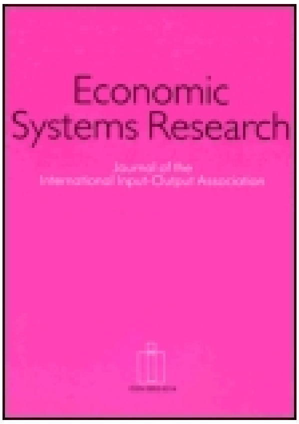

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This article describes the construction of the World Input–Output Tables (WIOTs) that constitute the core of the World Input–Output Database. WIOTs are available for the period 1995–2009 and give the values of transactions among 35 industries in 40 countries plus the 'Rest of the World' and from these industries to households, governments and users of capital goods in the same set of countries. The article describes how information from the National Accounts, Supply and Use Tables and International Trade Statistics have been harmonized, reconciled and used for estimation procedures to arrive at a consistent time series of WIOTs.

Keywords: World input–output tables; Supply and use tables; Bilateral trade data

1. INTRODUCTION

According to official trade statistics, China was the largest global exporter in 2012, having surpassed both Germany and the USA. In 1999, just 13 years ago, Chinese exports were less than a third of American exports (*The Economist*, 2012). To what extent did Chinese income and employment benefit from this surge in exports? To what extent did it suffer from increasing pollution associated with producing goods for foreign markets? And to what extent have countries that are important suppliers of China's imports such as Australia, Japan and Korea, gained from Chinese growth? More in general, what are the effects of fragmentation of production on the distribution of employment, income and the generation of emissions across countries and industries?

These are very relevant questions, given that many of today's products and services are no longer produced within a single country. Whereas, many electronic products are labelled 'assembled in China', their key components are often produced also in other parts of the world. In the last couple of decades, production processes have been sliced up more and more into ever smaller parts, many of which are subcontracted to specialized suppliers. In addition, this fragmentation crosses the borders of countries more and more. This coincides with the common viewpoint today that products and services are made in global value chains.[1]

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[1] In the same vein, the OECD and the WTO launched the 'Made in the World' initiative and proposed 'trade in value added' as a better approach for the measurement for international trade (OECD–WTO, 2012).

However, as pointed out by the European Commissioner for Trade, Karel De Gucht:[2]

> '… though we are aware of the rising importance of global value chains, we have so far been unable to properly measure their size, nature and effect. This is because our current statistical apparatus does not capture the domestic activity contained in a traded good or service'.

Recently, economic theory has also paid attention to the causes and consequences of this process which Baldwin (2006) refers to as the 'second wave of unbundling'. Grossman and Rossi-Hansberg (2008), for example, constructed a theory that does not focus on trade in products, but on 'trade in tasks'. The tasks are implicitly related to the production of intermediate inputs and vary with respect to the intensities of labour inputs of different skill levels. Firms decide on the location of these tasks on the basis of cost comparisons. As a consequence, some intermediate inputs might be produced in the home country, while others might be relocated abroad (either by acquiring or building production facilities, i.e. by foreign direct investment (FDI), or by buying from foreign suppliers). Grossman and Rossi-Hansberg (2008) show that improvements in the opportunities to relocate tasks might have an effect on the host country that is comparable to that of factor-augmenting technological change. Their theory leads to conclusions regarding the effects of trade that differ from what can be concluded from traditional trade theories. In the concluding paragraph, the authors state that 'the globalization of production processes mandates a new approach to trade data collection, one that records international transactions, much like domestic transactions have been recorded for many years' (Grossman and Rossi-Hansberg, 2008, p. 1996). Without such data, we are groping in the dark about the causes and consequences of the changing nature of international trade.[3]

Production processes are characterized by international fragmentation leading to an interdependent structure which has to be accounted for. The data that provide a description of such an interdependent production structure are given in supply and use tables (SUTs) and/or input–output tables (IOTs). Given the on-going trend in globalization, we agree with Wiedmann et al. (2011) that a database that is useful for analysing economic, social and environmental issues and policies should take *each* of the following three aspects into account. It must (i) be *global*, (ii) cover *changes over time* in order to evaluate past developments, and (iii) include a variety of *socio-economic and environmental indicators*. Moreover, it is necessary to have all data in a coherent framework (e.g. using the same product and industry classifications and consistent definitions).

The World Input–Output Database (WIOD) project (WIOD: Construction and Applications) was set up to create such an all-encompassing database, which provides a tool that can address both the quest for indicators by policy-makers and the need for empirical observations to test and quantify theories by academic researchers. The project ran for 3 years (May 2009–April 2012) and 11 international partners were involved.[4,5] The database

[2] Available at: http://trade.ec.europa.eu/doclib/docs/2012/april/tradoc_149337.pdf.

[3] An alternative theory of emerging geographical patterns in internationally fragmented production processes has been proposed by Costinot et al. (forthcoming).

[4] More information about the WIOD project can be found at: http://www.wiod.org/index.htm.

[5] The participants were: University of Groningen, The Netherlands; Institute for Prospective Technological Studies, Seville, Spain; The Vienna Institute for International Economic Studies (wiiw), Vienna, Austria; Zentrum

allows for addressing issues related to fragmentation and socio-economic aspects (such as jobs or the creation of value added) as well as environmental aspects (such as energy use, various emissions to air, or the use of water). The database combines detailed information on national production activities and international trade data. For each country, tables are constructed that reflect how much of each of 59 products is produced and used by each of 35 industries. By linking these tables to trade data, it is estimated, for example, how many dollars of Belgian fabricated metal products are used by the French transport equipment industry. This type of information is available in the WIOD database for 40 countries (all 27 European Union (EU) countries and 13 major other countries), plus estimates for the rest of the world (RoW); for the time period 1995–2007 (and estimates for 2008 and 2009); in current basic prices and in basic prices of the previous year. It should be emphasized that all data in the WIOD are obtained from official national statistics and are consistent with the National Accounts. The full database is publicly and free of charge available at: http://www.wiod.org/database/index.htm.

The rest of this paper is structured as follows. Section 2 will be devoted to the principles underlying the database, i.e. the choices that have been made in its construction. As a comparison between the various contributions in this issue reveals, different groups of researchers made different choices, as a consequence of which our world input–output tables (WIOTs) differ from the multi-regional input–output (MRIO) tables constructed by others.[6] A careful inspection of these principles (next to the coverage of the WIOTs in terms of industries, countries and years) should help the user to make a choice between our WIOTs and the available alternatives. The description of the construction of the WIOTs distinguishes three steps.[7] Section 3 discusses the construction of the time series of national SUTs and pays attention to aspects of harmonization and benchmarking the SUTs on the National Accounts. Section 4 describes how the international SUTs are derived. An important aspect is the estimation of the imports in the use table for which a bilateral trade database was built. Section 5 details how the international SUTs where combined so as to yield a world SUT, which then was transformed into a WIOT. Section 6 gives a listing of the contents of the WIOD database, including the socio-economic and environmental satellite accounts. The last section concludes.

2. THE UNDERLYING PRINCIPLES AND CHOICES

Constructing a large database like in the WIOD project implies that several choices need to be made. These choices are often directed by the particular applications the constructors have in mind when designing the database and its underlying fundamental principles.

für Europäische Wirtschaftsforschung, Mannheim, Germany; Österreichisches Institut für Wirtschaftsforschung, Vienna, Austria; Hochschule Konstanz, Germany; The Conference Board Europe, Brussels, Belgium; CPB Netherlands Bureau for Economic Policy Analysis, The Hague, The Netherlands; Institute of Communication and Computer Systems, Athens, Greece; Central Recherche SA, Paris, France; OECD, Paris, France.

[6] In the environmental and ecological literature, our WIOTs are often termed MRIO tables (or MRIOs). We prefer not to use the term MRIO, because of the traditional conceptual distinction between multi-regional IOTs and interregional IOTs (Miller and Blair, 2009) and because of the fact that our tables do not provide detail at the subnational level.

[7] A detailed description of the contents, sources and methods for the WIOD database can be found in Timmer (ed., 2012).

Uncovering these is important in order to understand the differences between various alternative databases.[8] Consequently, one database should *not* be seen as 'better' than another database. It may be better (or more appropriate) for answering some questions but not for other questions. For example, it must be a deliberate choice to include as many countries as possible or to strive for a high level of reliability by limiting the number of countries (knowing that for certain countries the quality of the data is poor or that data are not official). Another example is the choice of how to deal with discrepancies that exist between the export and import values recorded in the National Accounts Statistics (NAS) and in the International Trade Statistics (ITS), including the well-known problem that mirror statistics between bilateral trade partners are far from consistent.[9] One option is to take the absolute values from NAS and to assign these to countries-of-origin and countries-of-destination, using shares obtained from ITS. Other options are to take the values from ITS and adapt the product-level exports and imports from NAS, or to develop a construction algorithm that allows for specific choices at product or industry level. The rest of this section will point out the choices that have been made in constructing the WIOD database. In so doing, it will also sketch the main construction steps, each of which will be described in detail in later sections (references to related literature can be found in the sections that deal with the details).

First, we have used national SUTs as the starting point for the construction (Section 3.1). SUTs are the core statistical sources from which National Statistical Institutes derive national IOTs. In IOTs, it is assumed that each industry produces goods and services in exactly one product class. Consequently, the distinction between industry and product vanishes and the tables become square (or, in statistical parlance, symmetric). SUTs on the other hand are usually non-square and allow for secondary production, which makes them better reflect 'reality'. The supply table provides information on how much of each product is produced by each domestic industry and how much of this product is imported. The use table indicates the use of each product (combining domestically produced and imported products) by each of the industries and final use categories (e.g. consumption by households and government, investments, and gross exports). Both supply tables and use tables are thus of the product-by-industry dimension. Therefore, linking SUTs with international trade data (which are product based) and with socio-economic and environmental data (which are mainly industry-based) becomes more straightforward and accurate (Section 4.2).

Second, we have used the National Accounts as the benchmark. Typically, SUTs are only available for a limited set of years (e.g. every 5 years) and once released by the national statistical institute revisions are rare. National Accounts on the other hand are usually revised several times. This is because statistical systems develop, new methodologies and accounting rules are used, classification schemes change and new data become available. Occasionally, revisions are also carried through to ensure consistency and comparability over time. These revisions can be substantial, especially at a detailed industry level, implying discrepancies between information from the latest version of the National Accounts for a

[8] See, for example, Andrew and Peters (2013), Lenzen et al. (2013), Meng et al. (2013) and Tukker et al. (2013), all of which are included in this special issue. See also Oosterhaven et al. (2008) on the Asian International IOTs project, Wang et al. (2010) on a project at the US International Trade Commission and Wiebe et al. (2012) on the Global Resource Accounting Model project.
[9] See the discussion in Guo et al. (2009).

certain year and the published SUT for that year. So, in our approach, any revision of the National Accounts leads to an adaptation of the benchmark national SUTs to make them match (see Section 3.2 for details).

Third, one of our aims was to arrive at a time series of WIOTs. This required us to devise a method to estimate national SUTs for non-benchmark years as well. Time series for (gross) output and value added by industry, total imports and total exports and final use by use category were taken from the NAS and were used as constraints when generating time series of SUTs with the so-called SUT–RAS method. This method was developed for this specific purpose. Time series of SUTs have been derived for two price concepts: basic prices and purchasers' prices. Basic prices reflect all costs borne by the producer, whereas purchasers' prices reflect the amounts paid by the purchaser. Supply tables are always in basic prices and often have additional information on margins and net taxes by product. Use tables as available from public data sources are typically in purchasers' prices and had to be transformed to basic prices within the construction procedures. The difference between the two types of use tables is given in the so-called valuation matrices with the trade and transportation margins and the net taxes, which had to be estimated (Section 3.2 provides details about the harmonization of price concepts and derivation of the valuation matrices, while Section 3.3 describes the construction of time series of national SUTs by means of SUT–RAS).

Fourth, within the WIOD, the choice was made that the data used in the project should be publicly available. This ensures that users of the WIOTs are able to trace the construction process and are able to derive alternative tables by making different sets of assumptions. Moreover, officially published data are more reliable because thorough checking and validation procedures have been adopted by the National Statistical Institutes (when compared to data generated on an *ad hoc* basis for specific research purposes).

Fifth, an improved allocation of imports of goods has been applied. In the process of construction, the national SUTs have been combined with information from ITS to construct what we call international SUTs. Recall that use tables include both domestically produced and imported products. They have been split into the use of domestic products and use of foreign products first, and in a second stage the use of foreign products was split according to country of origin. The standard assumption in most databases is to apply import proportionality (where the same, fixed percentage of total use of a product is assumed to be imported, irrespective of its purchaser). For the import of goods, we have developed an estimation method that does not rely on this standard import proportionality assumption. Instead, we have determined (for each product) the share of its imports that goes to the 'intermediate consumption', to 'final consumption', and to the 'gross fixed capital formation' (the so-called end-use categories). This distinction by end-use categories was based on a refinement of the well-known BEC codes ('broad economic categories') distinguishing detailed trade data by use. Within each end-use category, the allocation was (as dictated by a lack of additional information) based on the proportionality assumption.[10] For intermediate use by industries, for example, we had to apply ratios between imported use and total use

[10] Personal communication with National Statistical Institutes led us to the conclusion that procedures to arrive at imports in published use tables and IOTs are often based on import proportionality at lower levels of product aggregation. Tables constructed along these lines do, therefore, not convey data of higher quality. Only for a small number of countries and years, import tables have been constructed using firm-level survey data on the sourcing of products.

that were equal across industries, but differed from the corresponding ratio for consumption purposes. A similar procedure was used to split the imports table according to the country of origin. Unlike under the standard proportionality assumption, country import shares differ across end-use categories (but not within these categories). Section 4.1 provides details and references to the related literature.

Sixth, given the types of application that we had in mind for the WIOD database, it is important also to have detailed information on the trade in services. For services trade, however, no standardized database on bilateral flows exists. The data have been collected from various sources (including UN, OECD, Eurostat), checked for consistency and integrated into a bilateral services trade database (see the last part of Section 4.1 for the particularities).

Seventh, for some applications, it is important to have data in constant prices. Therefore, WIOTs in pyp have been constructed based on gross output deflators from the National Accounts of each country, implicitly deflating imports by the exporters' gross output deflators (details are described in the last part of Section 5.2).

Eighth, one of the aims in the WIOD project was to link the WIOTs to satellite accounts that provide data at the same industry level. The socio-economic accounts focus on the inputs of production factors and the environmental accounts list requirements for and effects of production (e.g. energy use and emissions, respectively). In this paper, we do not describe these satellite accounts. See Erumban et al. (2012a) and Genty et al. (2012) for descriptions of the socio-economic and environmental satellite accounts, respectively.

These underlying principles and choices have guided us through the process of constructing the WIOD database. The next sections will go into the details of constructing a WIOT. First, we will discuss the construction of a time series of national SUTs, after which we will describe how they were linked to trade data so as to yield international SUTs. Finally, we show how international SUTs for the 40 countries were used to produce a world SUT. Finally, the world SUT was then transformed into a WIOT with additional modelling of the so-called RoW (which covers countries for which no national SUTs have been derived).

3. CONSTRUCTION OF A TIME SERIES OF NATIONAL SUTS

In the construction of the time series of national SUTs, we started with the SUTs as published by the National Statistical Institutes. Because national SUTs are only infrequently available and are often not harmonized over time, they have been benchmarked on consistent time series from the National Accounts. The construction involved three steps: harmonization and standardization of the published SUTs across countries and time (Section 3.1), benchmarking the harmonized national SUTs to National Accounts (Section 3.2) and building a time series of national SUTs (Section 3.3).

3.1. Harmonization and Standardization of the Published SUTs

The national SUTs were derived from statistics published by the National Statistical Institutes. Although SUTs and national account statistics are increasingly harmonized across countries, differences still remain, in particular for less developed countries. The national data also differ in the level of product and industry detail provided. Harmonization was thus required and involved the following aspects (details on a country-by-country basis are reported in Erumban et al., 2012b).

Commodity-by-industry classification: The level of industry and commodity detail in the basic SUTs and IOTs varied widely across countries, variables and periods. National SUTs (or IOTs) were converted into tables with 59 products (based on the international classification of products by activity, CPA) and 35 industries (based on the NACE revision 1 which corresponds to ISIC revision 3). For this, we developed concordance tables between national classifications and the classification used in the WIOD. The product classification corresponds to the classification used by Eurostat in its publications of SUTs for the EU27 countries. The choice for a 35 industry classification was based on the level of industry detail in the EU KLEMS database (O'Mahony and Timmer, 2009), which is the most important source of data for WIOD's socio-economic satellite accounts. Compared to that database, the textiles industry was further disaggregated to separate wearing apparel and footwear production which are both important industries in developing countries. We also provide some more detail for the transportation services industries as these are important for margin estimation and various environmental applications.

Price concepts: the price concept for gross outputs (basic prices) and intermediate inputs (purchasers' prices) has been harmonized across countries. Several countries, however, used a different price concept, including China and Japan (producers' prices), India and the USA (factor costs). Later in this section, we will discuss how the use tables in purchasers' prices were transformed into basic prices.

Harmonization involved aggregation and sometimes disaggregation based on additional detailed data. While for most European countries (due to a high level of harmonization of statistics in the EU), this was relatively simple, tables for non-EU countries proved more difficult. While aggregation of products or industries in a SUT is straightforward, disaggregation is not. To disaggregate an industry, first additional data from National Accounts was collected to breakdown value added and gross output by the sub-industry. To disaggregate an industry in a supply table, we assumed common product sales shares of the sub-industries.[11] To disaggregate an industry in a use table, we assumed common intermediate input coefficients for the sub-industries. Disaggregating products is more difficult because additional data by product are often not available (although in some cases a rough estimate could be made based on more detailed industry information). Disaggregating products in the supply table was based on common industry-production shares and, similarly, for the use table, we assumed common use shares.

National SUTs were also checked for consistency and adjusted to common concepts (e.g. regarding the treatment of financial intermediation services indirectly measured (FISIM) and purchases of residents abroad). In some cases, total supply and total use did not match at the product level, and differences were distributed across the final expenditure categories in order to balance supply and use. Undisclosed cells due to confidentiality concerns were imputed based on additional information and any negative entries in the intermediate block were reallocated. In particular, older SUTs do not have a

[11] Our philosophy of relying completely on official and publicly available data prevents us from disaggregating industries to lower levels. Lenzen (2011) provides evidence from Monte Carlo simulations that disaggregation – even on the basis of very incomplete data – is likely to produce more accurate multiplier values. Users of the WIOD database are encouraged to perform such disaggregation themselves, but the published database sticks to official numbers.

row allocation for FISIM in which case shares in financial services use or in value added were used.

Other aspects that were taken into account in the harmonization process are processing trade, re-exports, and transit trade. According to the System of National Accounts (SNA) 1993 (ISWGNA, 1994), following the Balance of Payments (BoP) manual, exports of goods and services consist of sales of goods and services from residents to non-residents, while imports consist of purchases of goods and services by residents from non-residents. This is the change-of-ownership principle. Goods that are in transit through a country are thus not to be included in export and import statistics, because they did not change ownership. Goods that are imported and exported again, without substantial change but that did change ownership (so-called re-exports), should be included.

The SNA 1993 recommends one exception to this change-in-ownership principle, namely for goods that are sent abroad for processing (without a change in ownership) and later re-imported (re-imports). These should be recorded gross by the processing economy as well as by the economy that sent the goods for processing, if the processing involves a substantial physical change in the goods (ISWGNA, 1994, p. 665). Unfortunately, national statistics offices have applied this recommendation in various ways. From our analytical perspective, any activity that generates value added should be included in the tables. Imports for processing should, therefore, always be recorded under intermediate consumption by the processing country, to reflect the underlying technology of the processing industry. This is also what we would like to see in our SUTs and IOTs. In practice, however, countries differ considerably in the application of this principle due to increasing reporting problems of processing firms. This has led to the new SNA 2008 (ISWGNA, 2009) recommendation to only record the processing fee as output and export of a service, and not the flow of intermediate imported goods (ISWGNA, 2009, p. 279). In the last decade, countries appear to differ widely in the treatment of processing trade and the actual treatment is often not well documented. For example, in the 2007 Chinese IOT, parts of imports for processing are excluded both in intermediate inputs and imports. On the other hand, many – but not all – European countries follow the SNA 1993 recommendation and record imports for processing as imports for intermediate consumption (e.g. Germany seems to be an exception).

This problem of recording imports is mirrored in the recording of exports and, thus, also statistical treatments for re-exports vary across countries. The US IOTs, for example, exclude re-exports and the associated imports, while most EU countries generally stick to the convention to include these.

In the WIOD project, we followed the SNA 1993 convention such that the output and the intermediate use of an industry best reflect the underlying production technologies. This means that, for example, a wearing apparel firm sewing shirts on the basis of imported parts should be represented by an intermediate flow of cloth and an output flow of shirts, instead of by the processing fee as output only (and no intermediate inputs). This holds, no matter which firm actually 'owns' the cloth parts and shirts in a juridical sense. We, therefore, add back re-exports, imports for processing purposes and exports of the processing industry into the original SUTs when this is needed and possible, notably for the USA and China. However, further research into this issue is warranted.

At this point, we have a published SUT for a given year that has been harmonized. Because we want to benchmark our data on National Accounts data, this harmonized SUT will be adapted (Section 3.2).

FIGURE 1. The national SUT.

	Products	Industries	Final use	Inventories	Exports	Total
Products		$\mathbf{U}$	$\mathbf{Y}$	$\mathbf{s}$	$\mathbf{e}$	$\mathbf{q}$
Industries	$\mathbf{V}_b$					$\mathbf{x}_b$
Imports	$\mathbf{m}'$					m
Value added		$\mathbf{w}_b'$				w_b
Margins	$\mathbf{t}_m'$					t_m
Net taxes	$\mathbf{t}_n'$					t_n
Total	$\mathbf{q}'$	$\mathbf{x}_b'$	$\mathbf{y}'$	s	e	

where:

$\mathbf{U}$ is the 59×35 use table in purchasers' prices;

$\mathbf{Y}$ is the 59×4 matrix of final use in purchasers' prices (with four categories: consumption expenditures by households; consumption expenditures by non-profit organizations serving households, NPISH; consumption expenditures by the government; and gross fixed capital formation);

$\mathbf{s}$ is the 59×1 vector with changes in inventories by product and its total is given by s;

$\mathbf{e}$ is the 59×1 vector with exports (fob) and its total is given by e;

$\mathbf{q}$ is the 59×1 vector with total use in purchasers' prices;

$\mathbf{V}_b$ is the 35×59 supply table in basic prices (indicated by subscript b);

$\mathbf{x}_b$ is the 35×1 vector of gross output in basic prices by industry;

$\mathbf{m}'$ is the 1×59 vector of imports (cif) and its total is given by m;

$\mathbf{w}_b'$ is the 1×35 vector of value added by industry and its total is given by w_b;

$\mathbf{t}_m'$ is the 1×35 vector of (i.e. trade and transport) margins, its total is given by t_m;

$\mathbf{t}_n'$ is the 1×35 vector of net taxes (i.e. taxes minus subsidies), its total is given by t_n;

$\mathbf{y}'$ is the 1×4 vector of final use totals;

$\mathbf{q}'$ is the 1×59 vector of total supply in purchasers' prices.

3.2. Benchmarking Harmonized National SUTs to the National Accounts

We start by describing the procedure for the years for which a full SUT is available, which is given in Figure 1.

Note that the use table is in purchasers' prices and the supply table in basic prices, and that the use table and final use matrix include imported products (which will be specified separately in the next section). Also note that $\boldsymbol{\iota}'\mathbf{V}_b + \mathbf{m}'$ (where $\boldsymbol{\iota}$ is used to indicate the summation vector with ones of appropriate length) gives the total supply in basic prices.

The national SUT in Figure 1 will be re-estimated on the basis of the following data that come from the National Accounts: total exports ($\bar{e}$), total imports ($\bar{m}$), gross output by the industry at basic prices ($\bar{\mathbf{x}}_b$); value added by industry ($\bar{\mathbf{w}}_b$); total final use at purchasers' prices ($\bar{\mathbf{y}}'$), total changes in inventories ($\bar{s}$), total margins ($\bar{t}_m$), and total net taxes ($\bar{t}_n$). An over bar is used to indicate that the information was obtained from the National Accounts.

For benchmark years, the import and export vectors (i.e. $\hat{\mathbf{m}}$ and $\hat{\mathbf{e}}$) are estimated as follows:

$$\hat{m}_i = m_i \left(\frac{\bar{m}}{m} \right) \quad \text{and} \quad \hat{e}_i = e_i \left(\frac{\bar{e}}{e} \right). \tag{1}$$

Supply tables are mostly in basic prices and often have additional information on margins and net taxes by product. The use table is typically in purchasers' prices and hence needs to be transformed into a basic price table in order to arrive at a common price concept. The difference between the two tables is given in the so-called valuation matrices (Eurostat, 2008, Chapter 6). These matrices are typically not available from public data sources and, therefore, need to be estimated. In the WIOD, we distinguish between margins (including all automotive trade, wholesale trade, retail trade and transport margins) and net taxes on products (taxes minus subsidies). The net tax rates by product are obtained from the supply tables and are retained to the extent possible. Tax rates are important elements in modelling applications that predict, e.g. the effects of changes in public tax systems. The margins are derived residually in two steps as follows.

First, the combination of margins plus net taxes is adapted to the National Accounts total. That is,

$$\hat{t}_i = \frac{(t_i^m + t_i^n)(\bar{t}_m + \bar{t}_n)}{t_m + t_n}, \tag{2}$$

where t_i^m indicates the trade and transport margins for product i and t_i^n indicates the net taxes for product i. For the estimation of the net taxes, we use net tax rates as derived from the SUT, i.e. $\tau_i = t_i^n / q_i$. For products that have no margins (these are mainly services), we have (as a first estimate) $\tilde{t}_i^n = \hat{t}_i$. For products that do have margins, we have $\tilde{t}_i^n = \tau_i q_i$. Because the sum of these estimates of the net taxes does not sum to $\bar{t}_n$, they need to be normalized in the second step.

For products that have no margins, we have $\hat{t}_i^n = \tilde{t}_i^n = \hat{t}_i$. Note that these net taxes are not affected by the normalization, because they cannot differ from $\hat{t}_i$ as the margins are zero. For products that do have margins, we have

$$\hat{t}_i^n = \tilde{t}_i^n \frac{\bar{t}_n - \Sigma_{i \in \{\text{no margin}\}} \tilde{t}_i^n}{\Sigma_{i \in \{\text{margin}\}} \tilde{t}_i^n}, \tag{3}$$

where {no margin} is the set of products that have no margin and {margin} is the set of products that do have margins. The margins are then obtained as $\hat{t}_i^m = \hat{t}_i - \hat{t}_i^n$.

In order to derive IOTs in the end, both the supply and the use table should adopt the same price concept. Using the estimates of the margins and net taxes, the data in purchasers' prices in the use table are transformed into basic prices as follows. First, the rates of the margins and taxes by product are calculated, assuming that they do not apply to exports. This is a reasonable assumption as the bulk of the margins and taxes are applied when the product is sold to the final domestic consumer (retailing margins are much higher than other margins and taxes for most products) and not when the product is exported. For product i we then have

$$\hat{\tau}_i^n = \hat{t}_i^n / (\hat{q}_i - \hat{e}_i) \quad \text{and} \quad \hat{\tau}_i^m = \hat{t}_i^m / (\hat{q}_i - \hat{e}_i). \tag{4}$$

Next, this rate is uniformly applied to the ith row of the intermediate use table in purchasers' prices (**U**), to the ith row of the final use matrix in purchasers' prices (**Y**), and to s_i. This provides the valuation matrix for net taxes and for margins. Subtracting the valuation matrices from **U**, **Y** and **s** yields initial estimates for the use table in basic prices ($\hat{\mathbf{U}}_b^0$) and the final use matrix in basic prices ($\hat{\mathbf{Y}}_b^0$).

FIGURE 2. The national SUT, with estimates on the basis of National Accounts.

	Products	Industries	Final use	Inventories	Exports	Total
Products		$\hat{\mathbf{U}}_b^0$	$\hat{\mathbf{Y}}_b^0$	$\hat{\mathbf{s}}$	$\hat{\mathbf{e}}$	...
Industries	$\mathbf{V}_b$					$\bar{\mathbf{x}}_b$
Net taxes		$\hat{\mathbf{t}}'_{\text{ind}}$	$\hat{\mathbf{t}}'_{\text{fin}}$	t_{inv}		$\bar{t}_n$
Imports	$\widehat{\mathbf{m}}'$					$\overline{m}$
Value added		$\overline{\mathbf{w}}'_b$				$\overline{w}_b$
Total	...	$\bar{\mathbf{x}}'_b$	$\bar{\mathbf{y}}'$	$\bar{s}$	$\bar{e}$	

Unfortunately, data on changes in inventories by product are typically not collected by National Statistical Institutes on an annual basis and are occasionally measured as a residual in the attempt to balance supply and use at the product level. Given this uncertainly in the official estimates, we decided to adopt a procedure that would be robust, such that the estimation of the other elements in the SUTs would not be greatly affected. Our approach is to estimate them based on total changes in inventories as can be found in the National Accounts. We thus have

$$\hat{s}_i = s_i + \frac{|s_i|}{\Sigma_i |s_i| (\bar{s} - s)}. \tag{5}$$

Note that the difference between the National Accounts total (i.e. $\bar{s}$) and the total in the SUT (i.e. s) is distributed according to absolute shares for products, and not proportionally. This is because proportionality would lead to sizable swings over time due to the fact that changes in inventories can be both positive and negative.[12]

Using the estimates obtained so far yields the situation as depicted in Figure 2. Note that the column sums of the valuation matrix for net taxes appear as a separate row (i.e. $\hat{\mathbf{t}}'_{\text{ind}}$, $\hat{\mathbf{t}}'_{\text{fin}}$ and t_{inv}). It should be emphasized that the table in Figure 2 is not consistent in the sense that columns do not sum to the given column totals, for example. Figure 2 just describes the available information at this stage. The (blocks of) cells in Figure 2 that are coloured grey, contain data that are obtained directly from the National Accounts (using an over bar) or contain estimates that are benchmarked to the National Accounts (using hats). What remains is to estimate the matrices $\hat{\mathbf{U}}_b$, $\hat{\mathbf{Y}}_b$ and $\hat{\mathbf{V}}_b$ that make the table in Figure 2 consistent. This is done with the so-called SUT–RAS method developed by Temurshoev and Timmer (2011). This method is akin to the well-known bi-proportional updating method for IOTs known as the RAS-technique.[13] This technique has been adapted for updating SUTs and has been shown to outperform other methods for the generation of (time-series of) SUTs. The SUT–RAS method requires initial estimates (which are given by $\hat{\mathbf{U}}_b^0$, $\hat{\mathbf{Y}}_b^0$ and $\mathbf{V}_b$ in the uncoloured blocks) which are iteratively adapted, where the information in the grey cells is taken as given and fixed. Note that SUT–RAS does *not* require exogenous information for the total supply/use in basic prices. The SUT–RAS procedure results in estimates for the

[12] It should be stressed that changes in inventories may be very large. For example, the total changes in inventories amounted for Indonesia to 3.4% of GDP in 1997. Due to the economic crisis, many firms decided to eat into their reserves so that the total changes in inventories were no less than −8.7% of GDP in 1998 (and the differences between the 2 years are much larger at the level of single industries).

[13] For an overview of earlier contributions to this literature, see Lahr and de Mesnard (2004). See, for example, Lenzen et al. (2007, 2009) and Minguez et al. (2009), for recent developments. Jackson and Murray (2004) and Temurshoev et al. (2011) tested the accuracy of several RAS-like methods against other updating procedures.

supply table ($\hat{\mathbf{V}}_b$), the use table ($\hat{\mathbf{U}}_b$) and the final use matrix ($\hat{\mathbf{Y}}_b$), all in basic prices. The total supply/use in basic prices then follows from summation, which yields $\hat{\mathbf{q}}_b$.

3.3. Building a time series of national SUTs

In this subsection, we will describe how the national SUTs are estimated for any intermediate year t, given that published SUTs are available for years b_1 and b_2 (with $b_1 < t < b_2$). For each year t, all information in the final column and row of Figure 2 with an over bar is available from the National Accounts. Like it was the case in the previous subsection, we need to estimate imports/exports, changes in inventories, margins and net taxes at the product level before SUT–RAS is applied.

For exports in years b_1 and b_2, Equation 1 is used, which yields $\hat{e}_i^{(b_1)}$ and $\hat{e}_i^{(b_2)}$ for the exports based on information from the published national SUTs. For intermediate years, the export data by product need to be interpolated. This is based on ITS. Interpolation is done using the annual growth rates of ITS at the product level. To accommodate the annual fluctuations but at the same time retain the levels in b_1 and b_2, we employ a procedure that uses the movement of the ITS data with a correction for differences in average annual growth rates. If we denote the exports in year t of product i in the ITS by $ew_i^{(t)}$ we have

$$\hat{e}_i^{(t)} = \hat{e}_i^{(t-1)} \cdot \frac{ew_i^{(t)}}{ew_i^{(t-1)}} \cdot \sqrt[b_2-b_1]{\frac{\hat{e}_i^{(b_2)}/\hat{e}_i^{(b_1)}}{ew_i^{(b_2)}/ew_i^{(b_1)}}}. \tag{6}$$

Next, these estimates need to be normalized such that they add to the total exports ($\bar{e}^{(t)}$) from the National Accounts. That is,

$$\hat{\hat{e}}_i^{(t)} = \bar{e}^{(t)} \frac{\hat{e}_i^{(t)}}{\Sigma_i \hat{e}_i^{(t)}}. \tag{7}$$

Imports at the product level are estimated in the same way.

For the margins and net taxes, we can follow the same steps as outlined above, including Equations 2–4. For this, we can take two starting points, b_1 or b_2. This also leads to two outcomes for the initial estimate (for year t) of the use table in basic prices, for example. Let us denote them by $\hat{\mathbf{U}}_b^{(b_1-\text{based})}$ and $\hat{\mathbf{U}}_b^{(b_2-\text{based})}$. The SUT–RAS is initialized with an average as follows

$$\hat{\mathbf{U}}_b^{(t)} = \frac{(b_2 - t)\hat{\mathbf{U}}_b^{(b_1-\text{based})} + (t - b_1)\hat{\mathbf{U}}_b^{(b_2-\text{based})}}{b_2 - b_1}. \tag{8}$$

The same applies to the other two matrices that are required to initialize SUT–RAS. That is,

$$\hat{\mathbf{Y}}_b^{(t)} = \frac{(b_2 - t)\hat{\mathbf{Y}}_b^{(b_1-\text{based})} + (t - b_1)\hat{\mathbf{Y}}_b^{(b_2-\text{based})}}{b_2 - b_1}$$

and

$$\hat{\mathbf{V}}_b^{(t)} = \frac{(b_2 - t)\mathbf{V}_b^{(b_1)} + (t - b_1)\mathbf{V}_b^{(b_2)}}{b_2 - b_1},$$

where $\mathbf{V}_b^{(b_1)}$ indicates the supply table in year b_1.

For the changes in inventories, the procedure is similar to Equation 2. From the National Accounts, we have information on totals, i.e. $\bar{s}^{(t)}$. From the published SUTs, we used changes in inventories at the product level, i.e. $s_i^{(b_1)}$ and $s_i^{(b_2)}$, and their totals $s^{(b_1)}$ and $s^{(b_2)}$. Proceeding in a forward way gives us

$$\hat{s}_i^{(t)} = s_i^{(b_1)} + \frac{\left|s_i^{(b_1)}\right|}{\Sigma_i \left|s_i^{(b_1)}\right|}(\bar{s}^{(t)} - s^{(b_1)}). \tag{9a}$$

In the same fashion, proceeding in a backward way yields

$$\hat{s}_i^{(t)} = s_i^{(b_2)} + \frac{\left|s_i^{(b_2)}\right|}{\Sigma_i \left|s_i^{(b_2)}\right|}(\bar{s}^{(t)} - s^{(b_2)}). \tag{9b}$$

We have used the simple (arithmetic) average of the two outcomes as our estimate for the changes in inventories at the product level in year t.

The estimates so far, provide the same situation as depicted by Figure 2. The final step is to apply the SUT–RAS method again. This yields the supply table, the use table and the final use matrix, all for year t and all in basic prices. The total supply/use follows again from summation. Extrapolation for years before the first official SUT ($t < b_1$) and after the most recent one ($t > b_2$) are produced from initial estimates based on a single table only.

4. CONSTRUCTION OF THE INTERNATIONAL SUTS

The starting point for this stage is a national SUT with all the information in basic prices. As mentioned earlier, the intermediate use and the final use matrices include imported goods and services. In this section, it will be described how the imports are separated from the domestic deliveries. After that the imports of goods and services will be further broken down according to the country of origin (including the RoW as a single 'country'). We have termed the resulting tables as 'international SUTs'. For this procedure, we will use information from the bilateral trade database that was constructed within the WIOD project (see Foster et al., 2012, for details). Section 4.1 will describe the bilateral trade database and Section 4.2 will discuss the split of the national SUT so as to obtain an international SUT.

4.1. The Bilateral Trade Database

The bilateral trade database covers trade in goods and trade in services. The raw data for the trade in goods were taken from the UN Comtrade database (http://comtrade.un.org/db/default.aspx) and downloaded at the six-digit level in the Harmonized System (HS). The trade database contains the 40 WIOD countries over the period 1995–2010 as reporter countries and all other countries as partner countries. The data for most countries are in HS 1996 for the years 1996–2010 and in HS 1992 for 1995. In some cases, trade data are missing and some gaps have been filled using data from other sources or have been gathered from the respective National Statistical Institutes (NSIs) on request.

In a next step, confidentiality issues had to be tackled. Such confidentiality issues arise when NSIs decide not to report either which amount of a certain product they have been trading (i.e. product-related confidentiality) or with whom they have been trading (i.e. partner-related confidentiality). This is typically the case when there is a near-monopoly situation for a specific product in a country. To allow for this, NSIs report this trade in an artificial partner country indicated as 'Special Categories' or 'Areas, nes'. Such trade flows are included in the information on total imports and exports in the national SUT and need to be attributed. Because an alternative is lacking, trade with partners 'Special Categories' and 'Areas, nes' has been distributed (proportionally to the reported trade values) among the other partner countries according to the difference between total reported trade and the sum of trade for the HS six-digit codes.

There were also some problems specific to particular countries, which had to be handled separately. For example, two particularly thorny issues related to China's trade data. First, data for trade with Taiwan do not exist in the UN Comtrade. Second, the special administrative regions (SARs) of China, i.e. Hong Kong and Macao, were included separately in the trade data. We have handled China and the SARs as one economic entity as is also done in the national SUTs for China. Therefore, trade with (or of) China, therefore, includes the trade with (or of) mainland China, Hong Kong and Macao, which is consistent with the trade reported in the Chinese national SUTs. Flows between China and the SARs have been netted out as well as re-imports and re-exports. We have used the reporter countries' trade with 'Other Asia, nes' to identify trade with Taiwan as a partner, following common practice. Trade data for Taiwan as a reporter country were obtained through the OECD.

Starting from HS six-digit which provides information on bilateral flows of goods of about 5,000 products, the individual flows were merged with a correspondence of the HS six-digit products to use categories distinguishing 'intermediate consumption', 'final consumption', and 'capital goods'. This correspondence was constructed from the Broad Economic Categories (BEC revision 3) classification as provided by UN and the correspondence between these detailed end-use categories into broader groups as applied by OECD. For about 700 products, the correspondence to a particular use category was, however, revised by reclassifying products to the above-mentioned three categories. The classifications do not deal with the problem that one particular good might qualify for more than one use category. For example, cars are both used as final consumption and as investment, and motor spirits as intermediate inputs by firms or as final use by consumers. Therefore, for such products at the HS six-digit level, weights have been assigned (applying simple rules like $1/3 - 2/3$ or $1/2 - 1/2$) allowing for a classification into our three end-use categories.[14] Furthermore, the HS six-digit data were merged with a correspondence to NACE revision 1 at the two-digit level as made available by the Eurostat corresponding to the CPA classification in the national SUTs.

[14] This is still a rather rough procedure. In principle, reporter–product specific (if not reporter–partner–product specific) weights would have to be assigned (e.g. for imports/exports of shirts and parts of shirts which are classified in one HS six-digit category).

The procedure of estimating the bilateral import flows in the national SUTs is as follows.[15] The share of the imports of (each of approximately 5,000) product j that has country h as origin and that goes to each of the three end-use categories is given by , $\alpha_{jh}^{\text{interm}}$, $\alpha_{jh}^{\text{finalcons}}$ and $\alpha_{jh}^{\text{gfcf}}$ and are derived from the ITS. We will use m_j^{ITS} to indicate the total imports of product j in the ITS, because they differ from the imports as given in the national SUTs (which will be indicated later by m_i^{SUT}). This implies

$$m_{jh}^{\text{interm}} = \alpha_{jh}^{\text{interm}} m_j^{\text{ITS}}; m_{jh}^{\text{finalcons}} = \alpha_{jh}^{\text{finalcons}} m_j^{\text{ITS}}; m_{jh}^{\text{gfcf}} = \alpha_{jh}^{\text{gfcf}} m_j^{\text{ITS}}$$

with $\Sigma_h(\alpha_{jh}^{\text{interm}} + \alpha_{jh}^{\text{finalcons}} + \alpha_{jh}^{\text{gfcf}}) = 1$. Next the products are aggregated into the 59 product groups of the WIOD classification. Each of the WIOD-products i $(= 1, \ldots, 59)$ consists of $1, \ldots, n_i$ HS six-products. We thus have for $i = 1, \ldots, 59$;

$$m_{ih}^{\text{interm}} = \sum_{j=1}^{n_i} m_{jh}^{\text{interm}}; \quad m_{ih}^{\text{finalcons}} = \sum_{j=1}^{n_i} m_{jh}^{\text{finalcons}}; \quad m_{ih}^{\text{gfcf}} = \sum_{j=1}^{n_i} m_{jh}^{\text{gfcf}}$$

For the total imports of each WIOD-product, we have $m_i^{\text{ITS}} = \sum_{j=1}^{n_i} m_j^{\text{ITS}}$. At the level of WIOD-products, the share of the imports originating from a country h that goes to each of the end-use categories is then given by

$$\alpha_{ih}^{\text{interm}} = m_{ih}^{\text{interm}}/m_i^{\text{ITS}}; \quad \alpha_{ih}^{\text{finalcons}} = m_{ih}^{\text{finalcons}}/m_i^{\text{ITS}}; \quad \alpha_{ih}^{\text{gfcf}} = m_{ih}^{\text{gfcf}}/m_i^{\text{ITS}}. \tag{10}$$

For the construction of the bilateral data on services flows across countries, it is important to emphasize that services have unique characteristics that greatly affect their tradability and the ability to observe them by current statistical methods. The two most obvious characteristics include intangibility and in many cases of non-storability. In addition, they often require customers having to participate in the production process (Francois and Hoekman, 2010). To capture these aspects, the WTO defines in its General Agreement on Trade in Services (GATS), services trade to span the following four modes of supply. Mode 1 – Cross-border: services supplied from the territory of one country into the territory of another, Mode 2 – Consumption abroad: services supplied in the territory of a nation to the consumers of another, Mode 3 – Commercial presence: services supplied through any type of business or professional establishment of one country in the territory of another (i.e. FDI), and Mode 4 – Presence of natural persons: services supplied by nationals of a country in the territory of another. In the data set collected for the WIOD, only data on cross-border services trade in the GATS mode 1 has been used. The WIOTs are constructed on a territorial basis meaning that they include all activities that take place on the territory of the country, either by residents or non-residents, so mode 3 and 4 are not considered as part of imports and exports. Mode 2 activities are already covered by the items 'purchases of non-residents on domestic territory' and 'foreign purchases of residents' in the national SUTs and are not split further by the country of supply.

[15] Throughout the rest of this subsection, we will use the index j for the 5000 products at the HS six-digit level and the index i for the 59 products in the WIOD SUTs.

To create a data set covering bilateral services flows data from the UN, Eurostat, and OECD have been collected and used.[16] These sources provide bilateral services trade flows with a dual breakdown, i.e. by partners and by BoP codes. The most comprehensive coverage of reporting countries among the three sources is UN, which provides data for 190 reporter countries. Eurostat and OECD provide data for a limited number of reporters: Eurostat covers 27 EU members plus Croatia, Iceland, Japan, Norway, Turkey, Switzerland, and USA; while OECD covers 28 countries (all the OECD members apart from Chile, Iceland, Israel, Slovenia, and Switzerland). The time coverage is the largest in EUROSTAT, which reports data starting from 1995. Since the quality of existing services data is rather poor as compared with merchandize trade statistics, the data had to be adjusted extensively to assure their consistency.

Working with multiple sources made it somewhat easier to identify problems in the data linked to simple errors. For example, there were clear cases where one source reports flows three times larger than the other two sources. Based on the examination of the data, comparisons across sources have been made to filter errors of this type, as well as other problems apparently linked to identifiable data entry errors. It became clear from this examination that the UN sources have (in many cases) identified and cleaned up errors that remain in the EUROSTAT and OECD series. For this reason, the UN data have become the preferred data source.

The resulting data set contains data on bilateral services trade flows for the 40 WIOD countries as reporters and partners plus the RoW. Additionally, for each of the countries data on trade with the world is available. It includes more than 20 economic activities according to the BoP classification. However, not all sectors have the same coverage in terms of time and trading countries. In general, the higher the level of disaggregation, the fewer observations are available. As a word of caution, it should be added that the quality of trade data in services is still far away from being comparable to trade data for merchandize goods. Due to the importance for collecting tariff revenues, trade data for goods have been collected with quite high quality and accuracy. Due to intangibility and nonstorability of services, at-the-border-duties cannot be applied to services, which have resulted in compilation practices with considerably less accuracy. There is ample space for further improvements in the measurement of services trade. The WIOD database for trade in services should be seen in this light as the best currently available approximation to a comprehensive picture of global trade flows in Mode 1 services.

4.2. Estimation of the Use of Imports in the SUTs

This subsection describes how the international SUTs have been obtained from combining national SUTs with information from the bilateral trade database. First, all data had to be converted into current US-$. The exchange rates (year averages) applied were collected from the International Financial Statistics database of the International Monetary Fund (IMF). This resulted in a set of 40 national SUTs for each year over the period 1995–2009 expressed in (millions of) current US-$. The decision to convert national currencies into US-$ (rather than, for example, euros) was motivated by the fact that trade statistics are also

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[16] See http://unstats.un.org/unsd/servicetrade/default.aspx, http://epp.eurostat.ec.europa.eu/portal/page/portal/balance_of_payments/data/database, http://www.oecd.org/std/internationaltradeandbalanceofpaymentsstatistics/oecdstatisticsoninternationaltradeinservicesdetailedtablesbypartnercountry2004-20072009edition.htm

reported in US-$ terms, but any other numéraire currency could have been applied and the choice would have had no consequence for the construction process.

The supply table provides information for the imports (in cost, insurance and freight; cif prices) of each of 59 products (given by the row vector $\widehat{\mathbf{m}}'$ in Figure 2). Let us denote the imports of product i by m_i^{SUT} (in contrast to the imports m_i^{ITS} from ITS data). The use table gives the use of product i by industry j as u_{ij}, which is split into the use of product i that is domestically produced and the part that is imported. For this, we have used the shares given in Equation 10. That is, for $i = 1, \ldots, 59$ and $j = 1, \ldots, 35$,

$$u_{ij}^{\mathrm{IMP}} = \frac{u_{ij}}{\sum_{k=1}^{35} u_{ik}} \left(\sum_h \alpha_{ih}^{\mathrm{interm}} \right) m_i^{\mathrm{SUT}} \quad \text{and} \quad u_{ij}^{\mathrm{DOM}} = u_{ij} - u_{ij}^{\mathrm{IMP}}, \tag{11}$$

where the index h indicates the country of origin.

The same procedure is applied to the final consumption categories, with final consumption expenditures by households, by non-profit organizations serving households (NPISH), and by the government (i.e. the first three columns of the matrix $\mathbf{Y}$ in Figure 1). That is, for $i = 1, \ldots, 59$ and $j = 1, \ldots, 3$,

$$y_{ij}^{\mathrm{IMP}} = \frac{y_{ij}}{\sum_{k=1}^{3} y_{ik}} \left(\sum_h \alpha_{ih}^{\mathrm{finalcons}} \right) m_i^{\mathrm{SUT}} \quad \text{and} \quad y_{ij}^{\mathrm{DOM}} = y_{ij} - y_{ij}^{\mathrm{IMP}}. \tag{12}$$

For gross fixed capital formation (which is the fourth column of the matrix $\mathbf{Y}$ in Figure 1 and is, therefore, indicated by y_{ij}^{IMP} with $j = 4$), we have

$$y_{i4}^{\mathrm{IMP}} = \left(\sum_h \alpha_{ih}^{\mathrm{gfcf}} \right) m_i^{\mathrm{SUT}} \quad \text{and} \quad y_{i4}^{\mathrm{DOM}} = y_{i4} - y_{i4}^{\mathrm{IMP}}. \tag{13}$$

Note that we have made some assumptions here. First, it was assumed that changes in inventories are only related to domestic production. Similarly, we assumed that exports can only be made out of domestic production.

It should be emphasized that it occasionally has happened that the imports as given in the national supply tables (i.e. m_i^{SUT}, which equals $\hat{m}_i$ in Figure 2) were larger than the total domestic use $\sum_j u_{ij} + \sum_k y_{ik}$. By definition, this also means that exports are larger than domestic production. In those cases, we have defined 're-exports' as $m_i^{\mathrm{SUT}} - (\sum_j u_{ij} + \sum_k y_{ik})$ and these have been subtracted from the total imports. Consequently, in cases where imports were larger than total domestic use, we have taken $u_{ij}^{\mathrm{IMP}} = u_{ij}$ and $u_{ij}^{\mathrm{DOM}} = 0$ for all $j = 1, \ldots, 35$, and $y_{ik}^{\mathrm{IMP}} = y_{ik}$ and $y_{ik}^{\mathrm{DOM}} = 0$ for all $k = 1, \ldots, 4$. Total imports change to m_i^{SUT} minus re-exports, which equals $\sum_j u_{ij} + \sum_k y_{ik}$. Note that re-exports thus defined are assumed not to be part of the domestic production process.

The shares of re-exports in total exports (i.e. exports plus re-exports as defined above) vary largely across countries, going up to 18% in the Netherlands and 14% in Cyprus (averaged over the years). Also other small economies (e.g. Lithuania, Estonia, and Luxembourg) have large shares (between 5% and 10%). In more than 30 countries, however, the shares are smaller than 5% and in about half of the countries they are lower than 2%, while they are even zero for Japan, China and Brazil. Overall, the shares tend to increase over time. With respect to products, the shares can be very high in some countries for particular products (e.g. mining). In the manufacturing sectors, large shares of re-exports are found for tobacco products (CPA 16) in the case of Slovakia and Slovenia, for leather and leather products (CPA 19) in Belgium, Denmark, Luxembourg and the Netherlands, for coke and refined petroleum products (CPA 23) in Cyprus and Slovenia, and for electronic products (CPA 30 to CPA 33) in a number of countries. The next step is to split the use of imported products according to the country of origin. Using the shares from Equation 10, we have

$$u_{ij}^{h} = \frac{\alpha_{ih}^{\text{interm}}}{\sum_h \alpha_{ih}^{\text{interm}}} u_{ij}^{\text{IMP}}. \tag{14}$$

For any of 40 target countries in the WIOD, the index h covers each of the remaining 39 WIOD countries and the RoW, which is obtained from summing over all countries in the trade database that are non-WIOD countries. A similar procedure was also used for the final use and gross fixed capital formation,

$$y_{ij}^{h} = \frac{\alpha_{ih}^{\text{finalcons}}}{\sum_h \alpha_{ih}^{\text{finalcons}}} y_{ij}^{\text{IMP}} \quad \text{and} \quad y_{i4}^{h} = \frac{\alpha_{ih}^{\text{gfcf}}}{\sum_h \alpha_{ih}^{\text{gfcf}}} y_{i4}^{\text{IMP}}. \tag{15}$$

A major advantage of this procedure is that the imports of goods do not rely on the standard proportionality assumption that is popular in the literature and applied in various other databases, see, for example, Peters et al. (2011) and Johnson and Noguera (2012). In those cases, a common import proportion is used for all cells in a use row, irrespective of the user. This common proportion is simply calculated as the share of imports in total supply of a product. We find that import proportions differ widely across use categories and importantly, within each use category they differ also by country of origin.[17] Our detailed bilateral approach ensures that this type of information is reflected in the international SUTs and consequently the WIOT. To highlight the differences between the two assumptions, an example is given in Table 1. Table 1 gives a hypothetical example of computers that are used by two industries (financial intermediation and transport equipment), by two categories of final consumption (households and government), for gross fixed capital formation, and for exports. The total uses (including imports) are given in row (1). Exports are sourced only from domestic production. Suppose that it is given that the imports from the USA are 60 and from the RoW 40. Total use minus exports amounts to 200 and therefore 30% of domestic use are imports from the USA and 20% from RoW. Applying the standard proportionality assumption means that the import proportion for the USA (30%) is the same for all uses (except exports, which can only be domestically sourced). Hence, row (2) is obtained by multiplying row (1) with 0.3, except for the exports. Similarly, row 3 uses an import proportion of 20% for RoW. The use of domestic goods is obtained as (1) − (2) − (3), which (for the standard proportionality assumption) is the same as multiplying row (1) with the proportion (i.e. 50%) of domestic use.

In the lower part of Table 1, i.e. rows (5)–(7), we have applied the following shares: $\alpha_{\text{US}}^{\text{interm}} = 0.30$; $\alpha_{\text{US}}^{\text{finalcons}} = 0.25$; $\alpha_{\text{US}}^{\text{gfcf}} = 0.05$; $\alpha_{\text{RoW}}^{\text{interm}} = 0.32$; $\alpha_{\text{RoW}}^{\text{finalcons}} = 0.05$; $\alpha_{\text{RoW}}^{\text{gfcf}} = 0.03$. The imports are 62 for intermediate use, which are proportionally distributed within this category, thus 31 to financial intermediation and 31 to transport equipment. The imports for final use are 30, 18 for household consumption and 12 for government consumption.

[17] See Puzzello (2012) for more empirical evidence of the implausibility of the proportionality assumption.

TABLE 1. An example to illustrate the effect of different assumptions for imports.

	Intermediate		Consumption				
Computers	Fin Int	Trans Eq	Househ	Govern	Gfcf	Exports	Total
(1)	70	70	30	20	10	10	210
(2) USA = 30%	21	21	9	6	3	0	60
(3) RoW = 20%	14	14	6	4	2	0	40
(4) DOM = 50%	35	35	15	10	5	10	110
(5) USA	15	15	15	10	5	0	60
(6) RoW	16	16	3	2	3	0	40
(7) DOM	39	39	12	8	2	10	110

The imports for gross fixed capital formation amount to 8. The domestic use follows from Equations 11–13, and the split of the imports between the USA and the RoW from Equations 14 and 15.

In the real data, the German imports of CPA 34 (Motor vehicles, trailers, and semi-trailers) and CPA 35 (Other transport equipment) were at about the same level for intermediate use and final use in 1995. However, the import share of these products in 2008 had more than quadrupled for intermediate use whereas it only increased by 70% for final use. The 1995 German imports of these two products for intermediate use were about 50% of the total import use (i.e. for intermediate plus final use) and this share increased to 70% in 2008. In the Czech Republic, a target country for offshoring, this share was already 65% in 1995 and increased to more than 80% in 2008. So the application of a non-proportional approach is not only a theoretical refinement, but is also empirically important.

Derivation of import use proportions for services trade is more complicated than for goods. Unfortunately, the BoP data for services trade does not provide any indication on the use of the services imported. For a rough estimate, we have examined information from existing import IO tables from Eurostat which are available in the product by product dimension. These tables indicate which shares of services imports by CPA categories are used as intermediates and final goods. However, close inspection revealed huge differences across countries and over time for individual countries. Therefore, we used a simple average of these shares across countries and over time which has been applied to all years and countries. On average, the bulk of service imports (about 70%) is intermediate imports. A second remark on services trade is that a correspondence between BoP codes and CPA had to be made in order to derive the bilateral shares (the levels were given in the national SUTs). Only a very rough match is possible, given the limitations of detailed bilateral services trade data for particular BoP codes and the differences in classifications of BoP versus CPA codes.

A final remark is with respect to the international trade and transport margins. So far, imports are given in cif prices. In order to match them with export flows, which are expressed in 'free on board' (fob) prices, the imports are converted from cif prices into fob prices. This required the estimation of bilateral international trade margins by the product category. Using detailed trade data from the UN Comtrade database, the ratio of import unit values and export unit values has been estimated in a gravity model with distance, land-lockedness and dummy for the same continent as explanatory variables. This resulted in a set of bilateral

FIGURE 3. The international SUT for country *A*.

	Products	Industries	Final use	Inventories	Export	Total
Products, country *A*		$\mathbf{U}^{AA}$	$\mathbf{Y}^{AA}$	$\mathbf{s}^{A}$	$\mathbf{e}^{A}$	$\tilde{\mathbf{q}}^{A}$
Imports (fob) from country *B*		$\mathbf{U}^{BA}$	$\mathbf{Y}^{BA}$			$\tilde{\mathbf{m}}^{BA}$
Imports (fob) from RoW		$\mathbf{U}^{RA}$	$\mathbf{Y}^{RA}$			$\tilde{\mathbf{m}}^{RA}$
Industries, country *A*	$\mathbf{V}^{A}$					$\mathbf{x}^{A}$
Imports (cif) by country *A*	$(\mathbf{m}^{BA}+\mathbf{m}^{RA})'$					m^{A}
Value added		$(\mathbf{w}^{A})'$				w^{A}
International transport margins		$(\mathbf{tm}_{\mathbf{U}}^{A})'$	$(\mathbf{tm}_{\mathbf{Y}}^{A})'$			tm^{A}
Total	$(\mathbf{q}^{A})'$	$(\mathbf{x}^{A})'$	$(\mathbf{y}^{A})'$	s^{A}	e^{A}	

Note: $\mathbf{U}^{BA}$, $\mathbf{U}^{RA}$, $\mathbf{Y}^{BA}$, $\mathbf{Y}^{RA}$, $\tilde{\mathbf{m}}^{BA}$ and $\tilde{\mathbf{m}}^{RA}$ are all expressed in fob prices.

cif–fob margins for each CPA product.[18] These have further been benchmarked by the trade balance of the WIOD countries in the margins sectors (transport and trade) as outlined in Streicher and Stehrer (2012). This results in estimated overall transport costs of 5–7% of imports on average.

The final outcome of these procedures are import use tables (distinguishing between countries of origin) in cif terms from which the bilateral trade and transport margins were subtracted to generate the use tables in fob terms. The imported use in fob terms can be aligned with the export vector of the origin country when constructing the world SUTs in the next section. Figure 3 sketches the international SUT for country *A*, assuming that there is one other country (i.e. *B*) in the database and that there is a RoW. Potential users can download the 1995–2009 time series of international SUTs of this type for all 40 countries included in the WIOD.

Note that $\tilde{\mathbf{q}}^{A}$ gives the total use of *domestically* produced products (which equals $\boldsymbol{\iota}'\mathbf{V}^{A}$) and that $\mathbf{q}^{A}$ gives total supply of products.

5. CONSTRUCTION OF THE WIOTS

This section describes how the international SUTs for each country discussed in the previous section have been transformed into symmetric WIOTs of the industry-by-industry type for the whole set of countries.

The international SUTs have a product-by-industry nature. Symmetric WIOTs could thus be of the product-by-product type, or the industry-by-industry type. Both types of tables have their advantages (see Chapter 5 in Miller and Blair, 2009, and references therein). Most analytical work links IOTs to additional data available at the industry level, like the data available in the socio-economic and environmental satellite accounts in the WIOD. Consideration of the potential use of the data led to the decision to construct WIOTs of the industry-by-industry type.[19] To produce a WIOT of the industry-by-industry type from international SUTs, two steps were taken. First, the international SUTs have been merged into what we call a 'world SUT'. Next, the world SUT was transformed into a WIOT, by using the fixed product sales structure assumption.

[18] See Streicher (2012) for further details.

[19] Because the international SUTs are available in the WIOD, interested users could produce WIOTs of the product-by-product type themselves. The relative advantages of various methods to construct such tables have been extensively discussed in Eurostat (2008).

FIGURE 4. The world SUTs.

	A products	*B* products	*A* industries	*B* industries	*A* final use	*B* final use	Invent	RoW exports	Total
Products, *A*			$\mathbf{U}^{AA}$	$\mathbf{U}^{AB}$	$\mathbf{Y}^{AA}$	$\mathbf{Y}^{AB}$	$\mathbf{s}^{A}$	$\mathbf{e}^{AR}$	$\tilde{\mathbf{q}}^{A}$
Products, *B*			$\mathbf{U}^{BA}$	$\mathbf{U}^{BB}$	$\mathbf{Y}^{BA}$	$\mathbf{Y}^{BB}$	$\mathbf{s}^{B}$	$\mathbf{e}^{BR}$	$\tilde{\mathbf{q}}^{B}$
Products, RoW			$\mathbf{U}^{RA}$	$\mathbf{U}^{RB}$	$\mathbf{Y}^{RA}$	$\mathbf{Y}^{RB}$			
Industries, *A*	$\mathbf{V}^{A}$								$\mathbf{x}^{A}$
Industries, *B*		$\mathbf{V}^{B}$							$\mathbf{x}^{B}$
Imports (cif)	$(\mathbf{m}^{BA})'+(\mathbf{m}^{RA})'$	$(\mathbf{m}^{AB})'+(\mathbf{m}^{RB})'$							
Value added			$(\mathbf{w}^{A})'$	$(\mathbf{w}^{B})'$					
International transport margins			$(\mathbf{tm}_{\mathbf{U}}^{A})'$	$(\mathbf{tm}_{\mathbf{U}}^{B})'$	$(\mathbf{tm}_{\mathbf{Y}}^{A})'$	$(\mathbf{tm}_{\mathbf{Y}}^{B})'$			*tm*
Total	$(\mathbf{q}^{A})'$	$(\mathbf{q}^{B})'$	$(\mathbf{x}^{A})'$	$(\mathbf{x}^{B})'$					

5.1. Constructing World SUTs

In what follows, we continue the hypothetical 'two-country plus RoW' example from the previous section. Figure 3 gave the international SUT for country *A* and a similar SUT is available for country *B*. The world SUT in this case is obtained by combining the information and rearranging the original information, which yields Figure 4.

In Figure 4, the intermediate inputs parts of the use tables for country *A* are exactly the same as those given in Figure 3. Note, however, that the exports of intermediate products from country *A* to country *B* were obtained during the construction of the international SUT for country *B*. The same applies to the exports of final products from *A* to *B*. This is by way of construction: we assume that the exports from *A* to *B* are mirror flows of the imports of *B* from *A* which have been calculated as described above. Because exports are in fob terms and because exports are taken as the mirror flows of imports, it was necessary in Section 4.2 to transform imports in cif terms to imports in fob terms. Total exports of country *A* in the international SUT was given by $\mathbf{e}^{A}$ and exports to country *B* amount to $\mathbf{U}^{AB}\boldsymbol{\iota} + \mathbf{Y}^{AB}\boldsymbol{\iota}$. Exports to RoW can thus be derived as a residual (i.e. as $\mathbf{e}^{A} - \mathbf{U}^{AB}\boldsymbol{\iota} - \mathbf{Y}^{AB}\boldsymbol{\iota}$).

There are downsides to this residual approach to determine exports to RoW. All measurement errors, aggregation biases, inconsistencies between National Accounts and ITS, and other problems that pertain to the trade flows among the WIOD countries tend to accumulate in the residual. In particular, it is possible that exports to ROW when measured residually become negative. This is undesirable and, therefore, we ruled out this possibility by creating an additional trade reporter 'RoW' in the previous step when trade shares were calculated, described in Section 4.1. For each product at the HS six-digit level, the world aggregate (i.e. the sum over all countries) of exports and of imports were downloaded from the UN Comtrade database. Subtracting the exports and imports by the WIOD reporters from this world aggregate provided the exports and imports of RoW. For trade in services, the available trade in services database in the WIOD has been used.

Using this information, a RAS procedure was applied to reconcile bilateral trade flows. This yielded a bilateral trade matrix and total imports and exports for each product for all WIOD countries and RoW. Moreover, the imports and exports totals are in line with the information from the national SUTs. It should be noted that this procedure adjusted the bilateral trade shares when compared to the shares from the original trade in goods and services data as described in Section 4.1. These adjusted trade data have then been used to construct the international SUTs following the steps reported in Section 4.2.

5.2. From World SUTs to WIOTs

The final part was the transformation of the world SUT into a symmetric WIOT. Note that the world SUT can be considered as a detailed (and partitioned) national SUT for the world economy. Hence, well-known transformation methods to obtain symmetric IOTs from a SUT system could be applied. Given the choice to derive WIOTs of the industry-by-industry type, two transformation methods could be considered (see Rueda-Cantuche and ten Raa, 2009, for an extensive discussion of alternative methods to derive industry-by-industry IOTs from SUTs). The difference between the two methods is in the treatment of secondary products. The supply table in the world SUT also contains a lot of positively valued cells that do not relate to the main products of an industry (since the number of products exceeds the number of industries in the WIOD, this phenomenon emerges by construction). Eurostat (2008, Chapter 11) provides a very accessible explanation of the main characteristics of both methods, which are commonly referred to as 'Model C' and 'Model D'.

Model C treats secondary products according to the *fixed industry sales structure* assumption. This assumption boils down to assuming that each industry has its own sales structure (for intermediate input deliveries to other industries, and to various final demand categories). This implies that it sells its secondary products to exactly the same industries and final users and in exactly the same proportions as its main products. In Model D, the *fixed product sales structure* assumption is the point of departure. In this case, each product has its specific sales structure. It does not matter in which industry the product has been produced and consequently, the sales structure is assumed to be identical for products that have been produced as an industry's principal output or as a secondary product by another industry.

Practitioners have developed a clear preference for Model D. This preference is based on two major disadvantages of Model C. First, and most importantly, the fixed industry sales structure is considered to be much more implausible in an empirical sense than the fixed product sales structure assumption. Secondly, application of Model C can yield IOTs with negative entries in columns where only nonnegative values should appear (i.e. in the intermediate inputs block and in consumption), even if the original SUT does not. Some *ad hoc* methods have been proposed to solve these problems, but the two drawbacks of Model C taken together have been sufficient to make Model D the clearly dominant transformation method. In the WIOD, this transformation method has been applied as well.

The mathematical expressions that are involved in the transformation according to Model D can be found in Eurostat (2008, p. 349). That is, define the industry-by-product matrix $\mathbf{B}^A = \mathbf{V}^A(\hat{\tilde{\mathbf{q}}}^A)^{-1}$ with its element b_{ij}^A indicating the share of domestic output of product j that is produced by industry i. A similar definition holds for $\mathbf{B}^B$. Figure 5 depicts the WIOT for the case of countries A and B, and a RoW. The industry-by-industry matrices of intermediate deliveries are then given by

$$\mathbf{Z}^{AA} = \mathbf{B}^A\mathbf{U}^{AA}, \quad \mathbf{Z}^{AB} = \mathbf{B}^A\mathbf{U}^{AB}, \quad \mathbf{Z}^{BA} = \mathbf{B}^B\mathbf{U}^{BA}, \quad \text{and} \quad \mathbf{Z}^{BB} = \mathbf{B}^B\mathbf{U}^{BB}.$$

Similarly, we have for the final use matrices at the industry level

$$\mathbf{F}^{AA} = \mathbf{B}^A\mathbf{Y}^{AA}, \quad \mathbf{F}^{AB} = \mathbf{B}^A\mathbf{Y}^{AB}, \quad \mathbf{F}^{BA} = \mathbf{B}^B\mathbf{Y}^{BA}, \quad \text{and} \quad \mathbf{F}^{BB} = \mathbf{B}^B\mathbf{Y}^{BB}.$$

FIGURE 5. The WIOT.

	Intermediate use			Final use			Inventories	Total
	A	*B*	RoW	*A*	*B*	RoW		
Industries, *A*	$\mathbf{Z}^{AA}$	$\mathbf{Z}^{AB}$	$\mathbf{Z}^{AR}$	$\mathbf{F}^{AA}$	$\mathbf{F}^{AB}$	$\mathbf{F}^{AR}$	$\tilde{\mathbf{s}}^{A}$	$\mathbf{x}^{A}$
Industries, *B*	$\mathbf{Z}^{BA}$	$\mathbf{Z}^{BB}$	$\mathbf{Z}^{BR}$	$\mathbf{F}^{BA}$	$\mathbf{F}^{BB}$	$\mathbf{F}^{BR}$	$\tilde{\mathbf{s}}^{B}$	$\mathbf{x}^{B}$
Industries, RoW	$\mathbf{Z}^{RA}$	$\mathbf{Z}^{RB}$	$\mathbf{Z}^{RR}$	$\mathbf{F}^{RA}$	$\mathbf{F}^{RB}$	$\mathbf{F}^{RR}$		$\mathbf{x}^{R}$
Value added	$(\mathbf{w}^{A})'$	$(\mathbf{w}^{B})'$	$(\mathbf{w}^{R})'$					
Int. transp. marg.	$(\mathbf{tm}_{\mathbf{U}}^{A})'$	$(\mathbf{tm}_{\mathbf{U}}^{B})'$	$\mathbf{0}$	$(\mathbf{tm}_{\mathbf{Y}}^{A})'$	$(\mathbf{tm}_{\mathbf{Y}}^{B})'$	$\mathbf{0}$	0	*tm*
Output	$(\mathbf{x}^{A})'$	$(\mathbf{x}^{B})'$	$(\mathbf{x}^{R})'$					

The vectors for exports to RoW and changes in inventories at the industry level are obtained as

$$\tilde{\mathbf{e}}^{AR} = \mathbf{B}^{A}\mathbf{e}^{AR}, \quad \tilde{\mathbf{e}}^{BR} = \mathbf{B}^{B}\mathbf{e}^{BR}, \quad \tilde{\mathbf{s}}^{A} = \mathbf{B}^{A}\mathbf{s}^{A}, \quad \text{and} \quad \tilde{\mathbf{s}}^{B} = \mathbf{B}^{B}\mathbf{s}^{B}.$$

For the construction of WIOTs from world SUTs, one step was necessary that is not required when national IOTs are constructed. In the use tables in the international SUTs, information about imports (by product) from RoW is contained in $\mathbf{U}^{RA}$ and $\mathbf{U}^{RB}$. To transform these product-by-industry matrices into industry-by-industry matrices, a similar transformation as $\mathbf{B}^{A}$ and $\mathbf{B}^{B}$ was needed for RoW. It was estimated by constructing a condensed supply table for the 40 WIOD countries (i.e. $\mathbf{V}^{R} = \mathbf{V}^{A} + \mathbf{V}^{B}$ for the two-country example of Figures 4 and 5) and dividing its cells by aggregated product output (i.e. $(\tilde{\mathbf{q}}^{R})' = \boldsymbol{\iota}'\mathbf{V}^{R}$), which yields $\mathbf{B}^{R} = \mathbf{V}^{R}(\hat{\tilde{\mathbf{q}}}^{R})^{-1}$. This procedure should yield a sensible estimate of the true transformation matrix if the distribution of products over supplying industries in RoW is rather similar to that of the countries covered in the WIOD. The estimates in Figure 5 are given by

$$\mathbf{Z}^{RA} = \mathbf{B}^{R}\mathbf{U}^{RA}, \quad \mathbf{Z}^{RB} = \mathbf{B}^{R}\mathbf{U}^{RB}, \quad \mathbf{F}^{RA} = \mathbf{B}^{R}\mathbf{Y}^{RA}, \quad \text{and} \quad \mathbf{F}^{RB} = \mathbf{B}^{R}\mathbf{Y}^{RB}.$$

The column $\tilde{\mathbf{e}}^{AR}$ with exports of country *A* to RoW was split into exports for intermediate use ($\mathbf{Z}^{AR}$) and for final use ($\mathbf{F}^{AR}$). For this, we used the average export shares to these use categories by developed economies to developing economies included in the WIOD. The developing economies considered are Brazil, Russia, India, China, Indonesia, and Mexico (BRICIM). For example, the average export shares of Austria's agricultural sector to the BRICIM across intermediate use industries and final use categories was used to split up the Austrian agricultural exports to RoW. This was done cell-wise (if the exporting country was a BRICIM country, it was excluded from the BRICIM average for these particular cells). The same approach resulted in the matrices $\mathbf{Z}^{BR}$ and $\mathbf{F}^{BR}$ in Figure 5.

Finally, the domestic deliveries in RoW (i.e. $\mathbf{Z}^{RR}$ and $\mathbf{F}^{RR}$) have been estimated, based on data collected from the UN National Accounts. First, value-added data by economic activity and final demand category were summed for all countries not included in the WIOD to arrive at estimates of GDP by broad sectors and final demand categories for RoW. Gross output levels were obtained by applying the industry-specific average ratios of gross output to value added for developing economies in the WIOD (BRICIM). To split the broad manufacturing sector in the UN National Accounts into the considerably more disaggregated manufacturing industries in the WIOD, the average shares by the industry from the UNIDO industrial statistics for all countries not included in the WIOD for the period from 1995 to 2009 were used.

Next, initial estimates of the domestic intermediate use block and the domestic final demand block have been obtained as weighted averages shares from the BRICIM countries. Jiang et al. (2012) arrived at the conclusion that such an 'averaging coefficients' procedure performs relatively well if unknown tables can be estimated by using data from other countries or regions for the same time period. Finally, to arrive at a balanced table, for which the column sums equal the row sums for RoW, we applied the RAS algorithm. To this end, we only RASsed the domestic block of RoW in the WIOTs, which implies that exports from RoW remained unchanged. The initial values fed into the algorithm were the input coefficients from the BRICIM countries, whereas the row and column totals were given by the externally provided data based on the UN National Accounts and UNIDO industrial statistics as described.

The WIOD database also contains WIOTs of the pyp. These tables have been obtained by applying row-wise deflation using industry output deflators, as published in the National Accounts. It should be stressed that the cells in the value-added row of the WIOTs in pyp have been obtained by double deflation, as residuals (the values of which ensure that the tables in pyp are balanced). NSIs derive value added in pyp (and therefore GDP in pyp) using much more detailed price information. Hence, the value-added figures in the WIOTs in pyp are not necessarily equal to those published by NSIs.[20] For value-added figures in constant prices as published by the NSIs, one is referred to the value-added volume indices in WIOD's socio-economic accounts. Dietzenbacher and Hoen (1998) proposed a method in which such externally constructed data in pyp can be used to arrive at an IOT in pyp, but this method is not suitable to address the problem at hand. It supposes that data on gross output and final demand in pyp are available at the level of industries. Such data are not available from National Accounts or any other source.

6. THE CONTENTS OF THE WIOD

The WIOD covers 27 EU countries and 13 other major countries in the world and provides annual data for the period from 1995 to 2009. The countries are listed in Table 2. They are selected on the basis of the quality and the public availability of their data in combination with their economic importance (together they account for approximately 85% of world GDP). All SUTs are of the format 35 industries by 59 products and all IOTs are 35 industries by 35 industries. The product and industry classifications are given in Tables A1 and A2, respectively, in a separate supplementary document that is accessible through the website of this journal. All data are downloadable at http://www.wiod.org/database/index.htm. The database includes the following information.

[20] For the RoW, this approach could not be used because industry output deflators are not systematically available for major countries that belong to RoW. Therefore, all cells in the RoW blocks have been deflated by the US GDP deflator. This approximation would be close to what would have been obtained with proper deflators if the exchange rates between the RoW currencies and the US dollar would be completely flexible, and the – in theoretical work popular – law of one price would hold. Both conditions are clearly not met in reality, but it is the best that can be attained, given data availability. Updates of the WIOD might contain WIOTs in pyp in which published value-added figures are combined with published industry gross output deflators, and where a biproportional method is used to yield balanced tables. More analysis is needed, however, to see whether such an approach yields empirically sensible results.

TABLE 2. WIOD countries and the regional aggregation adopted for the interregional WIOTS.

Euro-zone		Non-Euro EU	NAFTA	China	East Asia	BRIIAT
Austria	Italy	Bulgaria	Canada	China	Japan	Brazil
Belgium	Luxembourg	Czech Rep.	Mexico		Korea	Russia
Cyprus	Malta	Denmark	USA		Taiwan	India
Estonia	Netherlands	Hungary				Indonesia
Finland	Portugal	Latvia				Australia
France	Slovakia	Lithuania				Turkey
Germany	Slovenia	Poland				
Greece	Spain	Romania				
Ireland		Sweden				
		UK				

World tables

- International SUTs in current prices and pyp, with use split into domestically produced products and imported products by country of origin.
- WIOTs in current prices and pyp.
- Interregional IOTs for six regions (see Table A1 for the regional aggregations).

National tables

- National SUTs in current prices and pyp
- National IOTs in current prices

Socio-economic accounts (for details, see Erumban et al., 2012a)

- Industry output and value added, both in current and constant prices (indexed with 1995 as 100).
- Capital stock and investments.
- Wages and employment (in hours) by skill type, distinguishing low-, medium- and high-skilled workers.

Environmental accounts (for details, see Genty et al., 2012)

- Gross energy use by sector (i.e. industries and households) and energy commodity.
- Emission relevant energy use by sector and energy commodity.
- CO_2 emissions modelled by sector and energy commodity.
- Emissions to air by sector and pollutant.
- Land use, materials use and water use by type and sector.

7. CONCLUDING REMARKS

This paper describes the construction of the core of the WIOD: a time series of industry-by-industry IOTs for 40 countries plus the RoW for the period 1995–2009. Starting from a set of underlying principles, among which reconciliation with time series from National

Accounts and the use of official and public data are key), the construction procedure has been explained on a step-by-step basis. Some weaknesses of the approach have been touched upon, but there are more detailed issues that require closer scrutiny in follow-up research. An example of such an issue is international tourism. NAS appeared to record this part of international trade in very different ways. Given time limitations, the decision was made not to pursue this further, and to tackle problems that are relevant for almost all countries (such as differences in price concepts and treatment of re-exports and imports for processing activities). Nevertheless, data improvements for countries that depend relatively heavily on tourism seem possible, and more examples of opportunities for further work could be given.

In the longer run, continuing developments in the international statistical arena might lead to fundamental improvements regarding the data on which WIOD-like WIOTs could be constructed. First, the country coverage could most likely be improved after the Asian Development Bank launched an effort to assist NSIs of export-oriented countries such as Malaysia, the Philippines, Thailand and Vietnam in starting to construct SUTs. Second, the recent OECD–WTO 'Made in the World' Initiative has already led to plans regarding the systematic construction of data material that would explicitly distinguish between production structures of the parts of industries that export and of those parts that only deliver to domestic purchasers. Pioneering work by Chen et al. (2008) for China has shown that the implications of such a distinction for 'trade in value added' figures are substantial (see also Koopman et al., 2010, Johnson and Noguera, 2012).

A final long-term opportunity to improve on the current state of affairs is related to trade in services. The increasing importance of trade in services has led the United Nations Statistics Division to introduce a separate section on services trade in its trade statistics commission. Hopefully, this will lead to a much better coverage of bilateral services trade in a product classification, together with a distinction into end-use categories.

In the last section, we listed the contents of the satellite accounts that accompany the IOTs. These satellite accounts contain industry-level indicators regarding the inputs of production factors (such as capital and various types of labour), energy use and indicators of pollution due to industrial activity (such as emissions of greenhouse gases). These data enabled us already to come up with answers to the first question posed in the introduction. Between 1995 and 2007, the number of Chinese jobs that depended on consumption and investment demand in foreign countries increased from about 110 million to about 180 million (Los et al., 2012). Of these 180 million workers, actually more than 60% were not working in the manufacturing industries although Chinese exports are mainly manufacturing goods. This shows the importance of the indirect effects to which input–output analysis pays much attention. In other work, we found that fragmentation has led to a new division of tasks between advanced and emerging economies, with the former increasingly specializing in capital and high-skill intensive production activities (Timmer et al., 2012). We hope and think that combining data from these satellite accounts and the WIOTs in the WIOD will lead to many more studies that empirically examine the socio-economic and environmental consequences of globalization.

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