011).[6]

2.2 Construction of IOTs

Input-output tables are usually derived from supply and use tables. The Supply table consists of a matrix of products produced by industries, plus additional rows comprising: imports, distribution margins (trade and transport), and taxes less subsidies on products. The Use table consists of a matrix with the use of intermediate products by domestic industries, and the use of consumption and investment products by households, governments and investing industries. Besides, there are additional columns with changes in stocks and exports, and additional rows with the various components of gross value added, such as labour costs, capital use, net taxes on production and net operating surplus. Such a rectangular SUT, with, for example, m industries and n products, represents the most appropriate framework for balancing the supply and demand of products, and to compile the Gross Domestic Product (GDP), because it is not based on analytical assumptions, but on statistical data.

Symmetric IOTs can be derived from SUTs by means of behavioural assumptions. Their dimension can be either product-by-product or industry-by-industry.[7] The fact that IOTs are

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[5] For a detailed definition of basic prices, see Eurostat (2008, p. 163). Basically, basic prices refer to the valuation of goods and services before they are conveyed to markets.

[6] The IOT tables constructed with the method described in this paper can be downloaded from: http://epp.eurostat.ec.europa.eu/portal/page/portal/esa95_supply_use_input_tables/data/database. The relevant metadata can be found at: http://epp.eurostat.ec.europa.eu/cache/ITY_SDDS/en/naio_esms.htm

[7] Rueda-Cantuche (2011) discusses the pros and cons of the choice of dimension of IOTs. Briefly speaking, product-by-product tables are more homogeneous in their description of the transactions. They are the most commonly used tables in input-output analysis. However, they require labour

square is crucial for input-output modelling, as that requires a homogenous representation of the relationships between either products or industries. Productivity, energy and environmental analyses are well-known examples of impact studies for which symmetric IOTs need to be constructed. The same holds for our own decomposition of the error of using national IOT to estimate the EU value added that is embodied in EU exports to third countries.

2.3 Construction of consolidated IOTs

There are essentially two approaches to construct an IOT for a group of countries. First, one may use a variant of what are known as *non-survey* methods. This type of method is generally used for a top-down estimation of a regional IOT from a national IOT (see Miller & Blair, 2009, for an overview). The subset of methods that uses another region´s IOT or the national IOT to estimate an unknown regional IOT (e.g. Hewings, 1977) is suited to estimate unknown supra-national IOTs. This approach requires that, for the target supra-national IOT, total output, value added, total use, and imports and exports are given by industry, along with at least the totals, but preferably the full columns of the various domestic final demand categories. These totals are then used to define the row and column constraints of the unknown inner part of the target IOT, while the IOT of another country is used as the base for the application of the RAS biproportional adaptation method (see Bacharach, 1970, for an extensive treatment, and see Lenzen *et al*. 2004, and Eder *et al*, 2006 for applications to the Rest of the World and the EU).[8]

Here, however, we apply a method that uses mainly *survey* data to estimate the target supra-national IOT. For such a method, there are essentially two alternative routes. The route followed in this paper involves the direct aggregation of the national IOTs and the intra-group imports and exports of the countries concerned. Remarkably, this route has hardly been chosen before, even though national IOTs are available for many countries.[9] In that sense this paper presents a new and more direct approach. The second route involves the estimation of a full international IOT, which is then aggregated to the required supra-regional level. This approach requires much more work, but also generates more information. Eurostat has opted for the less resource intensive, less problematic and more direct route.

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intensive compilation and are based on analytical assumptions that take final results away from observed market transactions. Hence, the integration with other statistical sources is more difficult. Industry-by-industry tables, on the other hand, are much closer to statistical sources; they allow for an easier comparability with other statistical databases and they are less labour intensive to compile.

[8] Recently Minguez *et al*. (2009) developed a cell-correction to the RAS method (CRAS), which uses not a single IOT but multiple IOTs to improve the estimate of the target IOT (see Oosterhaven & Escobedo, 2011, for the first cross-regional application).

[9] See Ungar & Heuschling (1994) for the construction of an EU12 IOT for 1991 based on 1985 national tables, Brockmeier (1997) for an EU12 IOT for 1992, Van Leeuwen & Verhoog (1999) for an EU15 IOT for 1993 and Van Leeuwen (2002) for an EU15 IOT for 1995. The documentation of the construction of these tables is, however, rather scanty. More recently, Rueda-Cantuche et al. (2009) constructed an EU27 IOT for 2000.

All earlier work relates to the direct *bottom-up* construction of a supra-regional IOT from national IOTs. Nowadays, however, practically all IOTs are constructed from SUTs (Eurostat, 2008; European Commission et al. 2009). Hence, this will most certainly also hold for the future construction of supra-regional IOTs. Only recently, a start has been made with the construction of international IOTs from international SUTs, due to two large EU-financed research projects, namely EXIOPOL (see Tukker *et al*. 2013) and WIOD (see Dietzenbacher *et al*. 2013). In that sense, this paper also presents a new approach, as we derive a consolidated group SUT directly from national SUTs.

The first international IOTs were constructed for the much smaller old EU for 1959, 1965, 1970 and 1975 (Schilderinck, 1984). The harmonized IOTs of the individual countries for those years already had a split up of the matrix with foreign imports, into a matrix with intra-EU imports and one with extra-EU imports, as well as a comparable split-up of the column with foreign exports. The essence of the construction method consisted of further splitting up the national intra-EU import matrices by country of origin. This was done by means of row-wise uniform national import ratios, which were derived from international import statistics. The row totals of full matrix with these bilateral import flows implicitly represent intra-EU exports of the industry and EU-country at hand. The difference with the actual intra-EU exports was assigned to a column with so-called “expenditure balances”.

This procedure is statistically clear, but economically unsatisfactory, as the off-diagonal submatrices with the bilateral trade flows were measured in ex customs’ import prices, whereas the domestic transaction submatrices on the diagonal of the IO checkerboard were measured in producer prices. Moreover, the intra-EU export matrices were estimated by means of the import data of the receiving country, without taking the size and composition of their own intra-EU export data in to account. Finally, double counting intra-EU re-exports was not corrected for.

Most likely for these reasons, the resulting “expenditure balances” were as large as 11.5% for manufacturing, 21.5% for fuel and power and even 40% for agriculture (see Oosterhaven, 1995). The current WIOD project partly follows the same procedure in constructing a time series of intercountry SUTs for 1995-2009 with 40 countries, but it combines its equivalent of Schilderinck’s “expenditure balances” with the exports to their small Rest of the World (RoW). Given the nature of this procedure and the smallness of their RoW, some of these export flows may turn out to be negative for some products.

Van der Linden and Oosterhaven (1995) re-estimated Schilderinck’s intercountry EU-IOTs for 1965-1975, and elongated the series for 1975-1985. They rearranged the re-export flows to avoid double counting, and used RAS to re-price and balance the bilateral intra-EU import tables with the rescaled intra-EU export columns of the countries at hand. The difference between the original intra-EU exports and its rescaled equivalent was put in a “rescaling column” that amounted to only 1% of the original intra-EU exports value.

The second major effort to construct intercountry IOTs is the Asian Input-Output Table (AIOT) project (Meng *et al.*, 2013). The AIOTs combine nine Asian countries and the USA, and are constructed with five year intervals for 1985-2000. The harmonization of the ten national IOTs is the most complicated part of the construction of the AIOTs. The rest of the construction, in essence, follows the EU-method, while incorporating additional information from two extensive surveys. Opposed to the EU-approach, however, the AIOT-method does not use RAS to re-price the import matrices, but does so directly. Moreover, it rescales the bilateral imports to match the bilateral exports total, and combines the rescaling difference with the imports from third, non-AIOT countries, which has the disadvantage of possibly distorting the IO column coefficients.[10]

The use of row-wise uniform ratios has been termed the 'proportionality assumption' in recent literature (Trefler and Zhu, 2010). Some evidence shows that international IOTs obtained by applying the proportionality assumption may strongly deviate from results obtained when using survey data. Puzzello (2011) finds that using the proportionality assumption results in countries being a little more intensive in their own factors. Koopman *et al.* (2010) show that it may overestimate the share of intermediate goods in the imports of developed countries, whereas it may underestimate the share of final goods in the exports of many developing countries.

Most recent contributions on the factor content of trade construct an international IOT starting from the GTAP database. The core of the GTAP construction process is the FIT program, which uses entropy methods to update and create the database. It enforces consistency among the IOTs, trade, protection, macro and energy data.[11] The GTAP database includes total import matrices and consistent international trade data, but not bilateral trade matrices. Trefler and Zhu (2010) and Johnson and Noguera (2012) both use the proportionality assumption to derive the bilateral trade matrices.

The above discussed international IOT construction procedures all aim to provide the data for the *ideal* international input-output table and model (Isard, 1951). This so-called ideal, however, represents only one member of a whole family of possible multi-national IOTs and models. As regards multi-national SUTs, there also is a whole family of possible accounting schemes with accompanying models (Oosterhaven, 1984).

From this family, the EXIOPOL project and the WIOD project have chosen for the combination of a single intercountry Use table with a set of national Supply tables. From the single intercountry Use table one may derive a full intercountry **A**-matrix with intermediate input coefficients, while from the set of national Supply tables one may derive a single diagonal

[10] Oosterhaven et al. (2008) compare the survey AIOT for 2000 with the outcomes of four simple, less time-consuming, semi-survey methods. All four methods report differences in the intercountry trade flows of 10-50% compared to the semi-survey AIOT for 2000. Using increasingly more information from the export statistics reduces the differences, but not systematically for each and every country.
[11] www.gtap.org, last accessed 08-03-2012.

block **S**-matrix with national industry shares in the domestic supply of each product on the diagonal blocks. Together, these two matrices enable the calculation of an intercountry Leontief-inverse, $\mathbf{L} = (\mathbf{I} - \mathbf{S}\,\mathbf{A})^{-1}$, with all its associated applications.

In summary, the method described in this paper differs from these earlier methods in several ways. First, it is based on a different organization of the data as we use SUTs instead of IOTs, while we only derive a consolidated IOT after constructing the consolidated SUT. Second, we use the available matrices with the intra-EU and extra-EU imports by EU-country, instead of the proportionality assumption at the bilateral country level. Third, our focus on the supra-national level allows us to correct the data for re-export flows without making assumptions about the intra-EU geographical distribution of the re-exports. Finally, we re-price the import data of the importing countries into the basic prices of the producing exporting countries.

3. Consolidation of national SUTs into a supra-regional SUT

From the above overview, it follows that the core of the consolidation process requires the redefinition and re-estimation of the member states' intra-EU trade flows, as domestic transactions at the EU27 level. Therefore, a prerequisite for the consolidation procedure is the availability of an intra-EU import use matrix (separated from the extra-EU import matrix) and an intra-EU export column (separated from the extra-EU export column). The method developed in this paper presupposes the availability of 27 harmonized national SUTs, in which this distinction between intra-EU and extra-EU trade has been made.[12]

The construction method for the consolidated EU27 SUT consists of three main steps, and seven sub-steps. First, the national Use tables are aggregated into a *draft* EU27 Use table, which has a structure as shown in Figure 1. It consists of the simple sum of (1) all domestic use tables, (2) all intra-EU import tables, (3) all extra-EU import tables, each including all domestic final use categories, and (4) the simple sum of all intra-EU and extra-EU export columns, and re-exports columns.[13] Second, in a seven sub-steps procedure, the gray-marked intra-EU trade flows in Figure 1 are merged with the domestic intermediate and final use matrix, right above them, to get the consolidated EU27 Use table. Third, not shown in a figure, the main, domestic industry parts of the national Supply tables are simply aggregated to the domestic industry part of the consolidated EU27 Supply table, while the imports row of the consolidated EU27 supply table equals the simple column-wise aggregation of the matrix with the re-estimated extra-EU import use matrix from Step 2. After this third step, the consolidated EU27 SUT is transformed into the consolidated EU27 input-output table.

[12] See Eurostat (2011) for the details on the construction of the missing intra-EU and extra-EU import matrices.

[13] The individual country SUTs and this aggregate draft use table have been prepared by Eurostat, the Joint Research Centre's Institute for Prospective Technologies (JRC-IPTS) and the Konstanz University of Applied Sciences (Eurostat, 2011).

Figure 1: Scheme of the aggregated, draft Use table

Domestic intermediate use	**Domestic final use**	**1**	**2**
Intra-EU intermediate imports	**Intra-EU final imports**	**3**	**4**
Extra-EU intermediate imports	**Extra-EU final imports**	**5**	**6**
TLS	**TLS**	**7**	**8**

Legend for the columns in Figure 1

1: Exports to intra-EU countries

2: Exports to extra-EU countries

3: Re-exports, imported from intra-EU, exported to intra-EU

4: Re-exports, imported from intra-EU, exported to extra-EU

5: Re-exports, imported from extra-EU, exported to intra-EU

6: Re-exports, imported from extra-EU, exported to extra-EU

7: Taxes less subsidies on products (TLS) on intra-EU exports

8: Taxes less subsidies on products (TLS) on extra-EU exports

The first and the third step of the overall procedure only require a simple aggregation, which needs no further discussion. The core of the construction method therefore consists of the seven sub-steps needed to derive from Figure 1 the consolidated EU27 use table. The main problem of the seven sub-steps is to balance the intra-EU import table with the information on intra-EU exports in column 1, as each trade flow is reported by two countries, which usually do not match. This problem is known as the *mirror trade statistics puzzle*. There is a series of factors explaining the puzzle, such as time lags between exports and imports, different statistical coverage and response rates, statistical confidentiality, different treatment of revisions, and currency conversion issues (see section 2.17 of Eurostat, 2006).

The economically most important explanation of the puzzle is the structural difference in the prices used: exporting countries usually report their exports in free-on-board (f.o.b.) prices, whereas importing countries usually report their imports in cost-insurance-freight (c.i.f.) prices (see section 2.13 of Eurostat, 2006). The difference between these two prices is made up of international trade and transport margins. In the f.o.b. priced exports, the exported trade and transport services are recorded in the rows pertaining to the service sectors that produce services. In the c.i.f. priced imports, however, the trade and transport margins are included in the value of the various rows with imported goods. In the aggregated draft EU27 use table, exports are actually valued in basic prices. The difference between the exports in basic prices and the imports in c.i.f. prices consists of three valuation layers (see Table 1):

taxes less subsidies levied in the country of export, trade and transport margins within the country of export, and the international trade and transport margins discussed above.

Table 1: Valuation layers in international trade

Country	
R	**Exports by *R* in basic prices of *R***
R	+ Valuation layer: taxes and subsidies
R	+ Valuation layer: trade and transport
R	**= Exports by R in f.o.b. price of *R***
International	+ Valuation layer: international trade and transport margins
S	**= Imports by *S* in c.i.f. price of *S***
S	+ Valuation layer: taxes and subsidies
S	+ Valuation layer: trade and transport
S	**Imports by *S* in purchaser prices of *S***

In order to merge the intra-EU import use table with the domestic use table, both need to be valued in the same prices. Since all kind of applications require that employment, value added, and environmental impacts are allocated to the industries that actually produce the products traded, it is necessary to measure all transactions in *basic prices of the country of origin*. The domestic use table is already measured in such prices, in contrast to the draft intra-EU import use table in Figure 1. Only the latter therefore needs to be re-priced into basic price of the exporting country. Fortunately, information on intra-EU exports in basic prices can be used to balance the intra-EU import table. This is the most important step in the seven sub-steps procedure that changes the draft EU-Use table into the consolidated EU27 Use table. Table 2 gives an overview of all seven steps.

Table 2: Overview of steps taken to arrive at the consolidated EU27 Use table

Step 1:	Adjust for taxes less subsidies on intra-EU imports (cell 7)
Step 2:	Correct trade flows imported from intra-EU, re-exported to intra-EU (column 3)
Step 3:	Correct trade flows imported from intra-EU, re-exported to extra-EU (column 4)
Step 4:	Correct trade flows imported from extra-EU, re-exported to intra-EU (column 5)
Step 5:	Re-scale all import values to the total of the intra-EU exports (column 1)
Step 6:	Balance the rescaled intra-EU import table with the intra-EU export vector, using GRAS
Step 7:	Aggregate the domestic and balanced intra-EU import table

Step 1: Adjust for taxes less subsidies on intra-EU imports

Since intra-EU imports are valued at c.i.f. prices, they include, among others, the taxes less subsidies on products (TLS) that are associated with these transactions. The first step will be to reallocate (deduct) the TLS from the intra-EU import matrix. The total amount to be reallocated is given by cell 7 of Figure 1, which contains the taxes less subsidies linked to the same transactions, as reported by the exporting country. In order to do this, we proportionally distribute the value in cell 7 of Figure 1 over the values in the row identified by 'TLS' in Figure 1.

In other words, we reallocate the net taxes levied by exporting countries to the domestic industries and the domestic categories of final demand of the importing countries by means of the shares of taxes less subsidies paid by these industries, final consumers and investors. The changes in the TLS row represent an average increase of 0.38% over the period 2000-2007, whereas the changes in intra-EU import columns show an average decrease of 0.25%. At the end of this step, which is summarized in Figure 2, the intra-EU imports are adjusted to c.i.f. prices, net of taxes less subsidies.

The next three steps correct re-exports that are correctly measured from the perspective of the country that assembles these data, but not from an intercountry input-output perspective (see Guo *et al*. 2009). The core problem is to reallocate re-exports to the real country of origin. This is increasingly important, as re-exports grow, especially in countries like Hong Kong, Singapore and the Netherlands (see Mellens *et al*. 2007). Existing databases only provide ad hoc solutions for some of these countries (e.g. Feenstra *et al*. 2005, and Narayanan *et al*. 2012). We propose simple solutions, but solutions that are applicable to all 27 EU countries.

Step 2: Correct for double counting intra-EU trade flows that are re-exported within the EU

An example best clarifies how re-exports within the EU are double counted. Take Italian shoes that are re-exported by Austria to the Czech Republic. Clearly, this transaction will be reported in the Italian use table as an intra-EU export (in column 1 in Figure 1), and in the Czech use table as an intra-EU import of final goods. Therefore, the transaction on re-exports reported by the Austrian tables (column 3 in Figure 1) is redundant. Both the exporting country and the importing country record these trade flows in a correct way, so no adjustment has to be made. Maintaining the re-exports of Austria would result in double counting.[14] Therefore, the values in column 3 are simply deleted, as indicated in Figure 3.

[14] By correcting for the re-exports as described in Step 2, 3 and 4, it is assumed that re-exports are not again re-exported by the "final" importer.

Figure 2: Step 1

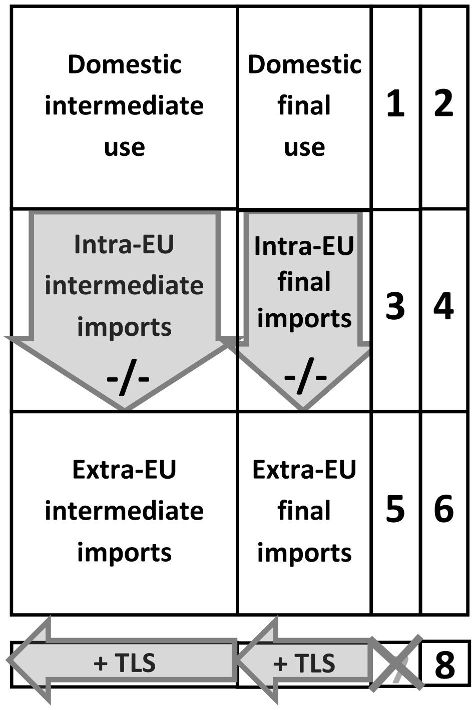
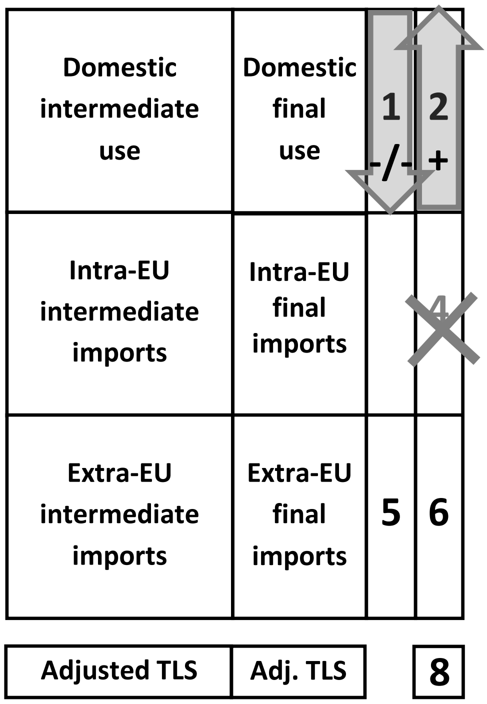


Figure 3: Step 3



Step 3: Correct for trade flows imported from within the EU and re-exported outside the EU

Next, consider the case in which Austria re-exports the Italian shoes to Switzerland (outside the EU) instead of to the Czech Republic (inside the EU). Because Italy not necessarily knows what Austria is doing with its shoes, in this case, Italy wrongly records this transaction as an intra-EU export, whereas it should have been reported as an extra-EU export. When constructing an inter-country SUT the necessary correction cannot be made at the individual country level, because the origin or destination of the re-exports is not recorded in the individual country SUT. At the level of a consolidated EU Use table, however, this correction can be made due to the differentiation between intra-EU re-exports and extra-EU re-exports. Column 4 of Figure 1 depicts precisely the goods and services that are imported from intra-EU countries and re-exported outside the EU. The values of column 4 are therefore subtracted from column 1 with the intra-EU exports, and added to column 2 with the extra-EU exports as indicated in Figure 3. This correction leads to a considerable average decrease of 7.6% in total intra-EU exports, along with an even larger average increase of 12.4% in total extra-EU exports over the period 2000-2007.

Step 4: Correct for trade flows imported from outside the EU and re-exported within the EU

Next, consider the reverse case of the re-export of Swiss chocolate by Spain to Portugal. Portugal wrongly records this transaction as an intra-EU import, since it does not ´know´ that Spain has imported these goods from Switzerland. Spain will report this transaction in column 5 of Figure 1. The correction therefore entails reducing the reported imports from EU countries, and increasing the reported imports from countries outside the EU, as indicated in

Figure 4. This is done by subtracting the values of column 5 proportionally, row-by-row, from the values of the intra-EU imports, and adding the subtracted values to the corresponding cells of the extra-EU import matrix. These changes lead to an average decrease of 11.6% in total intra-EU imports, and an average increase of as much as 17.4% in total extra-EU imports over the period 2000-2007.

Figure 4: Step 4

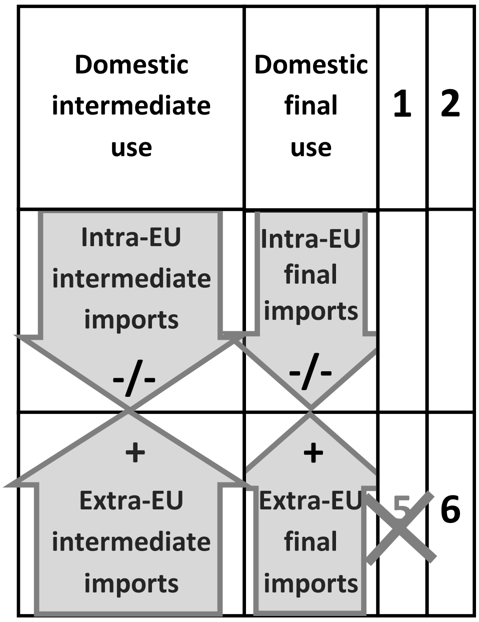
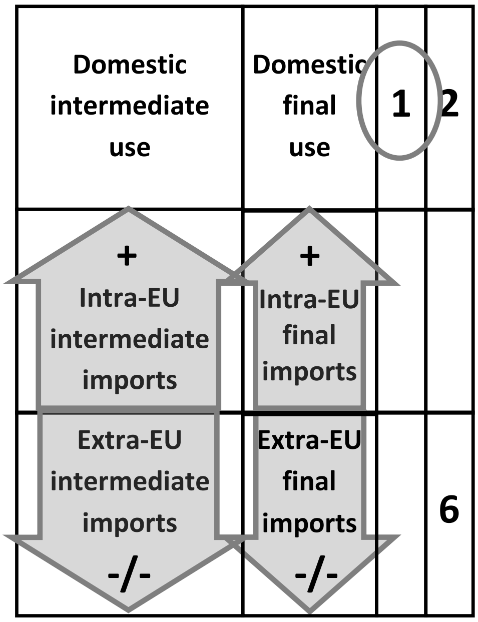


Figure 5: Step 5



Finally, as regards the re-exports, note that the re-export column 6 is maintained without any change in the consolidated table, as indicated in Figure 5. Both the original exporting country and the final importing country are non-EU countries. This combination is correct and does not require adjustments in the consolidated EU27 Use table.

Step 5: Rescale all intra-EU imports such that their total equals that of the intra-EU exports

After the above tax and the re-export corrections, each of the row sums of the adjusted intra-EU import table has to match the values reported in the adjusted intra-EU export column 1. The actual matching is done in the next step, but to undertake this matching successfully, it is required that the two adjusted overall totals are equal. To achieve this, all cells in the adjusted intra-EU import table, i.e., both intermediate and domestic final demand, are further adjusted by multiplying each cell with the sum of the adjusted intra-EU export values and dividing it by the overall sum of the adjusted intra-EU import table, as indicated in Figure 5.

Theoretically, the rescaling factor reflects the share of trade and transport margins included in imported goods from country *r* by *s* that do not balance against the trade and transport margins recorded as exports of *r* to *s*. This discrepancy occurs when non-EU carriers deliver part of the trade and transport services. For this reason and also because we do not want to change value added by industry or total final demand by category, the matrix with rescaling differences is added to the matrix with the extra-EU imports, as illustrated in Figure 5.

In practice, however, all factors identified to contribute to the *mirror trade statistics puzzle* may contribute to the difference in the adjusted totals of the intra-EU imports and the intra-EU exports. The actual rescaling factor for the EU tables for 2000-2007 is on average 1.10, with all yearly values within a 0.02 maximum deviation from this value. Thus, before rescaling, the adjusted total intra-EU export value was about 10% higher than the adjusted total intra-EU import value. The compensating change in the extra-EU imports amounted to -15%.

Note that this scaling down of the extra-EU imports does not necessarily represent an improvement, as it might be argued that its adjusted value (+17.4% in Step 4) is measured more correctly than the adjusted value of the extra-EU exports (+12.4% in Step 2). In our consolidation method, however, we give precedence to the belief that the split-up between intra- and extra-EU exports is better measured than the split-up between intra- and extra-EU imports.[15] Also note that one of the consequences of our re-estimation of both extra-EU imports and exports is that the EU external trade balance gets roughly +10 percent points larger than it than it was measured originally.[16]

Step 6: Balancing the intra-EU import table with the intra-EU export column using GRAS

Next, the Generalized RAS method of Junius & Oosterhaven (2003) is used to balance the adjusted intra-EU import totals by product, with the adjusted intra-EU exports by product. GRAS is a bi-proportional adjustment method very similar to RAS (Stone, 1961). The difference is that it can deal with negative values in the same fashion as with positive values. RAS and GRAS can be applied to any table for which an initial structure is given (or assumed), and new row and column totals are supplied, provided that the total of the row totals equals the total of the column totals, as secured in Step 5. The method's solution is equivalent to adding minimum information to the table obtained after Step 5, such that it just satisfies the new totals. RAS has been widely used to update input-output tables (see Miller & Blair, 2009), but it can also be used to balance import matrices with given export totals, as done by Van der Linden & Oosterhaven (1995) and Oosterhaven *et al*. (2008).

By using the export values in basic prices of the country of origin as row constraints in the GRAS procedure, the trade and transport margins included in the c.i.f. priced import values are effectively redistributed to the rows with the corresponding services. In this way, the

[15] An additional, much weaker argument is that both changes (+17.4% in Step 4 and -15% in Step 5) compensate for each other. Alternatively, the difference between imports and exports could have been added to the extra-EU exports, as was done in the older EU-method discussed in Section 2. That would, however, lead to an even larger upward correction of the extra-EU exports (+12.4% in Step 2 and +15% in Step 5).

[16] This +10 percent point is the result of the +17.4% and -15% in Step 4 and 5 for extra-EU imports and the +12.4% in Step 2 for extra-EU exports.

balanced intra-EU import use table is implicitly re-priced into basic prices. At the end of this step, the adjusted intra-EU export column 1 of figure 5 has become redundant.

Step 7: Aggregation of the domestic use table and the balanced intra-EU import table

In the last step of the Use table consolidation, the adjusted and balanced intra-EU import table is added to the table with the sum of the unchanged domestic use tables. The resulting consolidated EU27 Use table now only contains one import table, namely the imports from extra-EU countries.

Two final observations are of importance. First, note that the balance of total demand and total supply by product, and the balance of total input and total output by industry, in each of the national SUTs, is maintained in the consolidated SUT, while intra-EU export values and intra-EU import values are merged with the domestic transactions.

Second, note that gross domestic product (GDP) of the EU27 is not altered by the consolidation method. In the procedure, the member state's exports are decreased by the amount of intra-EU exports and their imports are decreased by the amount of intra-EU imports, as these flows are merged with the domestic transactions. As both exports and imports decrease by the same amount, the net values of exports less imports do not change, and the EU27 GPD remains unchanged.

Once the consolidated supply and use tables have been constructed, an industry-by-industry consolidated EU27 input-output table (IOT) is estimated by using the *fixed product sales structure assumption* (see Eurostat, 2008, p. 349 – Model D).[17] We opted for an industry-by-industry IOT due to the fact that value added is predominantly linked to industries rather than to products.

4. Decomposition of the 'true' value added embodied in the EU27 exports

We evaluate the empirical consequences of the different consolidation steps by estimating the EU27 value added embodied in the EU27 exports to third countries (extra-EU exports). This specific test is chosen for two reasons. First, value added impacts are chosen as GDP represents the single most important policy indicator available. Second, extra-EU exports are chosen to weight the implicitly used value added multipliers, as external competitiveness is a major EU policy goal. Besides, it is of direct interest to evaluate the actual importance of extra-EU exports for the EU-value added by industry.

The empirical consequences of the new consolidation method are evaluated in two main steps. First, we estimate the embodied EU27-value added by means of the national IOTs, i.e. by summing the outcomes of 27 national Leontief models. Second, we study how this

[17] Note, however, that the Eurostat consolidated IOTs are of the product-by-product type.

summed estimate changes when the consolidated IOT is used to specify a single Leontief quantity model for the whole of the EU27.

The core variables of the standard input-output (IO) model are: **x** = a column vector with total output by industry, **Z** = an industry-by-industry matrix with intermediate inputs, and **y** = a column vector with total final demand (the sum of consumption, investments, government expenditures and exports) by producing industry. In the standard IO model, supply follows demand, i.e., **x** = **Z i** + **y** (with **i** being a summation vector of ones). Final demand **y** is assumed to be determined exogenously, while intermediate demand is determined by total output per industry, i.e., **Z i** = **A x**. The matrix **A**, with the intermediate input coefficients, is calculated from the IOT data by means of **A** = $\mathbf{Z}\hat{\mathbf{x}}^{-1}$ (with $\hat{\mathbf{x}}$ being a diagonal matrix of **x**). The well-known solution of the standard IO model then reads: **x** = $(\mathbf{I} - \mathbf{A})^{-1}\,\mathbf{y}$.

In our application of this model we only add **v′**, the IOT row with total value added by industry, and let it be determined by total output by industry, i.e., $\mathbf{v}' = \mathbf{c}'\,\hat{\mathbf{x}}$, where **c′** is a row with value added coefficients, calculated from the IOT data by means of **c′**= $\mathbf{v}'\,\hat{\mathbf{x}}^{-1}$. The test variable in this paper only considers a part of final demand, namely, the EU27 exports to third countries **e**. Adding **c′** and **e** to the standard model allows us to calculate which part of the value added of each industry is embodied in the extra-EU exports of each commodity. Using diagonal matrices of **c** and **e**, this can be done in a very detailed way: $\mathbf{V} = \hat{\mathbf{c}}\,(\mathbf{I} - \mathbf{A})^{-1}\hat{\mathbf{e}}$.

Summing **V** across its rows gives the value added of the EU-industry at hand that is embodied in the extra-EU exports of all commodities. Summing **V** across its columns gives the value added in all EU-industries that is embodied in the extra-EU exports of the commodity at hand. Here we report only the results for the latter summation, as its outcomes are more relevant for policy formulation, which mostly focuses on the exporting industries.

A first approximation of the EU-wide value added embodied in the extra-EU exports, using only national IOT data, can be made by taking the *EU-sum of the domestic impacts* of each and every Member State's exports to third countries:

$$\mathbf{v(1a)} = \sum_r \mathbf{c}^{r\prime}\left(\mathbf{I} - \mathbf{A}^{rr}\right)^{-1}\hat{\mathbf{e}}^r \qquad \text{(1a)}$$

where r = 1, …, 27 (EU-member countries), and

$\hat{\mathbf{e}}^r$ = diagonal matrix with extra-EU exports by industry of member state r, taken from the final demand part of the IOT of member state r, i.e. uncorrected for re-exports.

$\mathbf{A}^{rr}$ = industry-by-industry matrix of domestic intermediate input coefficients of country r (this matrix does not change during the consolidation procedure), and

$\mathbf{c}^{r\prime}$ = row with the value added coefficients by industry of country *r* (this vector also does not change during the consolidation procedure).

Evidently, (1a) systematically under-estimates the EU-wide impacts, as it ignores each country´s spillover effects on the value added of the remaining EU member states, caused by its needs of imports from these member states. This means, for example, that the value added of French car parts' producers that service the German car exports to China is ignored. These *first order intra-EU spillovers*, however, can also be estimated by means of national IOT data, namely as follows:

$$\mathbf{v(1b)} = \sum_r \mathbf{c}^{r\prime} \mathbf{A}^{er} \left(\mathbf{I} - \mathbf{A}^{rr} \right)^{-1} \hat{\mathbf{e}}^r \qquad (1b)$$

where, additionally:

$\mathbf{A}^{er}$ = interindustry matrix of intra-EU intermediate import coefficients of member state *r*, taken from *r*'s national IOT, i.e. uncorrected for re-pricing and balancing these imports with the corresponding exports.

Nevertheless, taking the sum of (1a) and (1b) still systematically underestimates the EU-wide impacts of the extra-EU exports. This second underestimation results from the fact that the *higher order intra-EU spillovers and feedbacks* are not included. This means, for example, that the value added of subpart producers that service the French car part producers that service the German car export to China is not included. When these subpart producers are located in Germany one speaks of intra-EU *feedback* effects of German exports via the rest of the EU27 back to German industries. When the subpart producers are located in the rest of the EU one speaks of *higher order* intra-EU *spillover* effects (see Oosterhaven, 1981; Miller and Blair, 2009). These higher order effects may be estimated, again using only national IOTs, by taking the difference between the total EU-wide impacts, and the sum of (1a) and (1b), as follows:

$$\mathbf{v(1c)} = \sum_r \mathbf{c}^{r\prime} \left(\mathbf{I} - \mathbf{A}^{rr} - \mathbf{A}^{er} \right)^{-1} \hat{\mathbf{e}}^r - \mathbf{v}(1\mathbf{a}) - \mathbf{v}(1\mathbf{b}) \qquad (1c)$$

Note that taking the sum of $\mathbf{A}^{rr}$ and $\mathbf{A}^{er}$ in (1c) implies the use of the incorrect assumption that, for example, the French car part products that are exported to the German car industry are produced by means of the technology of the German car part producers.

The sum of (1a), (1b) and (1c) gives an estimate of the *total EU-impacts* of all extra-EU exports when only national IOTs would be available. This total can, of course, also be calculated directly as:

$$\mathbf{v(1)} = \sum_r \mathbf{c}^{r\prime}\left(\mathbf{I} - \mathbf{A}^{rr} - \mathbf{A}^{er}\right)^{-1}\hat{\mathbf{e}}^r \tag{1}$$

but having only the outcomes of (1) does not allow us to study the decomposition of the EU-wide impact into domestic impacts (1a), first order intra-EU spillovers (1b), and higher order intra-EU spillovers and feedbacks (1c).

Next follows the question whether the construction of a consolidated SUT, and its transformation into a consolidated IOT, does make a difference to the outcomes of (1). To study this, we separately consider the consequence of the adjustments made to each of the sets of coefficients present in (1).

The first source of error in (1) relates to using $\mathbf{c}^{r\prime}$. These national value added coefficients are used correctly in (1a) to estimate the domestic value added impacts, but they are used in (1b) as a proxy for the weighted average of the value added coefficients of the rest of the EU, while they are used as a proxy for the value added coefficients of the whole of the EU in (1c). Using the true value added coefficients for the EU27 in (1), corrects for these two errors in one go. The related *value added coefficient error* can therefore be calculated as follows:

$$\mathbf{v(2a)} = \sum_r \left(\mathbf{c}^e - \mathbf{c}^r\right)'\left(\mathbf{I} - \mathbf{A}^{rr} - \mathbf{A}^{er}\right)^{-1}\hat{\mathbf{e}}^r \tag{2a}$$

with:

$\mathbf{c}^e$ = vector with EU27 value added coefficients.

Note that this measurement error does not have a systematic bias. We expect that the underestimations caused by countries with small value added coefficients will compensate the overestimations of those with large value added coefficients. On average, the value added coefficient error should be close to zero.

Second, we consider the impact of aggregating the 27 national SUTs into the consolidated EU27 SUT that is directly derived from Figure 1, i.e. without redistributing taxes and re-exports, and without re-pricing and balancing the intra-EU import table with the re-estimated intra-EU exports column. After this crude SUT aggregation, a non-corrected EU27 IOT was derived by means of the fixed product sales structure assumption, in precisely the same way as the national IOTs were derived from the national SUTs. The *aggregation error* is calculated as follows:

$$\mathbf{v(2b)} = \mathbf{c}^{e\prime}\left(\mathbf{I} - \mathbf{A}^{ee}_{non}\right)^{-1}\hat{\mathbf{e}}^e_{non} - \sum_r \mathbf{c}^{e\prime}\left(\mathbf{I} - \mathbf{A}^{rr} - \mathbf{A}^{er}\right)^{-1}\hat{\mathbf{e}}^r \tag{2b}$$

with, additionally:

$\mathbf{A}_{non}^{ee}$ = interindustry matrix with the non-corrected intra-EU27 input coefficients, i.e., with the industry output weighted average of all $\left(\mathbf{A}^{rr}+\mathbf{A}^{er}\right)$, which is calculated by post-multiplying the sum of the domestic input coefficients and the intra-EU import coefficients, calculated from Figure 1, with the EU-27 domestic industry shares, calculated from the consolidated supply table, and

$\hat{\mathbf{e}}_{non}^{e}$ = a diagonal matrix with the non-corrected EU27-exports to third countries, i.e. the simple sum of all $\hat{\mathbf{e}}^{r}$ with its diagonal elements taken directly from column 2 of Figure 1.

Note that this aggregation error also does not have a systematic bias. We expect that the average aggregation error will be close to zero.

Third, the consolidation procedure includes the treatment of the re-exports, detailed in Section 3. Step 3 in that section corrects for intra-EU exports that are actually re-exported to third countries. The non-treatment of these re-exports leads to an underestimation of the impulse vector, i.e. the extra-EU exports, of around 11% on average over the period 2000-2007. This error due to the *underestimation of extra-EU exports* can simply be calculated as follows:

$$\mathbf{v(2c)}=\mathbf{c}^{e\prime}\left(\mathbf{I}-\mathbf{A}_{non}^{ee}\right)^{-1}\left(\hat{\mathbf{e}}^{e}-\hat{\mathbf{e}}_{non}^{e}\right) \qquad (2c)$$

where: $\hat{\mathbf{e}}^{e}$ = a diagonal matrix with the corrected extra-EU exports from the consolidated IOT (column 2 in Figure 3).

Finally, we consider the error that occurs if the sum of the national intra-EU import matrices, from Figure 1, would remain unbalanced with the intra-EU exports. This error consists of four sub-errors:

1. The information on taxes less subsidies on intra-EU exports (cell 7 of Figure 2) is used to downscale the intra-EU import values by an average of 0.25% to get c.i.f. prices net of the TLS on products.
2. The intra-EU imports are further downscaled by an average of 11.6% to correct for intra-EU imports that are actually re-exported outside the EU (column 5 of Figure 4).
3. These downscaled intra-EU imports are scaled up by an average of 9.6% to match the total of the re-estimated intra-EU exports (see Figure 5).
4. Finally, these imports are balanced with the intra-EU exports by product, by means of GRAS, which leads to an scaling up of the rows with trade and transport margins and scaling down of the remaining rows, in order to arrive at the basic prices of the exporting country (see Step 6).

The combined *non-balancing error* can be calculated as follows:

$$\mathbf{v(2d)} = \mathbf{c}^{e\prime}\left(\mathbf{I}-\mathbf{A}^{ee}\right)^{-1}\hat{\mathbf{e}}^{e} - \mathbf{c}^{e\prime}\left(\mathbf{I}-\mathbf{A}_{non}^{ee}\right)^{-1}\hat{\mathbf{e}}^{e} \quad \text{(2d)}$$

where, additionally:

$\mathbf{A}^{ee}$ = the "true" interindustry matrix with the intra-EU intermediate input coefficients being derived from the consolidated EU27 input-output table.

The four corrections of the intra-EU import use table, summarized above, without doubt represent a major improvement compared to the crude consolidation of national SUTs. It´s aggregate impact, however, will be relatively small, as the four sub-errors largely compensate each other. We therefore expect that its main impact will be found at the industry/ commodity level.

Obviously, the overall error of not having a correctly consolidated SUT, when estimating EU-wide value added impacts, is the total of (2a)-(2d). This total error can also be calculated directly as:

$$\mathbf{v(2)} = \mathbf{c}^{e\prime}\left(\mathbf{I}-\mathbf{A}^{ee}\right)^{-1}\hat{\mathbf{e}}^{e} - \mathbf{v}(1) \quad \text{(2)}$$

but with only the results of (2) it would not be possible to study the decomposition of the errors that is presented in (2a)-(2d). The latter is important, amongst others, because the aggregation error has a different nature than the other errors. The other errors represent errors that are due to *not* consolidating the national SUTs correctly, whereas the aggregation error is an unavoidable error of the consolidation procedure itself. The ideal would be to use a full 27x27 intercountry EU27 SUT, but that SUT would have considerable errors in its intra-EU trade matrices, as a correct re-allocation of the re-export column to the original exporting countries is hardly possible, and because then we would have to use the proportionality assumption to allocate intra-EU trade to the industries and final demand categories of destination. All these errors, which are avoided by the consolidation, may well outweigh the aggregation error.

5. Decomposition of value added embodied in the EU27 exports for 2000-2007

In this section we discuss whether our theoretical expectations about the size of the different impacts (1a)-(1c), and the different measurement errors (2a)-(2d) correspond with the actual empirical outcomes for 2000-2007. To present our results at a manageable level, we only show the exported commodities that have an average impact on the value added of the whole EU27 economy equal or greater than 1% during the period 2000-2007. This resulted in a selection of 31 commodities out of 59.

The bottom row of Table 3 shows that, on average, the value added embodied in extra-EU exports is underestimated by “about” 27% (100% – 72.9%) if we use the 27 national IOTs rather than the consolidated EU27 IOT. The wording “about” is added, as an unknown aggregation error is related to using a consolidated IOT for the EU27 instead of a full intercountry IOT with harmonized and balanced bilateral trade matrices between all 27 individual EU member states. The actual aggregation error of 0.8% of column *e* that we do make is an unreliable indication of this “true” aggregation error, as it relates to aggregating 27 unadjusted national IOTs instead of aggregating an adjusted full intercountry 27x27 IOT.

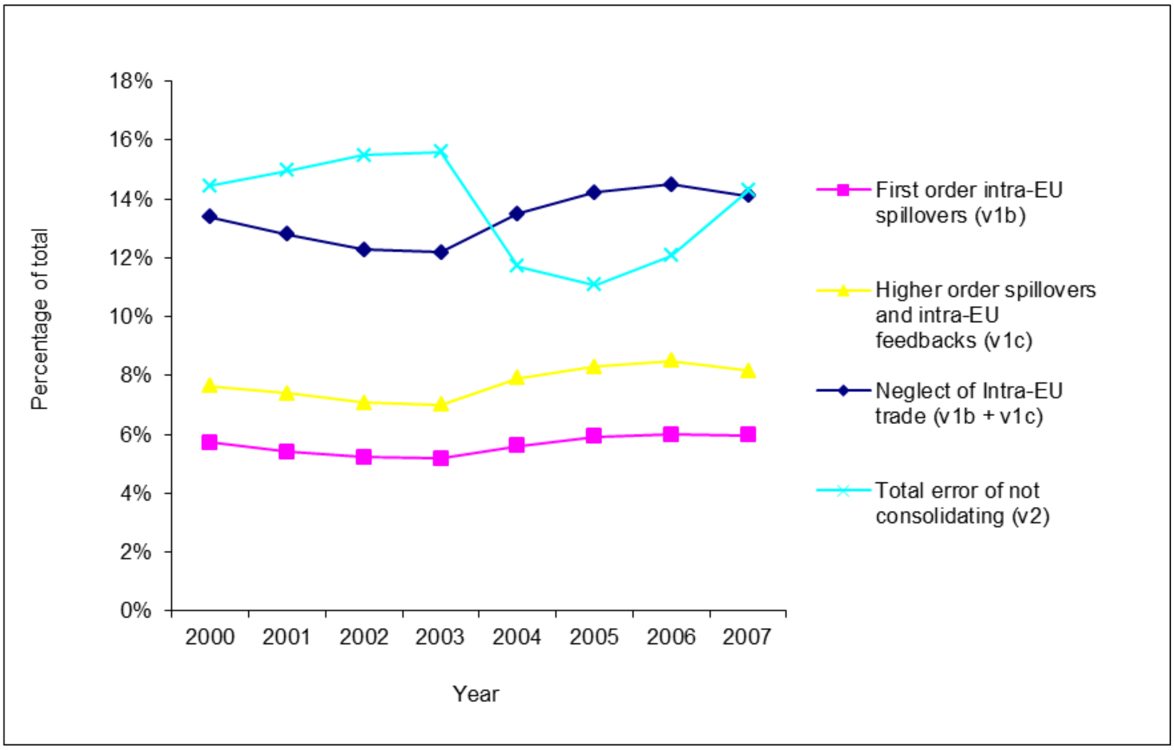
Table 3: Decomposition of EU27 value added embodied in extra-EU exports, average for 2000-2007

	Selected group of commodities with an impact larger than 1%	Using only national IO models			Errors of not using the consolidated EU27					Contribution of extra-EU exports to EU27 value added
		Domestic impacts	First order Intra-EU spillovers	Higher order intra-EU spillovers and feedback	Due to factor coefficients	Due to aggregation	Due to extra-EU exports	Due to intra-EU imports	Total of non-consolidation	
		(a)	*(b)*	*(c)*	*(d)*	*(e)*	*(f)*	*(g)*	*(h) = (d) + (e) + (f) + (g)*	*(i) = (a) + (b) + (c) + (h)*
		v1a	**v1b**	**v1c**	**v2a**	**v2b**	**v2c**	**v2d**	**v2**	**v1+v2**
23	Machinery and equipment n.e.c.	73.7%	5.9%	8.2%	-0.9%	1.6%	11.8%	-0.2%	12.2%	10.4%
18	Chemicals, chemical products and man-made fibres	62.8%	7.3%	9.7%	-0.2%	1.5%	18.9%	0.1%	20.2%	9.7%
28	Motor vehicles, trailers and semi-trailers	62.6%	7.4%	13.4%	-2.3%	2.4%	16.3%	0.3%	16.6%	9.1%
51	Other business services	84.9%	2.4%	2.6%	6.1%	-0.9%	4.7%	0.3%	10.1%	6.3%
36	Wholesale trade and commission trade services, except of mo	87.9%	3.4%	4.0%	3.4%	-0.1%	1.8%	-0.4%	4.7%	5.8%
9	Food products and beverages	73.0%	5.8%	7.9%	2.6%	-1.0%	11.5%	0.2%	13.3%	4.0%
21	Basic metals	64.3%	7.2%	12.1%	-0.2%	1.7%	14.8%	0.0%	16.4%	3.5%
25	Electrical machinery and apparatus n.e.c.	69.1%	6.3%	9.1%	0.1%	1.0%	15.5%	-1.1%	15.5%	3.4%
29	Other transport equipment	69.7%	6.2%	9.5%	0.3%	0.5%	16.0%	-2.2%	14.6%	3.2%
40	Water transport services	72.6%	9.2%	9.3%	-1.5%	6.0%	4.0%	0.4%	8.9%	2.7%
27	Medical, precision and optical instruments, watches and clock	72.1%	5.0%	6.4%	-1.6%	2.3%	16.6%	-0.9%	16.4%	2.7%
26	Radio, television and communication equipment and apparatu	63.0%	6.8%	9.2%	-2.0%	4.2%	22.9%	-4.1%	21.0%	2.7%
22	Fabricated metal products, except machinery and equipment	76.6%	5.5%	8.5%	-0.5%	1.0%	8.7%	0.3%	9.5%	2.2%
19	Rubber and plastic products	68.2%	7.0%	10.2%	0.3%	1.1%	13.5%	-0.2%	14.6%	2.1%
44	Financial intermediation services, except insurance and pensi	77.5%	4.2%	6.9%	17.9%	-13.5%	6.9%	0.1%	11.4%	1.9%
15	Pulp, paper and paper products	70.4%	6.6%	9.4%	-1.1%	2.4%	12.3%	0.0%	13.6%	1.8%
37	Retail trade services, except of motor vehicles and motorcycl	86.3%	1.6%	2.0%	7.3%	0.9%	1.5%	0.5%	10.2%	1.7%
30	Furniture; other manufactured goods n.e.c.	68.9%	5.9%	8.4%	2.7%	-1.5%	15.4%	0.2%	16.8%	1.7%
42	Supporting and auxiliary transport services; travel agency serv	84.5%	4.2%	5.1%	0.7%	-0.1%	4.3%	1.3%	6.2%	1.5%
35	Trade, maintenance and repair services of motor vehicles and	89.9%	3.1%	4.7%	-3.9%	4.3%	1.2%	0.7%	2.3%	1.5%
49	Computer and related services	86.5%	3.8%	3.4%	1.7%	1.1%	2.9%	0.7%	6.4%	1.5%
11	Textiles	66.5%	7.4%	10.3%	1.1%	0.1%	14.8%	-0.1%	15.8%	1.5%
41	Air transport services	74.4%	5.6%	7.3%	0.4%	1.4%	9.5%	1.3%	12.7%	1.4%
17	Coke, refined petroleum products and nuclear fuels	55.4%	16.3%	12.7%	4.2%	2.9%	11.9%	-3.5%	15.5%	1.4%
46	Services auxiliary to financial intermediation	84.4%	1.9%	2.2%	13.5%	-5.3%	3.3%	-0.1%	11.5%	1.4%
50	Research and development services	82.8%	3.7%	4.4%	1.4%	2.4%	5.6%	-0.4%	9.1%	1.3%
20	Other non-metallic mineral products	81.1%	5.1%	6.3%	0.7%	-0.1%	7.2%	-0.2%	7.6%	1.3%
39	Land transport; transport via pipeline services	87.0%	3.3%	3.8%	0.1%	2.2%	4.3%	-0.6%	6.0%	1.3%
24	Office machinery and computers	43.6%	7.3%	10.3%	3.5%	1.0%	40.4%	-6.0%	38.8%	1.2%
16	Printed matter and recorded media	75.6%	6.5%	6.6%	3.0%	2.6%	5.0%	0.7%	11.2%	1.1%
1	Products of agriculture, hunting and related services	81.1%	3.6%	5.0%	2.2%	-1.0%	8.9%	0.2%	10.3%	1.0%
	Selected total (billion €)	707.1	56.4	78.0	11.4	8.9	113.5	-2.9	130.9	972.3
	Total (billion €)	**769.1**	**59.6**	**82.2**	**17.3**	**7.9**	**122.0**	**-3.1**	**144.2**	**1,055.1**
	Percentage of EU27 value added embodied in exports	72.9%	5.7%	7.8%	1.6%	0.8%	11.6%	-0.3%	13.7%	100.0%
	NOTE: 1 billion = 1000 Mio Euro									

The overall underestimation of 27% consists of two main components: 13.5% point (5.7+7.8) of it is due to the neglect of intra-European spillover and feedback effects (v1), and 13.7% point is due to not consolidating the 27 national IOTs (v2). The highest two lines in Figure 6 illustrate the evolution of these two magnitudes during the whole period of 2000-2007. The error of neglecting intra-EU spillovers and feedbacks varies between 12% and almost 15%, while the error of non-consolidation varies between a little over 11% to almost 16%.

The overall error of 27% of course varies by exported commodity (see column *a* of Table 3). It is largest for office machinery and computers (industry 24, around 56%), followed by a group of eight manufactured goods that all have errors larger than 30%. The overall error is smallest for trade, maintenance and repairing services of motor vehicles, etc. (industry 35, around 10%), followed by a group of nine service industries, agriculture and other non-metallic mineral products that all have overall errors smaller than 20% .

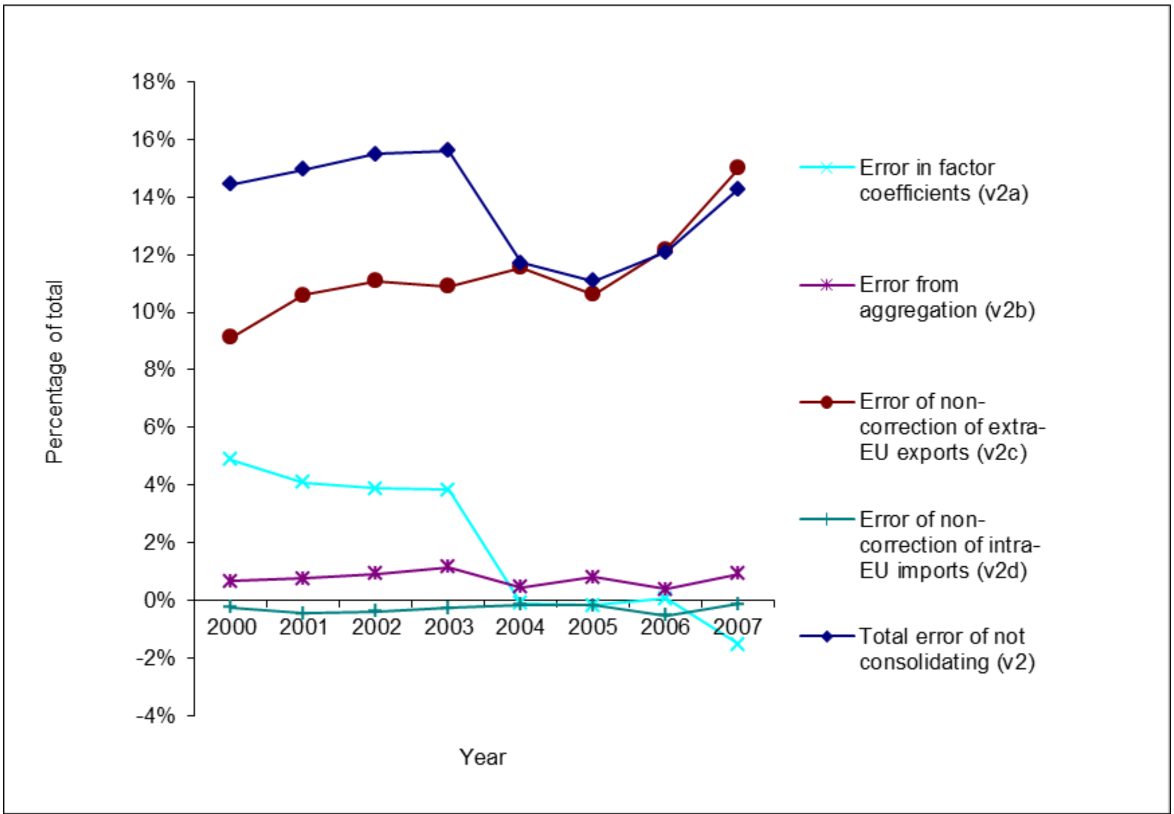
Figure 6: Errors made in estimating the value added embodied in EU27 exports



The size of the separate errors that occur when the consolidated IOT is not used also fluctuates over time as shown in Figure 7. We identified four sources of errors of using only national IOTs to estimate the embodied value added of the extra-EU exports: errors in value added coefficients; errors from aggregation; errors from the non-correction of extra-EU exports; and errors from the non-balancing of intra-EU imports (rescaling and product-wise balancing with extra-EU exports).

The error of using national value added coefficients (v2a) is rather small, as expected, while it becomes practically irrelevant at the aggregate level of the EU27 for the latter years studied. The convergence of the national value added coefficients towards the average EU value added coefficients suggests that the national production structures within the EU27 have been converging. The especially strong fall from 2003 to 2004 might be due to the accession of the 10 newest EU member states in 2004 and the subsequent application of the European System of Accounts in these countries, particularly with regard to the estimation of value added at basic prices and GDP. The fall in the total non-consolidation error from 2003 to 2004 in Figure 6 is, in fact, mainly due to the reduction in the error of using national value added coefficients shown in Figure 7.

Figure 7: Consolidation errors made in estimating value added embodied in EU27 exports



In line with our expectation of an unbiased aggregation error (v2b), the actual error turns out to be very small (0.8%, see Table 3, column *e*). The largest errors are found for financial services (industry 44) and services auxiliary to financial intermediation (industry 46). They partially compensate the even larger errors of national value added coefficients for the same industries. The large errors in these financial industries most likely are related to methodological differences in the treatment of FISIM[19] services among countries.

The error due to the underestimation of extra-EU exports (v2c) is by far the most significant, being responsible for around 11.6% of the total "true" impact (see Table 3, column *f*). It also grew persistently throughout the period 2000-2007 (see Figure 7). Its large size can partly be ascribed to the fact that the extra-EU exports constitute the driver of the Leontief quantity model used in all equations of Section 4. The problem of re-exports is particularly heavy for office machinery and computers (40%), followed by a group of thirteen manufactured goods

[19] Financial Intermediation Services Indirectly Measured

that all have errors between 10% and 20%. Not surprisingly, services all have relatively small re-exporting allocation errors.

As discussed in Section 4, the mutually compensating sub-errors of non-balancing the intra-EU imports with the intra-EU exports (v2d) do not result to a large aggregate error, while it is also quite stable over the period 2000-2007. The largest errors are overestimations, and are found for office machinery and computers (industry 24); radio, television and communication equipment (industry 26); and coke and refined petroleum products (industry 17) (see Table 3, column *g*).

Finally, and maybe most importantly, note that the percentage structure of the last column of Table 3 is not related to the consolidation process, instead it gives an indication of the commodity mix information that this type of application of a consolidated SUT and IOT may generate. Remarkable are the large contributions of the exports of machinery and equipment (10.4%), chemicals etc. (9.7%) and motor vehicles etc. (9.1%) to the total value added embodied in extra-EU exports. This total impact, of a little more than 1,000 billion euro, gives an indication of the relatively small importance of the exports to third countries for the value added of the EU27, as this amount represents only 11.2% of European GDP. Obviously, domestic EU27 consumption, investment and government expenditures are responsible for the remaining 88.8% of European GDP.

6. Conclusion and discussion

In this paper we developed a method to consolidate a series of national supply and use tables (SUTs) into a single supra-regional SUT. The method corrects for double-counting of intra-group re-exports, rebalances intra-group imports with the intra-group exports, and re-prices intra-group import matrices from c.i.f. prices to basic prices of the exporting industries. The method was tested with a seven-fold decomposition of the errors made in the estimation of the EU27 value added embodied in the EU27 exports to third countries for the years 2000-2007. With this new dataset, comparable estimates may now also be made for, inter alia, embodied CO_2-emissions, water use and employment.[20]

The first set of errors is due to the neglect of the intra-EU spillover and feedbacks effects that results if the domestic value added impacts, as calculated with the 27 national supply and use tables (SUTs), are simply summed. This leads to an underestimation of the EU27 value added embodied in the EU exports of 12-15%. The second set of errors relates to using the simple sum of 27 national SUTs instead of the consolidated EU27 with the above mentioned corrections included. Not using the correctly consolidated EU27 SUT leads to a further underestimation of the embodied value added of 11-16% over the period 2000-2007.

[20] See, e.g., Moll and Rémond-Tiedrez (2011) for a comparable CO_2 application.

Moreover, large industry-by-industry variations in errors of up to plus and minus 50% were observed behind these aggregate errors.

Even with these underestimations removed, the total EU27 value added embodied in the EU27 exports to third countries amounts to only a little over 11% of the gross domestic product (GDP) of the EU27. The remaining 89% is related to EU27 domestic private and public consumption and investment expenditures. This suggests that internal EU27 innovativeness and market efficiency might be more important for its GDP growth than the EU27´s external competitiveness.

Acknowledgements

This article is a spin-off of two projects financed by Eurostat. We thank Stephan Moll, and in particular Jörg Beutel, for extensive discussions on the methodology. The views expressed in this article are solely the views of the authors and do not necessarily reflect those of Eurostat or the European Commission services.

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