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World Input-Output Database (WIOD): Construction, Challenges and Applications

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Abstract
This paper describes the contents and construction of a new database to analyze the effects of globalization on socio-economic and environmental trends at the country and global level. This database called WIOD (World Input-Output Database) is constructed by linking national supply and use tables with statistics on international trade. In this way it is feasible to estimate e.g. the use of Chinese paint in German cars bought by Japanese consumers. This international input-output table is firmly grounded in national accounts statistics and complemented with additional socio-economic accounts on the use of various types of labour (by skill level) and capital (ICT and non-ICT assets). It also includes various environmental indicators such as energy use and greenhouse-gas emission. The database will include the major economies in the world covering 90% of world GDP and provide time series from 1995 onwards. We discuss the methods and datasources used in construction. In addition we give illustrative applications in the area of outsourcing and its impact on global production networks and emissions of greenhouse gases. The database is currently being constructed by a consortium of eleven research institutes in the WIOD-project (www.wiod.org) and the paper reports on the first phase of this project.

1. Introduction

The ongoing process of globalisation puts new challenges to the study of economic growth and development around the world. As finance, people, goods and services increasingly flow from one country to another, international interdependencies strongly impact on the development space of individual countries. Changing patterns of world trade drive income distributions across and within regions, and shift environmental burdens of production and consumption. This is manifest in the mushrooming of global production networks in which various stages of the production process take place at distant geographical areas. Intermediate goods and services are heavily traded across borders, driven by the opportunities offered by advances in information and communication technologies. A hard-disk drive manufactured in Thailand typically consists of inputs sourced from over fifteen different countries. A car in Spain is assembled out of imports from all around the world. This globalisation process provides new opportunities for a global division of labour and production, increasing employment opportunities and growth. On the other hand, shifting trade and production patterns might have adverse effects on local and global distributions of income and natural resources. For example, the pollution haven hypothesis maintains that rich countries are able to contain the environmental pressure of domestic production only by relocating pollution-intensive industries. This would lead to an increasing divergence between the actual use of resources in local production and the use of resources implicit in local consumption.

Globalisation also puts new demands on statistical information for research and policy analysis. A thorough analysis of globalisation and its effects on the economy and environment relies heavily on extensive monitoring of international trade. Existing international trade statistics provide information on the value of goods and services traded, but convey little about the value added in production by the exporting country. The latter though is crucial for an analysis of e.g. income, employment and environmental effects of local production. This type of information however is currently not being collected in statistical systems and researchers have to rely on datasets constructed outside the international statistical systems. Various alternative datasets have been built in the past of which the GTAP database is the most widely known and used. However, all these databases provide only one or a limited amount of benchmark years and do not offer an analysis of developments over time. In this paper we present a new database called the World Input-Output Database (WIOD) that aims to fill this gap. The WIOD will provide a time-series of world input-output tables from 1995 onwards. National input-output tables of forty major countries in the world are linked through international trade statistics. A world input-output table allows one to study say the use of Chinese chemicals in German automobiles bought by Japanese consumers over time. Moreover, the WIOD contains additional satellite accounts. A socio-economic account provides detailed information on the use of various type of labour (distinguished by skill level) and capital (including ICT and non-ICT) in production. The environmental accounts provide information on energy use, greenhouse-gas emissions and other air pollutants of production and final consumption. By standardising concepts and classifications, WIOD opens up a new range of feasible studies on the effects of globalisation. As the WIOD will be made available to the public for free in due time, we hope to stimulate new research in this area.

The remainder of the paper is organised as follows. In section 2 we outline the conceptual framework of a world input-output table. Methods of construction and datasources used are discussed in Section 3. Section 4 introduces datasources for the world input-output table and the socio-economic and environmental satellite accounts. In Section 5 we provide two preliminary applications of the WIOD: one on international trade in value added and another on consumption-based accounting of greenhouse-gas emissions. Section 6 concludes.

2. World Input-Output Table (WIOT): Concepts

In this section we outline the basic concepts of a world input-output table (WIOT). A natural starting point to investigate the increasing interdependence of countries is the use of international trade statistics. Export and import statistics are routinely produced by national statistical institutes (NSIs) on the basis of custom declarations and firm surveys. The compilation of this data is internationally harmonised and comparable statistics are frequently published by the European Union, the OECD and the United Nations. Exports and imports as a share of GDP are steadily increasing in most countries in the world and this measure is often used to indicate the increasing connection of national economies. An increasing share of this international exchange is trade in intermediate products. Rather than goods destined for final consumption, these goods are further used in the production process of the importing country. This phenomenon is also known as global production networks. Separate stages of the production process now take place at different geographical locations rather than being concentrated in a home country. For example, whereas in the past the production of personal computers took mainly place within the U.S., now the separate phases of component production, assembly, testing and packaging are scattered around the world. There is much evidence about the rise of these networks in the past decades but this consists mostly of single product studies based on firm-level cases (Kaplinsky 2000, Gereffi 1999; Sturgeon, van Biesebroeck and Gereffi 2008)

A major bottleneck in the study of global production networks and their socio-economic and environmental effects is the lack of information on cross-country inter-industry linkages. International trade statistics indicate the value of export of say disk-drives from Malaysia to Japan. But they do not convey any information about the value of the product that is actually created in the exporting country. The only information given in the trade statistics is the description of the product, following international product classifications, such as the Harmonised System (HS). When the components of the disk-drive, such as optical devices, semi-conductors and plastics, are imported by Malaysia, rather than produced domestically, the export value of the disk-drive will be a weak indicator of the value added by the Malaysian economy. It may range anywhere between virtually zero, in case Malaysia is merely re-exporting finished disk-drives from another country, to the full value in case all stages of production took place within the Malaysian economy. As a result, the increasing importance of global production networks diminishes the usefulness of international trade statistics for country-level analysis. It may lead to reliance on misleading indicators such as the share of high-tech products in total exports. This is a popular indicator of the strength of a national economy and innovation system. But this indicator can be high even for a country that is only involved in the last stages of production such as testing and packaging that require little skills or technical capabilities.

Clearly what is needed for this type of analysis is information not only on the international flow of products, but also on the inter-industry flows. This would enable one to track the origin of products used as intermediates, eiher being domestically produced or imported, and the industry from which it originated. This type of information is contained in a so-called international, or world, input-output table. To outline the framework of such a table we start with the discussion of a national input-output (IO) table.

In Figure 1 the schematic outline for a national input-out table (IOT) is presented. For ease of discussion we assume that each industry produces only one (unique) product.[1] The rows in the upper parts indicate the use of products, being for intermediate or final use. Each product can be an intermediate in the production of other products (intermediate use). Final use includes domestic use (private or government consumption and investment) and exports. The final element in each row indicates the total use of each product. The industry columns in the IOT contain information on the supply of each product. A product can be imported or domestically produced. The column indicates the values of all intermediate, labour and capital inputs used in production. The vector of input shares in output is often referred to as the technology for domestic production. The compensation for labour and capital services together make up value added which indicates the value added by the use of domestic labour and capital services to the value of the intermediate inputs. Total supply of the product in the economy is determined by domestic output plus imports. An important accounting identity in the IOT is that total supply equals total use for each product, such that all flows in the economic system are accounted for. The national IOTs are the basic building blocks for constructing our World IO table.

[Figure 1 about here]

Basically, a world input-output table (WIOT) is a combination of national IOTs in which the use of products is broken down according to their origin. Each product is produced either by a domestic industry or by a foreign industry. In contrast to the national IOT, this information is made explicit in the WIOT. For a country A, flows of products both for intermediate and final use are split into domestically produced or imported. In addition, the WIOT shows for imports in which foreign *industry* the product was produced. This is illustrated by the schematic outline for a WIOT in Figure 2.

[1] See Blair and Miller (2009) for an elaborate introduction to input-output tables and analysis.

[Figure 2 about here]

Figure 2 illustrates the simple case of two regions: country A and the rest of the world. In WIOD we will distinguish 40 countries and the rest of the World, but the basic outline remains the same. For each country the use rows are split into two separate rows, one for domestic origin and one for foreign origin. In contrast to the national IOT for country A it is now clear from which foreign industry the imports originate, and how the exports of country A are being used by the rest of the world, that is, by which industry or final end user. The WIOT contains similar information for all other countries in the table. This combination of national and international flows of products provides a powerful tool for analysis of global production chains and their effects on employment, value added and investment patterns and on shifts in environmental pressures. While national IO tables are routinely produced by NSIs, WIOTs are not as they require a high level of harmonisation of statistical practices across countries. In the following sections we outline our construction of a WIOT.

3. World Input-Output Table (WIOT): Construction and sources

In this section we outline the construction of the WIOT and discuss the underlying data sources. In short, we derive time series of national supply and use tables (SUTs) and link these across countries through detailed international trade statistics to crease so-called international SUTs. These international SUTs are used to construct the symmetric world input-output table which is product or industry based, depending on the set of alternative assumptions used. In Section 3.1 we provide an overview, while in section 3.2 we delve into methodologies and data sources used. For an elaborate discussion of construction methods, practical implementation and detailed sources, see Erumban et al. (2010, forthcoming).

3.1 Brief overview of WIOT construction

The construction of our WIOT has two distinct characteristics when compared to e.g. the methods used by GTAP, OECD and IDE-JETRO. First, we rely on national supply and use tables (SUTs) rather than input-output tables as our basic building blocks. Second, to ensure meaningful analysis over time, we start from output and final consumption series given in the national accounts and benchmark national SUTs to these time-consistent series. SUTs are a more natural starting point for this type of analysis as they provide information on both products and (using and producing) industries. A supply table provides information on products produced by each domestic industry and a use table indicates the use of each product by an industry or final user. The linking with international trade data, that is product based, and socio-economic and environmental data, that is mainly industry-based, can be naturally made in a SUT framework. In contrast, an input-output table is exclusively of the product or industry type. Often it is constructed on the basis of an underlying SUT, requiring additional assumptions.

In Figure 3 a schematic representation of a national SUT is given. Compared to an IOT, the SUT contains additional information on the domestic origin of products. In addition to the imports, the supply columns in the left-hand side of the table indicate the value of each product produced by domestic industries. The upper rows of the SUT indicate the use of each product. A SUT must obey two basic accounting identities: for each product total supply must equal total use, and for each industry the total value of inputs must equal total output value.

Let S denote supply and M imports, subscripts i and j denote products and industries and superscripts D and M denote domestically produced and imported products respectively. Then total supply for each product i is given by the summation of domestic supply and imports:

$$S_i = \sum_j S_{ij}^D + M_i \qquad (1)$$

Total use (U) is given be the summation of final domestic use (F), exports (E) and intermediate use (I) such that

$$U_i = F_i + E_i + \sum_j I_{i,j} \quad (2)$$

The identity of supply and use is then given by

$$F_i + E_i + \sum_j I_{i,j} = \sum_j S_{ij}^D + M_i \qquad \forall i \qquad (3)$$

The second accounting identity can be written as follows

$$\sum_i S_{ij}^D = VA_j + \sum_i I_{ij} \qquad \forall j \qquad (4)$$

This identity indicates that for each industry the total value of output is equal to the total value of inputs. The latter is given by the sum of value added (VA) and intermediate use of products.

[Figure 3 about here]

In the first step of our construction process we benchmark the national SUTs to time-series of industrial output and final use from national account statistics. Typically, SUTs are only available for a limited set of years (e.g. every 5 year) and once released by the national statistical institute revisions are rare. This compromises the consistency and comparability of these tables over time as statistical systems develop, new methodologies and accounting rules are used, classification schemes change and new data becomes available. These revisions can be substantial especially at a detailed industry level. By benchmarking the SUTs on consistent timeseries from the NAS, tables can be linked over time in a meaningful way. In the next section we provide further information about the extrapolation and linking procedures.

In a second step, the national SUTs are combined with information from international trade statistics to construct what we call international SUTs. Basically, a split is made between use of products that were domestically produced and those that were imported, such that

$$
\begin{aligned}
I_{i,j} &= I_{i,j}^{D} + I_{i,j}^{M} \quad \forall i, j \\
F_i &= F_i^{D} + F_i^{M} \quad \forall i \quad (5) \\
E_i &= E_i^{D} + E_i^{M} \quad \forall i
\end{aligned}
$$

This breakdown must be made in such a way that total domestic supply equals use of domestic production for each product:

$$\sum_j I_{i,j}^{D} + F_i^{D} + E_i^{D} = \sum_j S_{i,j}^{D} \quad \forall i \qquad (6)$$

and total imports equal total use of imported products

$$\sum_j I_{i,j}^{M} + F_i^{M} + E_i^{M} = M_i \quad \forall i \qquad (7)$$

The outline of an international SUT is given in Figure 4.

[Figure 4 about here]

So far we have only considered imports without any geographical breakdown. To study international production linkages however, the country of origin of imports is important as well. Let *k* denote the country from which imports are originating, then an additional breakdown of imports is needed such that

$$\sum_k \sum_j I_{i,j,k}^{M} + \sum_k F_{i,k}^{M} + \sum_k E_{i,k}^{M} = \sum_k M_{i,k} = M_i \quad \forall i \quad (8)$$

As a final step the international SUTs for each country are combined into a world input-ouput table, as given in Figure 2. This transformation step requires additional assumptions that are spelled out in more detail below.

3.2 Implementation and sources

In this section we outline the various steps taken in the construction process of the WIOT. These steps are summarised in Figure 5 that illustrates the basic data sources used and the various transformations applied. Four phases can be distinguished:

A. Raw data collection and harmonisation
B. Construction of time-series of SUTs
C. Breakdown of import and domestic production in Use table
D. Construction of WIOT

[Figure 6 about here]

A. Raw data collection and harmonisation

Three types of data are being used in the process, namely national accounts statistcs (NAS), supply-use tables (SUTs) and international trade statistics (ITS). Importantly, this data must be publicly available such that users of the WIOT are able to trace the steps made in the construction process. Moreover, official published data is more reliable as checking and validation procedures at NSIs are more thorough than for data that is ad-hoc generated for specific research purposes. The data is being harmonised in terms of industry- and product-classifications both across time and across countries. The WIOD classification list has 59 products and 35 industries based on the CPA and NACE rev 1 (ISIC rev 2) classifications. The product and industry lists are given in Appendix Tables 1 and 2. This level of detail has been chosen on the basis of initial data-availability exploration and ensures a maximum of detail without the need for additional information that is not generated in the system of national accounts. The 35-industry list is identical to the list used in the EUKLEMS database with additional breakdown of the transport sector as these industries are important in linking trade across countries and in the transformation to alternative price concepts (from purchasers' to basic prices, see below).[2] Hence WIOD can be easily linked to additional variables on investment, labour and productivity in the EU KLEMS database (see www.euklems.net, O'Mahony and Timmer 2009). The product list is based on the level of detail typically found in SUTs produced by European NSIs, following Eurostat regulations. It is more detailed than the industry list to allow for a maximum link with the very detailed product data from the ITS. It is well-known that non-survey methods to split up imports such as used in WIOD (see below) are best applied at the lowest level possible.

To arrive at a common classification, correspondence tables have been made for each national SUT bridging the level of detail and classifications in the country to the WIOD classification. This involved aggregation and sometimes disaggregation based on additional detailed data. While for most European countries this was relatively straightforward, tables for non-EU countries proved more difficult. National SUTs were also checked for consistency and adjusted to common concepts (e.g. regarding the treatment of FISIM and purchases abroad). Undisclosed cells due to confidentiality concerns were imputed based on additional information. The adjustments and harmonisation are described in more detail on a country-by-country basis in Erumban et al. (2010).

[2] In addition, in WIOD the EUKLEMS industry 17-19 is split into textiles and wearing apparel (17-18) and footwear (19) because of the large amount of international trade in these industries.

B. Construction of time-series of SUTs

As discussed above, national SUTs are only infrequently available and are often not harmonised over time. Therefore they are benchmarked on consistent time-series from the NAS in a second step. From the NAS data time series on output and value added by industry, total imports and total exports and final use by use category are derived. This data is used to generate time series of SUTs using the so-called SUT-RAS method (Temurshoev and Timmer 2009). This method is akin to the well-known bi-proportional updating method for input-output tables known as the RAS-technique. This technique has been adapted for updating SUTs.

Timeseries of SUTs are derived for two price concepts: basic prices and purchasers' prices. Basic price tables reflect the costs of all elements inherent in production borne by the producer, whereas purchasers' price tables reflect the amount paid by the purchaser. The difference between the two are the trade and transportation margins and net taxes. Both price concepts have their use for analysis depending on the type of research question. Supply tables are always at basic price and often have additional information on margins and net taxes by product. The use table is typically at a purchasers' price basis and hence needs to be transformed to a basic price table. The difference between the two tables are given in the so-called valuation matrices (Eurostat 2008, Chapter 6). These matrices are typically not available from public data sources and hence need to be estimated. In WIOD we distinguish 4 types of margins: automotive trade, wholesale trade, retail trade and transport margins. The distribution of each margin type varies widely over the purchasing users and we use this information to improve our estimates of basic price tables.

C. Breakdown of import and domestic production in Use table

The next step is a breakdown of the use table into domestic and imported origin. As margins are only generated by the domestic industries, a breakdown of the use table at basic price is made. Ideally one would like to have additional information based on firm surveys that inventory the origin of products used, but this type of information is hard to elicit and only rarely available. We use a non-survey imputation method that relies heavily on a classification of detailed products in the ITS into various use categories. Our basic data is bilateral import flows between all our countries at a 6-digit product level from WITS. Based on the detailed product description in the harmonised system (HS) used in WITS, products are allocated to four use categories: intermediate, consumption, investment or mix. This resembles the well-known Classification by Broad Economic Categories (BEC) but is much more fine-grained as BEC is only based on 3-digit product groups. Moreover, BEC only covers goods and not services which have become increasingly important in international trade. Based on our alternative use classification, we allocate imports across use categories in the following way.

Let $m_{i,k}^{l}$ indicate the share of use categories l (intermediate, final consumption or investment) in imports of product *i* by a particular country from country *k* defined as

$$m_{i,k}^{l} = \frac{\tilde{M}_{i,k}^{l}}{\tilde{M}_{i}} \text{ such that } \sum_{k}\sum_{l} m_{i,k}^{l} = 1 \qquad (9)$$

where $\tilde{M}_{i,k}^{l}$ is the total value from all 6-digit products that are classified by use category *l* and WIOD product group *i* imported from country *k*, and $\tilde{M}_{i}$ the total value of WIOD product group *i* imported by a country. These shares are derived from the bilateral international trade statistics and applied to the total imports of product *i* as given in the SUT timeseries to derive imported use categories as follows:

$$I_{i,j,k}^{M} = m_{i,k}^{I} M_{i} \frac{I_{i,j}}{U_{i}} \quad \forall j$$

$$F_{i,k}^{M} = m_{i,k}^{FC} M_{i} \frac{FC_{i}}{U_{i}} + m_{i,k}^{INV} M_{i} \frac{INV_{i}}{U_{i}} \qquad (10)$$

where FC denotes final consumption and INV gross fixed capital formation, together making up final use (F). Note that we use shares derived from the ITS rather than the actual values. There are discrepancies between the import values recorded in the National Accounts on the one hand, and in international trade statistics on the other. Some of them are due to conceptual differences, and others due to classification and data collection procedures (see extensive discussion in Guo, Web and Yamano 2009). As we rely on NAS as our benchmark tochoose to apply shares from the trade statistics to the NAS series. Finally, we derive the use of domestically produced products as the residual by subtracting the imports from total use as follows:

$$I_{i,j}^{D} = I_{i,j} - \sum_{k} I_{i,j,k}^{M} \quad \forall i,j$$

$$F_{i}^{D} = F_{i} - \sum_{k} F_{i,k}^{M} \quad \forall i \qquad (11)$$

$$E_{i}^{D} = E_{i} - \sum_{k} E_{i,k}^{M} \quad \forall i$$

Note that our approach differs from the standard proportionality method popular in the literature and applied e.g. by GTAP. In those cases, a common import proportion is used for all cells in a use row, irrespective 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, they differ also by country of origin. Our detailed bilateral approach ensures that this type of information is reflected in the international SUTs and WIOT.

D. Construction of WIOT

As a final step, international SUTs are transformed into a world input-output table. IO tables are symmetric and can be of the product-by-product type, describing the amount of products needed to produce a particular good or service, or of the industry-by-industry type, describing the flow of goods and services from one industry to another. In case each product is only produced by one industry, the two types of tables will be the same. But the larger the share of secondary production, the larger the difference will be. The choice for between the two depends on the type of research questions. Many foreseen applications of the WIOT, such as those described in the next sections, will rely heavily on industry-type tables as the additional data, such as employment or investment, is often only available on an industry basis. Moreover, the industry-type table retains best the links with national account statistics.

An IOT is a construct on the basis of a SUT at basic prices plus additional assumptions. We use the so-called "fixed product-sales structure" assumption stating that each product has its own specific sales structure irrespective of the industry where it is produced. Sales structure here refers to the proportions of the output of the product in which it is sold to the respective intermediate and final users. This assumption is most widely used, not only because it is more realistic than its alternatives, but also because it is a relative simple mechanical procedure. It does not generate any negatives in the IOT that would require manual rebalancing. Application of manual ad-hoc procedures would greatly reduce the tractability of our methods. Chapter 11 in the Eurostat handbook (Eurostat 2008) provides a useful and extensive discussion of the transformation of SUTs into IOTs, including a mathematical treatment.

In a first step the international SUTs for all countries are combined into a world SUT. Basically, the national tables are stacked and reordered to resemble a standard supply-use table. The framework for the world SUT is given in Figure 6. Subsequently, using the fixed product-sales structure, the world SUT is transformed into the WIOT given in Figure 2. To ensure consistency between bilateral flows of imports and exports, exports are defined as mirror flows from imports. More specifically, exports of product *i* from say country A to country B are assumed to be equal to the imports of this product by B from A.

[Figure 6 about here]

The full WIOT will contain data for forty countries covered in the WIOD. Including the biggest countries in the world, this set covers about 85 per cent of world GDP. Nevertheless to complete the WIOD and make it internally consistent, also a region called the Rest of the World (RoW) needs to be added. This region proxies for all other countries in the world. The RoW needs to be modelled due to a lack of detailed data on input-output structures. Exports from the RoW are simply the imports by our set of countries not originating from this set. Imports by the ROW are defined residually to ensure that exports from all countries equal the imports by all countries. Production and consumption in the ROW will be modelled based on totals for industry output and final use categories from the UN National Accounts, assuming an input-output structure equal to that of India. Also, at a later stage we will add in a separate oil-producing region that will be useful in particular in environmental applications.

4. Basic data sources

Sources for WIOT

As described in the previous section, the construction of the WIOT requires three type of data: national SUTs, National Accounts timeseries on industry output and final use, and international trade data. In Table 1 we provide an overview of the SUTs used in WIOD. For some countries full time-series of SUTs are available, but for most countries only some or even one year is available. This is indicated in the table. In some cases SUTs for a partiuclar year were available, but have not been used as they contained too many errors or inconsistencies to be useful. Also, for some non-EU countries SUTs are not available, but only IOTs. For these countries a transformation from IOT to SUT has been made by assuming a diagonal supply table at the product and industry level of the original national table which is often more detailed than the WIOD list. Table 1 provides details about the size of the original SUTs and IOTs and their price concept. The tables have been sourced from publicly available data from National Statistical Institutes and for many EU countries from the Eurostat input-output database.[3]

SUTs might be available for various years, but that does not imply that they are also comparable over time as revisions might have taken place in the National Accounts, while the historical SUTs have not revised. Therefore to link the SUTs over time, National Accounts statistics are used. Data for 1995-2007 was collected for the following series: total exports, total imports, gross output at basic prices by 35 industries, total use of intermediates by 35 industries, final expenditure at purchasers' prices (private and government consumption and investment), and total changes in inventories. This data is available from National Statistical Institutes and OECD and UN National Accounts statistics.

International trade data is derived from the World Integrated Trade Solution (WITS) database from the Worldbank. Data on export and import values in this database are based upon the United Nation Statistical Division (UNSD) Commodity Trade (COMTRADE) Data Base that contains exports and imports by commodity and partner country. Our basic data are bilateral import flows between all our countries at a 6-digit product level (Harmonised System, HS) from WITS. Alternatively, we could have relied on export flow data. It is well-known that official bilateral import and export trade flows are not consistent and hence this choice would make a difference. Following most other studies, we choose to use imports flows as these are generally seen as more reliable than export flows. As not all countries report trade at 6-digit detail, various cells have been imputed by means of mirror-statistics on exports and other estimation techniques. Statistics for trade in goods are well-developed, in contrast to trade in services. Although services trade is taking an increasing share of global trade flows, statistics are only rough and hard to reconcile across the various sources. One particular challenge is to allocate the statistics based on Balance of Payments codes to the various products in the WIOD list. The approach taken in constructing the bilateral trade data for WIOD is extensively described in Steher et al. (2010).

[3] These can be found at http://epp.eurostat.ec.europa.eu/portal/page/portal/esa95_supply_use_input_tables/introduction.

In addition to a WIOT, the WIOD also includes socio-economic and environmental sattelite accounts. In Figure 7 the conceptual framework of the extended national SUT is given. Value added is broken down into the compensation for the producution factors labour and capital.[4] In addition statistics on energy use, greenhouse-gas and other air emissions, and resource use by industry and final users are collected.

[Figure 7 about here]

Socio-economic accounts

The socio-economic accounts contain data on detailed labour and capital inputs for all 35 industries. This includes data on hours worked and compensation for three labour types (low-, medium- and high-skilled labour) and data on capital stocks and compensation for 8 asset types: 3 ICT assets (software, computer and telecommunication equipment) and 5 non-ICT assets (residential buildings, non-residential structures, transport equipment, other non-ICT machinery and equipment, and other assets). Labour service input is based on series of hours worked and wages of various types of labour. These series are not part of the core set of national accounts statistics put out by NSIs; typically only total hours worked and wages by industry are available from the National Accounts. For these series additional material has been collected from employment and labour force statistics. For each country covered, a choice was made of the best statistical source for consistent wage and employment data at the industry level. In most cases this was the labour force survey (LFS), which in some cases was combined with earnings surveys when wages were not included in the LFS. In other instances, an establishment survey, or social-security database was used. Care has been taken to arrive at series which are time consistent, as most employment surveys are not designed to track developments over time, and breaks in methodology or coverage frequently occur. Labour compensation of self-employed is not registered in the National Accounts, which as emphasised by Krueger (1999) leads to an understatement of labour's share. We make an imputation by assuming that the compensation per hour of self-employed is equal to the compensation per hour of employees. This is especially important for industries which have a large share of self-employed workers, such as agriculture, trade, business and personal services. Also, we assume the same labour characteristics for self-employed as for employees when information on the former is missing. These assumptions are made at the industry level.

For the breakdown of value added, compensation for each capital asset is needed. Capital input series by industry are generally not available from the National Accounts. At best, capital stocks are estimated for aggregate investment without distinguishing various asset types. Capital compensation is given by multiplying stocks with rental prices. The rental price of each asset consists of a nominal rate of return, depreciation and capital gains (Jorgenson and Yip, 1991).[5]

[4] Currently, we use the expost approach to capital measurement such that labour and capital compensation will exhaust value added. In a later stage we will use the ex-ante or exogenous approach such that a residual value remains which is called profit (Schreyer, 2009).

[5] Taxes have not been included due to a lack of data. Also, the assets do not cover land and inventories.

The nominal rate of return is determined ex-post as it is assumed that the total value of capital services for each industry equals capital compensation. Capital compensation is derived as gross value added minus labour compensation. This procedure yields an internal nominal rate of return that exhausts capital income and is consistent with constant returns to scale. The nominal rate of return is the same for all assets in an industry, but is allowed to vary across industries.

For each individual asset, stocks have been estimated on the basis of investment series using the perpetual inventory method (PIM) with geometric depreciation profiles. Depreciation rates differ by asset and industry, but have been assumed identical across countries. The basic investment series by industry and asset have been derived from capital flow matrices and benchmarked to the aggregate investment series from the National Accounts. Although the ESA provides a classification of capital assets, it is not always detailed enough to back out investment in information and communication equipment. Additional information has been collected to obtain investment series for these assets, or assumptions concerning hardware-software ratios have been employed. When the deflator for computers did not contain an adjustment for quality change, a harmonised deflator based on the United States deflator has been used as suggested by Schreyer (2002). The EU KLEMS database provides this data for a large set of OECD countries (see www.euklems.net). O'Mahony and Timmer 2009 provide a more detailed description of the methods used. For non-OECD countries additional data has been collected and prepared following the same harmonisation and construction procedures as used in the EU KLEMS database. Erumban, Gouma, de Vries and Timmer (2010) provides additional detail.

Environmental accounts [6]

The core of the environmental database consists of energy and air emission accounts. Energy-related air emissions is estimated using energy accounts and technology-specific emission factors. A large part of the air emissions resulting in the impact categories covered in WIOD (global warming, acidification and tropospheric ozone formation) are originated from gases emitted in energy-use processes. These emissions are complemented with non-energy related (process) emissions where appropriate, using inventory data from UNFCCC national reports (NIR – National Inventory Reports) and CLRTAP (Convention on Long Range Transboundary Air Pollution).

Energy accounts are compiled using IEA extended energy balances as a starting point, achieving the specification of energy accounts using additional information to bridge between territory and residence principles (bunkering and international transport, tourism, defence, embassies) and to allocate IEA accounts to the target classification and accounting concepts (distribution of transport activities and autoproduced electricity among industries). The very first step in deriving energy accounts from international energy balances, as provided by IEA, is to establish a correspondence-key linking energy balance items and NACE entries plus households. Some of the energy balance items can be directly linked to the production of certain NACE

[6] This text is based on the detailed documentation on the environmental accounts by Villaneuva, Genty and Neuwahl (2010) from Institute for Prospective Technological Studies (IPTS) in Seville. IPTS, an EC's joint research center, is responsible for the environmental accounts in the WIOD project.

entities, but in some cases the energy balance item is related to more than one industry. For instance, the energy balance item "road transport" needs to be distributed over all industries plus households. Likewise, the energy balance item "commerce and public services" needs to be distributed over a number of services. Losses are also a relevant part of the energy accounts and an important element in the assessment of energy efficiency. All losses are recorded and allocated to the supplier.

Air emissions are estimated from energy accounts. The general approach implies the use of activity data and emission factors, following the general formula: $E = AR \times EF$. The emission (E) is obtained by multiplying a certain triggering activity (AR: activity rate) by a certain emission factor (EF). Such factors embed the concept of a linear relationship between the activity data and the actual emissions. Several technical guidance documents provide such emission factors, in particular those prepared for the compilation of national emission inventories under international conventions (UNFCCC, CLRTAP). Additionally, two very important secondary sources of information for emission factors are used: the results of the FP6 project EXIOPOL and the EDGAR information system. Activity data will concern the use of energy, broken down into energy commodities and sectors as reported in IEA statistics.

Air emission data not related to energy consumption (e.g. CH4 emissions) will be collected from inventories to complement the energy-based emissions. The substances included in the database comprise the air emissions linked directly to the three environmental impact categories covered, namely:

- Greenhouse gas emissions to air (CO2, N2O, CH4, HFCs, PFCs, SF6), needed to derive Global Warming Potentials
- Emissions of CFCs, Halons, Methyl Bromide CH3Br, and HCFCs , needed to derive Ozone Depletion Potentials, and
- Emissions of acidifying substances to air (NOx, SOx, NH3), needed to derive Acidification Potentials

More detailed information on the construction of the environmental accounts can be found in Villaneuva, Genty and Neuwahl (2010).

5. Applications of the WIOD database

This section describes two applications of the WIOD database. In Section 5.1, the world input-output table is combined with socio-economic accounts to measure the factor content of trade. In Section 5.2, the world input-output table is combined with environmental accounts to measure greenhouse gas emissions as a result of production and consumption.

5.1 The factor content of trade

Trade has become increasingly fragmented, with production at different stages performed across multiple countries. At each stage in the production process, value is added to a product. The case study of the Apple iPod offers an illustrative example of fragmentation in production (Dedrick et al. 2008). The iPod is assembled in China and sold at the factory gate for $144, which is reflected in export statistics from China. However, the export of the iPod from China includes about $100 in imported Japanese value added (e.g. the hard drive, display, and battery), and $15 of imported U.S. value added (e.g. the processor, controller, and memory). Actually, China only adds $4 in value added. In addition, the production factors used in the various stages of production differ across countries. For example, the production of the processor in the U.S. requires mostly skilled labour, while assembly of the iPod components in China is performed mainly by low-skilled workers. So, while the international trade statistics suggest $144 of high-tech exports from China for each exported I-pod, the value actually added in China is only small and contains barely skills. An analysis of global value chains wuold reveal such information as it indicates for a product the value added by certain production factors in various countries. This requires accounting for trade in intermediate inputs as will be done in this section.

Literature on the factor content of trade is booming. For example, authors use the GTAP database to test the Heckscher-Ohlin-Vanek predictions of comparative advantage (e.g. Reimer (2006); Johnson (2008); Trefler and Zhu (2010)). Other authors aim to measure the factor content of trade for specific countries (e.g. Feenstra and Hong (2007) for China, see also de Backer and Yamano (2007). Our application contributes to this literature, because it uses a time-series input-output database. Previous studies examined the factor content for a particular moment in time. The time-series perspective in WIOD allows us to examine changes in the factor content due to increasing fragmentation and globalization. In addition, the socio-economic accounts allow a richer characterization of the production factors used by industries in creating value added. Previous studies distinguished capital and labor at best. However, as the iPod example illustrates, more detail in labor is needed as well. Assembly activities or production of high-tech intermediate inputs require very different skills. Taking these skills into account provide a richer description of the factor content of trade.

Data

Two datasets are considered, namely the world input-output table and the socio-economic accounts as described in the previous section. The current provisional world input-output table considers Germany, Japan, the United States, and the rest of the world for the year 1995. Therefore, the first rows of the table refer to Germany, whereas Japan, the U.S. and the rest of the world follow subsequently. The lay-out of this table is shown in Figure 2. The world input-output table and the socio-economic accounts distinguish 35 industries (so the first 35 rows refer to German industries). Values are in euros using exchange rates for conversion of local currencies. At a later stage relative prices (PPPs) will be used instead. Production factors in the socio-economic accounts are measured as value shares in gross output.

In the next version of this paper, we plan to integrate the other countries covered by WIOD in the world input-output table and consider the time period 1995 to 2006. Also, by using industry-level deflators, the tables will be put in previous year prices and production factors will be measured in volumes.

Method

The approach follows the methodology outlined in Reimer (2006) that closely resembles the techniques used in the input-output literature.[7] Let n=1,…,N index goods and services, and c=1,…,C index countries. Define the vector of net output ($\mathbf{y}^C$) as:

$$\mathbf{y}^C = \mathbf{x}^C - \mathbf{A}\,\mathbf{x}^C, \tag{12}$$

where $\mathbf{y}^C$ is a net output vector (NC x 1), $\mathbf{x}^C$ is a (NC x 1) gross output vector[8], and **A** is the world input-output matrix with intermediate input shares of dimension (NC x NC). The matrix **A** describes how a given producte is produced (or delivered) with different combinations of factors in different countries, and is used in the production of itself and other products around the world. The net output measures the amount of products available for final use in the economy, or for exports.

Let $\mathbf{t}^C$ be a (NC x 1) vector representing the exports and imports of goods and services by a country for intermediate or final use. Let the (NC x 1) vector $\mathbf{d}^C$ refer to demand for final domestic use. For example, the first element of $\mathbf{d}^{GER}$ indicates the amount of 'Agricultural products' produced in Germany and demanded by German final users; the 36th element indicates the amount of 'Agricultural products' produced in Japan and demanded by Germany for final use and so on.. Trade in goods and services are measured by:

$$\mathbf{t}^C = \mathbf{y}^C - \mathbf{d}^C. \tag{13}$$

If net output is bigger than domestic demand, the product will be exported (t is positive for this product). Conversely, if demand is higher than net output, the product needs to be imported (the element in t is negative). To impute the factor content of trade, consider **F**, a (F x NC) direct factor input matrix. Here, **F** has five rows, since five production factors are distinguished. This matrix considers country-specific direct factor inputs. An element in this matrix indicates the share in gross output of a production factor used directly by the country to produce a given product. For example, the first element indicates the value of ICT-capital used by Germany in production of one euro of output in the agricultural sector. The elements are direct factor inputs in the industry, because they do not account for production factors embodied in intermediate inputs used by this industry. Intermediate inputs are produced as well, requiring capital and labour and other intermediate inputs. These intermediate also need to be produced, and so forth. Summing all inputs yields the total production that is – directly and indirectly – required to produce for final demand. This is given by multiplying a given vector of final demand with the so-called Leontief inverse. In matrix notation, the Leontief inverse is $(\mathbf{I} - \mathbf{A})^{-1}$. For this reason a (F x NC) total factor input matrix $\mathbf{F}^*$ is imputed by:

[7] See also Dietzenbacher and Mukhopadhyay (2007).

[8] The vector x^{GER} for Germany has positive values of gross output for the first 35 rows and zeros everywhere else. The vector x^{JPN} for Japan has zeros on the first 35 rows, positive values of gross output for row 36-70, and zeros everywhere else, and so on.

$$\mathbf{F}^* = \mathbf{F}\,(\mathbf{I} - \mathbf{A})^{-1}, \tag{14}$$

where **I** is an (NC x NC) identity matrix. A typical element in $\mathbf{F}^*$ indicates the amount of the world production factor *f*, embodied in a country's product *n*. The net factor content of trade ($\mathbf{fac}^C$) for a country (of dimension F x 1) is then measured by:

$$\mathbf{fac}^C = \mathbf{F}^* \mathbf{t}^C. \tag{15}$$

It gives the difference between the value of a production factor both directly and indirectly embodied in exports from C and the amount of the same production factor embodied in the imports from all other countries. By appropriate modification of the F* matrix it is possible to distinguish between the regional origin of production factors. E.g. if one is interested in the embodied German labour and capital, all non-German elements in F* should be set to 0.

Results

We use equation (15) to impute the factor content of trade. It should be stressed that these results are provisional and subject to change once the world input-output matrix **A** is extended with other countries and the **F** matrix includes more detailed socio-economic information for the remaining countries in WIOD. The rest of the world is large in the current application, and therefore affects the results. The countries in WIOD cover over 90% of world GDP. Therefore, if the full table is considered, the rest of the world will shrink in size, as will its influence on the results.[9] Preliminary results for the United States in 1995 are shown in figure 8. For each production factor, we distinguish the factor content in total export and in total imports. The net factor content of trade is the factor content of exports minus imports. Importantly, exports in this figure refer to exports of US production factors, both directly and indirectly through the use of intermediates in the production for exports. Imports refer to the imports of embodied foreign production factors and they do not include US factors of production.

[insert figure 8 about here]

The results suggest that the U.S. is a net exporter of ICT capital, but a net importer of non-ICT. The biggest net exports though are in medium- and high-skilled labour. Only in low skilled-labour the US is a large net importer. Summed over all factors, the net factor content of trade is negative, reflecting the net trade balance in the US in 1995. However, the net trade balance is more negative than the net factor content of trade balance as we move to a value-added measure of trade. A relatively high share of exported value added returns to the US embodied in imported final goods (Powers et al. 2010, and the iPod example given above). Note that our measure of the

[9] We plan to use information on world GDP from the UN national accounts to construct a table for the rest of the world.

factor content of trade for the US only includes use of US production factors, not the use of foreign factors.

A comparison of the net trade between the U.S. and Japan in 1995 is shown in figure 9. The pattern observed for the U.S. is somewhat similar to that for Japan, as both are large net importers of low-skilled employment. However, the U.S. appears a relatively much larger net exporter of ICT-capital and in particular high-skilled employment than Japan.

[Figure 9 about here]

Another related application is the decomposition of global value chains. A global value chain indicates the value added by various production factors around the world in the production of a particular set of goods. Global value chain decompositions can be made for any set of products. For example, a breakdown of the value added of German public administration services would show that almost all of the value of this product group is created by German labour and capital, as only a limited amount of imported intermediates are being used. In contrast, production that relies heavily on the use of imported intermediates would show up as a case where the added value of domestic production factors is relatively minor and a sizeable share of output value is created by foreign production factors, as in the I-Pod example. We provide two of such examples.

In Figure 10 we show the global value chain for output from the Japanese electrical equipment manufacturing. The total value is given by the final use of this output by Japanese and other countries' final users. This value is decomposed into the value added by production factors in Japan, either directly by the use of Japanese labour and capital in the industry, or indirectly though the production of intermediates in Japan, and the value added by foreign production factors, which can only be indirectly through the delivery of intermediates. This is done by multiplying F* and the final demand vector for output from this industry, both in Japan and in the other countries.

The total output of electrical equipment manufacturing in Japan in 1995 is about 430,000 million euro. Of this, about 230,000 million euro is consumed by Japanese and foreign consumers, also called final output. The rest is used as intermediate input by other domestic and foreign industries. Of the final output value, about 40% is added outside Japan, mainly through foreign non-IT capital and low-skilled labour. In Japan itself the other 60% of the value is added, mainly through medium-skilled labourers and non-IT capital.[10] In Figure 11 we provide a similar example for the German transport equipment manufacturing. The final output from this industry contains a large share of value added outside Germany, again mainly low-skilled labour. We would like to stress that the results are preliminary and serve only to illustrate the type of questions that can be addressed with the WIOD. As yet, the factor content of trade with the rest of the world is modelled only rudimentary.

[10] Note that this decomposition is on a territory basis and does not convey any information about ownership. It might well be that some of the overseas factories delivering intermediates to the Japanese industry are owned by Japanese firms.

[Figure 10 about here]
[Figure 11 about here]

5.2 Greenhouse-gas emissions: production and consumption accounting

Emissions of greenhouse gases during production play a key role in climate policy discussions. For example, the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto protocol use a territorial-based approach. However, indirect consumer emissions may be very different due to the effects of trade and this raises new issues of responsibility. In a consumer-based approach, all emissions occurring along the chains of production and distribution are allocated to the final consumer of products (Wiedmann 2009). A consumer-based approach complements the production-based approach. It is useful in relation to the participation of developing countries in reducing carbon leakage, it quantifies environmental trade linkages between countries, and it raises awareness among consumers. In this section, we examine the relation between trade and CO_2 emissions.

Related literature to this is reviewed in Wiedmann (2009). Wiedmann (2009) describes different methodologies to estimate consumption- and production-related greenhouse gas emissions. Basically, previous literature on this subject can be divided into single-region input-output analyses, and multi-region input-output analyses. Because a single-region approach does not allow for a distinction between domestic and foreign production technology, a multi-regional approach is preferred, such as adopted by Davis and Caldeira (2009). For 2004, Davis and Caldeira (2009) find that developed countries are net importers of CO_2 emissions. The US, Japan, and large European countries are the biggest net importers of CO_2 emissions. Vice versa, developing countries are net exporters of CO_2 emissions. In particular, Russia, China, and India are large net exporters of CO_2 emissions.

Our application contributes to the literature because it uses a time-series input-output database. Previous studies examine consumption- and production-related CO_2 emissions for a particular moment in time. The time-perspective in WIOD allows us to examine change over time due to increased globalization. In addition, the environmental accounts allow us to consider a larger set of greenhouse gases. This is relevant, because in addition to CO_2 various other gases emitted during production are potent greenhouse gases (e.g. methane).

The approach follows the one described in 5.1. The only difference is the (1 x NC) vector **g**, which considers country-specific CO_2 emissions per unit of gross output. The vector **g** replaces the matrix **F** in section 5.1. The vector **g** measures direct CO_2 emissions per unit of output. Therefore, a (1 x NC) total emission vector $\mathbf{g}^*$ is imputed by:

$$\mathbf{g}^* = \mathbf{g}\,(\mathbf{I} - \mathbf{A})^{-1}, \tag{16}$$

A typical element in $\mathbf{g}^*$ indicates the amount of the CO_2 emissions embodied in a country's version of good *n*. The net CO_2 emissions of trade ($\mathbf{ghg}^{\mathbf{C}}$) for a country are measured by:

$$\mathbf{ghg}^{C} = \mathbf{g}^{*}\mathbf{t}^{C}. \tag{17}$$

We use equation (17) to impute the embodied emissions of trade as before. It should be stressed that these results are provisional and subject to change once the world input-output matrix **A** is extended with other countries and the vector **g** includes environmental information for the remaining countries in WIOD.

Emissions embodied in exports and imports are shown in Figure 12. Germany, Japan, and the United States are net importers of CO_2 emissions, a finding in line with results in Davis and Caldeira (2009), see also Nakano et al. (2009). This suggests that if a consumption-based approach is taken, these countries share a greater responsibility for the emission of greenhouse gases than on the basis of production only. At the global level, total CO_2 emissions embodied in exports equal that embodied in imports. The rest of the world (not shown in Figure 12) therefore is a large net exporter of CO_2 emissions.

[Figure 12 about here]

It is important to make a distinction between the amount of embodied gases in exports of a country emitted from the domestic territory and the amount of embodied gases emitted anywhere. The latter also includes gas emitted during the production of intermediates outside the domestic territory. For a discussion about a country's responsibility it is the former concept that is most infomative and this is the one we use in our analysis. Most other studies, e.g. Davis and Caldeira (2009) however provide information on emissions based on the second concept. The industry detail in WIOD allows us also to examine the emissions embodied in trade by industry. By using the Leontief inverse in equation (16) we measure the total amount of CO_2 emissions embodied in a country's version of good *n*. As before, the F* matrix is suitably adapted depending on the country of interest. If one is interested in the emissions exported by Germany, all non-German elements are put to zero.

Figure 13 shows industry emissions for Germany, where we distinguish between exports and imports. The breakdown of export emissions relate to the emissions on the German territory by the various German industries to produce the exports in 1995. Emissions exported from Germany are primarily embodied in chemicals and chemical products, basic metals and fabricated metal, transport equipment and services (as a sizeable share of German exports consists of services). The lower pie refers to CO2 emissions emitted on foreign territory embodied in German imports. Importantly, they do not include German emissions. The breakdown by industry now refers to the foreign industries where the emissions are being made. For example, mports of oil and gas (from foreign mining industries) contribute substantially to the embodied emissions, as do imports of petroleum refining products.

[Figure 13 about here]

6. Concluding Remarks

In this paper we presented the outline of the World Input-Output Database (WIOD) which contains a World Input-Output Table and socio-economic and environmental satellite accounts. The database construction is part of the WIOD-project currently carried out by a consortium of eleven research institutes across Europe. This new initiative has a number of distinguishing characteristics compared with alternative initiatives such as the GTAP database (Narayan and Walmsley 2009) , the OECD Input-Output database, EXIOPOL (Tukker at al. 2009) and Institute of Developing Economies, JETRO (IDE –JETRO 2006).

The main novelty of the WIOD is that it is explicitly focused on time-series analysis. This motivates a number of methodological choices such as the reliance on national accounts time series for industry output and inputs and final demand categories to link supply-and use tables over time in a consistent way. In addition, the tables will also be deflated by appropriate price indices to facilitate analysis of volume movements over time.

Secondly, the world input-output table is linked explicitly to international trade statistics and the socio-economic and environmental satellite accounts. This is greatly facilitated by starting from supply- and use-tables that contain both the product and industry dimensions, rather than starting from input-output tables as most other initiatives do.

Thirdly, it has an explicit attention for (trade in) services, whereas most other initiatives are mainly geared towards agricultural and industrial activities. This is achieved by providing industry detail in services sectors, an explicit treatment of the trade and transport industries (through tables at basic and purchasers' prices) and a new bilteral database on international trade in services.

Finally, it is based on official statistics that are publicly available, aiming for maximum of transparency in calculations and methodologies. This is achieved by making all data publicly available, not only of the resulting WIOT, but also of the intermediate products such as harmonised basic national SUTs, international SUTs, world SUTs, international trade data and national accounts series for extrapolation. The data will be made public starting in the summer of 2011 with full data availability by May 2012, free of charge through our website www.wiod.net.

We showed some possible applications of the database by decomposing trade in value added and global value chains, and study the differences between production and consumption accounting of greenhouse-gas emissions. Although the results are still preliminary, they illustrate the type of analysis that can be made and questions that can answered. It is hoped that the development of the WIOD will stimulate new research in this area and researchers are invited to contribute to future development e.g. by making available additional databases with new variables that can be easily linked into the structure of the WIOD. We also hope that this initiative is carried forward in due time by the international statistical community. Maintaining and updating a WIOT will require additional international effort and coordination. But given the relevance of such type of data for policy analysis and research purposes, it should be high on the agenda. The standardisation of environmental accounts in the new System of Environmental and Economic Accounting is an important development in this respect. And efforts initiated and supported by Eurostat and the OECD are hopeful signs that this type of data work will eventually be taken out of the research domain and become part of the routine statistical practice.

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Figure 1 Schematic outline of national Input-Output (IO) Table

	Industry	Final use		Total
Industry	Intermediate use	Domestic Final use	Exports	Total Use
	Value added			
	Output			
Rest of World	Imports			
Total	Total supply			

Figure 2 Schematic outline of World Input-Output Table (WIOT), three regions

		Country A Intermediate use *Industry*	Country B Intermediate use *Industry*	Rest of World Intermediate use *Industry*	Country A Final domestic use	Country B Final domestic use	Rest of World Final domestic use	Total
Country A	*Industry*	Intermediate use of domestic output	Intermediate use by B of imports from A	Intermediate use by RoW of imports from A	Final use of domestic output	Final use by B of exports from A	Final use by RoW of exports from A	Output in A
Country B	*Industry*	Intermediate use by A of imports from B	Intermediate use of domestic output	Intermediate use by RoW of imports from B	Final use by A of exports from B	Final use of domestic output	Final use by RoW of exports from B	Output in B
Rest of World (RoW)	*Industry*	Intermediate use by A of imports from RoW	Intermediate use by B of imports from RoW	Intermediate use of domestic output	Final use by A of exports from RoW	Final use by B of exports from RoW	Final use of domestic output	Output in RoW
		Value added	Value added	Value added				
		Output in A	Output in B	Output in RoW				

Figure 3 Schematic outline of National Supply-Use table

	Supply *Product*	Intermediate use *Industry*	Final use		Total
Product		Intermediate use (I)	Domestic final use (F)	Exports (E)	Total use by product (U)
Industry	Domestic supply (S^D)				Total output by industry (GO)
Rest of World	Imports (M)				
		Value added (VA)			
	Total supply by product (S)	Total input by industry			

Figure 4 Schematic outline of International Supply-Use table

		Supply *Product*	Intermediate use *Industry*	Final use		Total
country A	*Product*		Intermediate use of domestic output	Domestic final use of domestic output	Exports	Total use of domestic output
Rest of World (RoW)	*Product*		Intermediate use of imports	Domestic final use of imports	Re-exports of imports	Total use of imports
country A	*Industry*	Domestic supply				
Rest of World (RoW)		Imports				
		Total supply				
			Value added			
			Output			

Figure 5 Schematic outline of extended National Supply-Use table

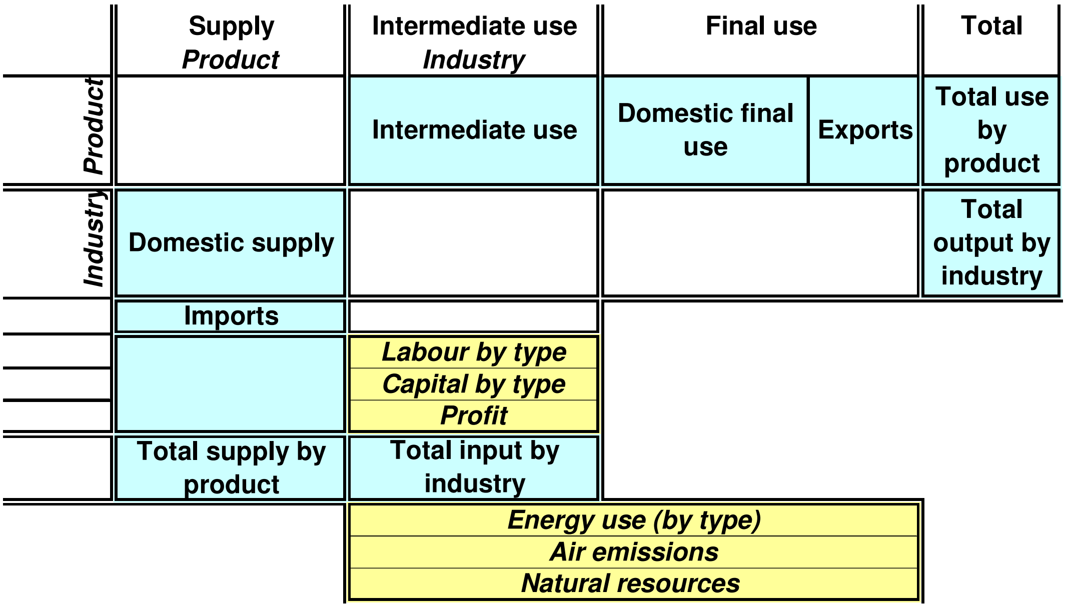


Figure 6 Dataflows and construction steps in WIOT

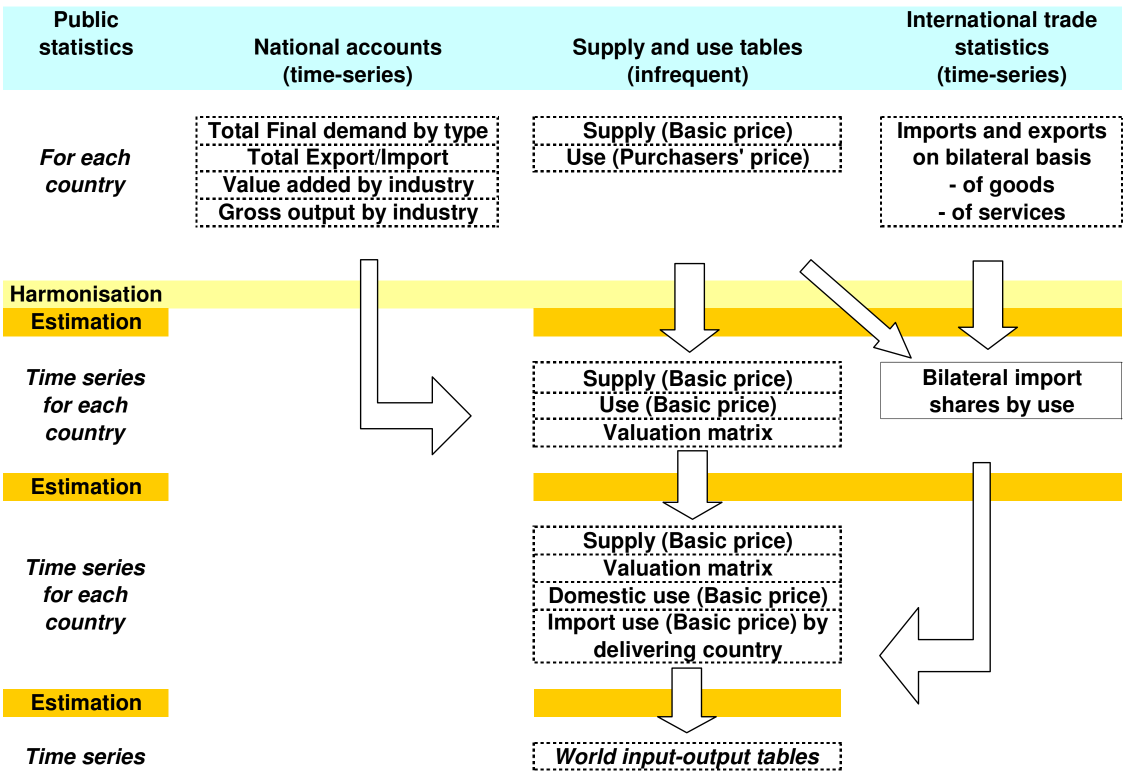
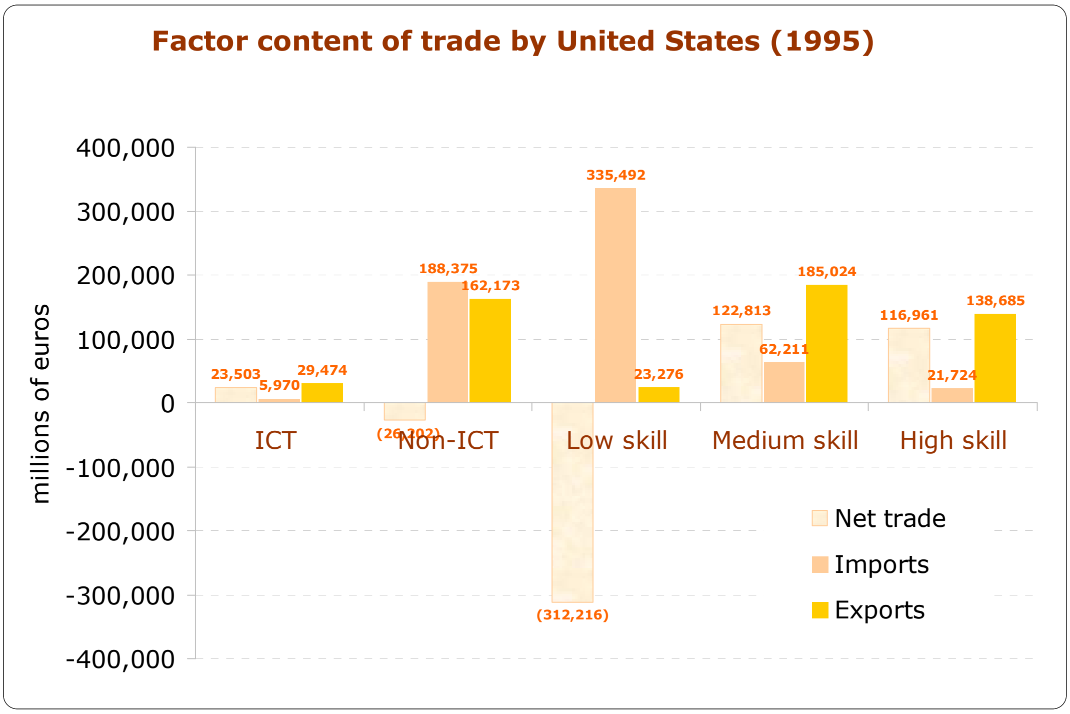


Figure 7 World Supply-Use table for three regions

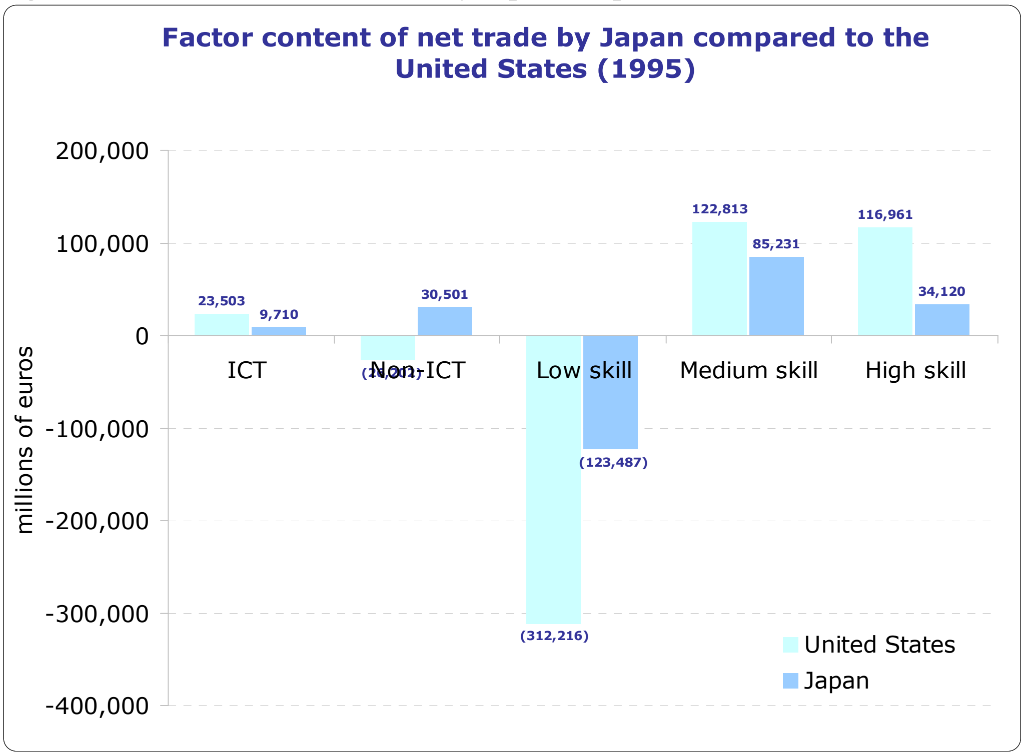
		Country A Supply *Product*	Country B Supply *Product*	Rest of World Supply *Product*	Country A Intermediate use *Industry*	Country B Intermediate use *Industry*	Rest of World Intermediate use *Industry*	Country A Final domestic use	Country B Final domestic use	Rest of World Final domestic use	Total
Country A	*Product*				Intermediate use of domestic output	Intermediate use by B of imports from A	Intermediate use by RoW of imports from A	Final use of domestic output	Final use by B of exports from A	Final use by RoW of exports from A	Output in A
Country B	*Product*				Intermediate use by A of imports from B	Intermediate use of domestic output	Intermediate use by RoW of imports from B	Final use by A of exports from B	Final use of domestic output	Final use by RoW of exports from B	Output in B
Rest of World (RoW)	*Product*				Intermediate use by A of imports from RoW	Intermediate use by B of imports from RoW	Intermediate use of domestic output	Final use by A of exports from RoW	Final use by B of exports from RoW	Final use of domestic output	Output in RoW
country A	*Industry*	Domestic supply									
Country B	*Industry*		Domestic supply								
Rest of World (RoW)	*Industry*			Domestic supply							
Country A			Imports	Imports							
Country B		Imports		Imports							
Rest of World		Imports	Imports								
Total		Total supply	Total supply	Total supply							
					Value added	Value added	Value added				
					Output in A	Output in B	Output in RoW				

Figure 8 Factor content of trade by United States (1995)



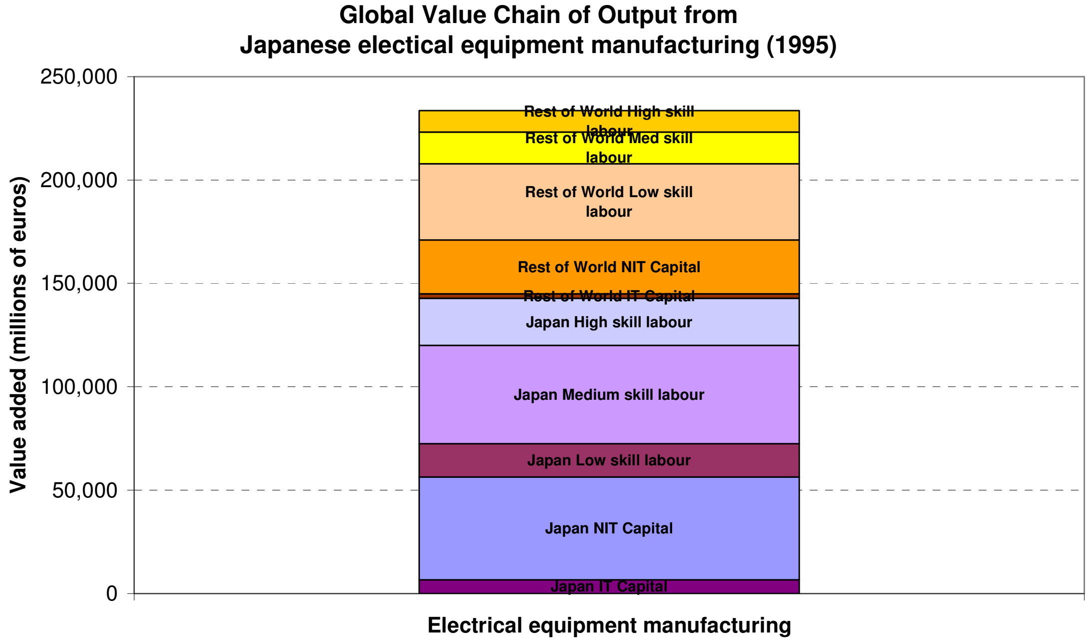
Note: based on WIOD, results are preliminary

Figure 9 Factor content of net trade by Japan compared to the United States (1995)



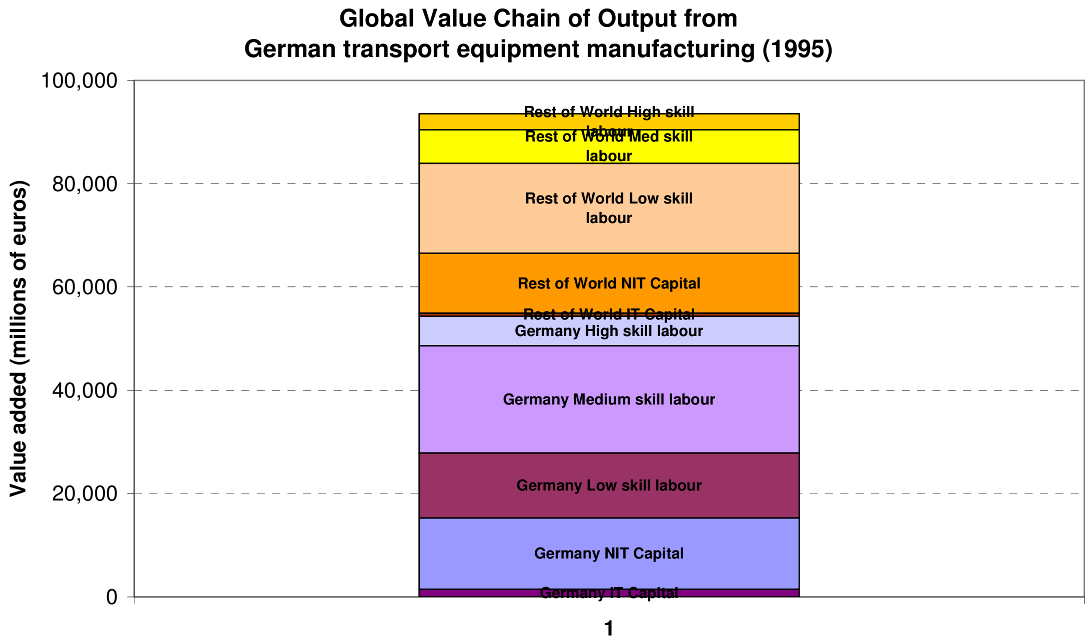
Note: based on WIOD, results are preliminary

Figure 10 Global Value Chain of Final Output from Japanese electical equipment manufacturing (1995)



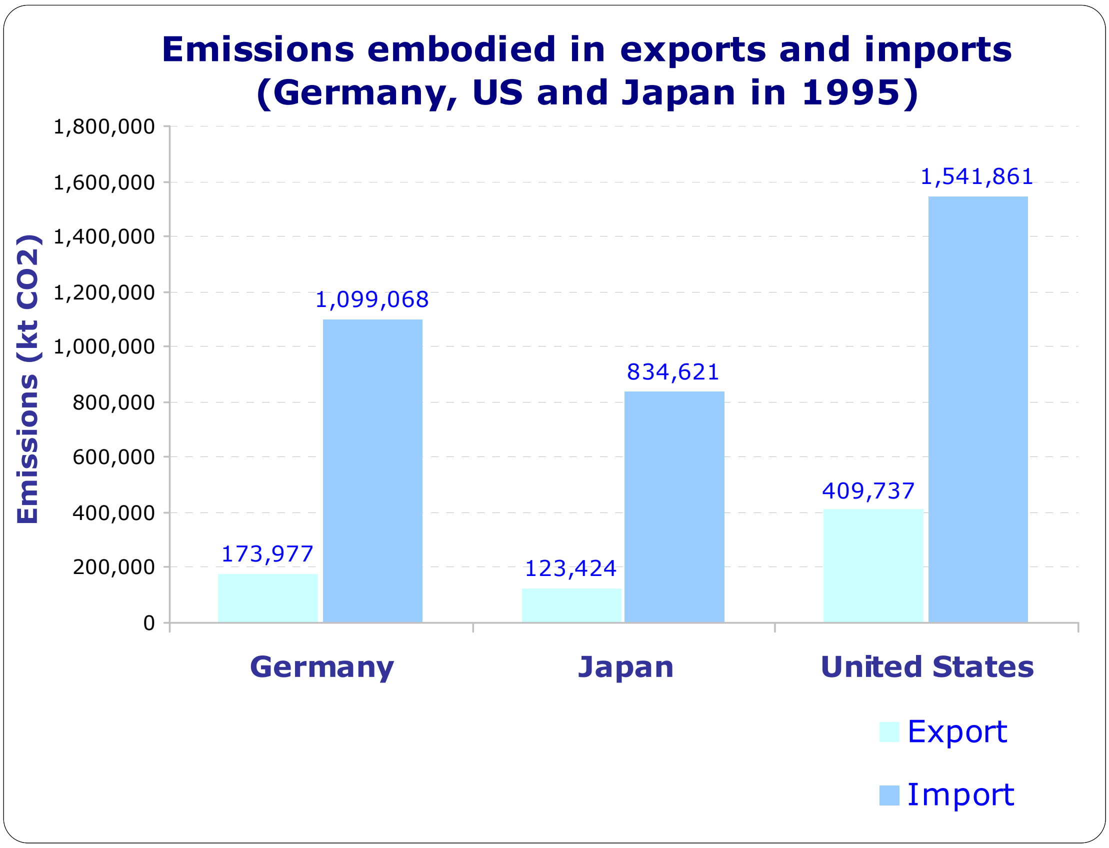
Note: based on WIOD, results are preliminary

Figure 11 Global Value Chain of Final Output from German transport equipment manufacturing (1995)



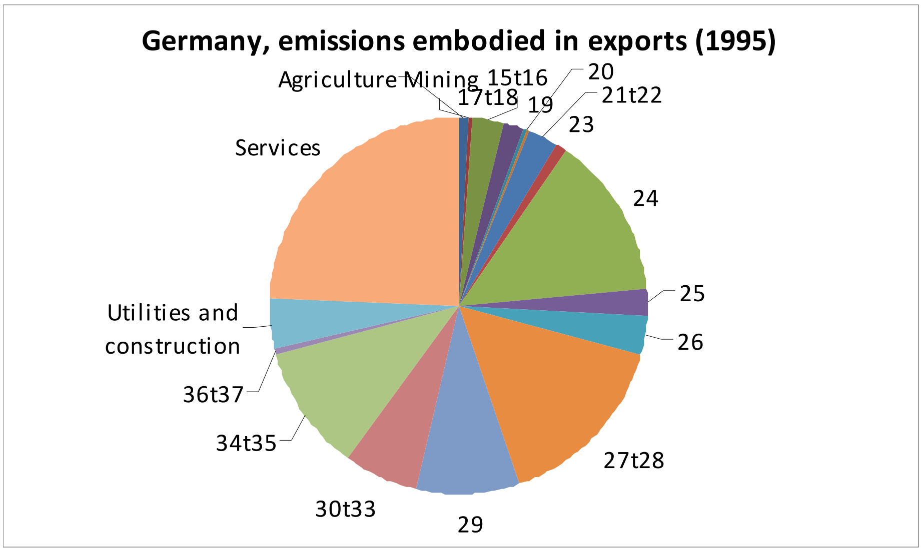
Note: based on WIOD, results are preliminary

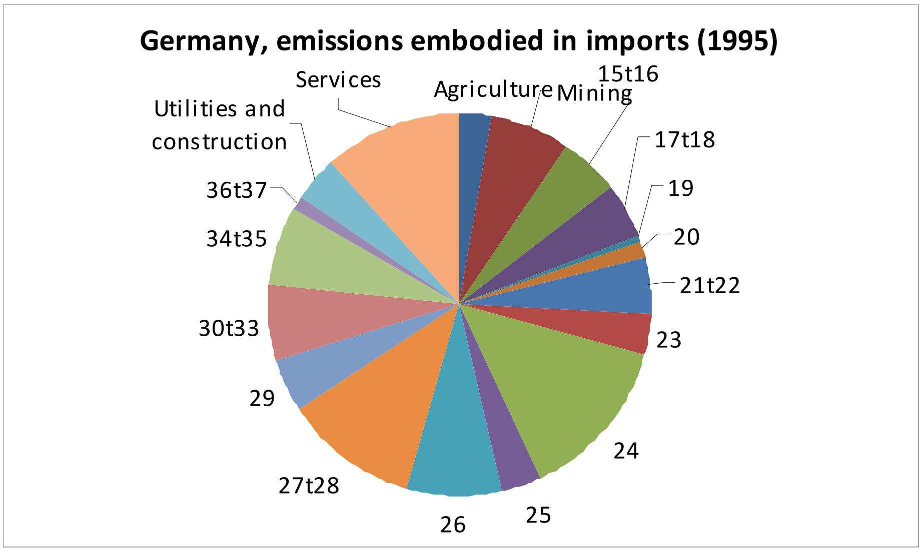
Figure 12 Emissions embodied in exports and imports (Germany, US and Japan 1995)



Note: based on WIOD, results are preliminary

Figure 13 Emissions embodied in exports and imports by Germany, 1995





Note: based on WIOD, results are preliminary. The following indsutries are shown:

15t16	Food, beverages, and tobacco	25	Rubber and plastics
17t18	Textiles and textile products	26	Other non-metallic minerals
19	Leather, leather and footwear	27t28	Basic metals and fabricated metals
20	Wood, and products of wood and cork	29	Machinery, n.e.c.
21t22	Pulp, paper, and printing and publishing	30t33	Electrical and optical equipment
23	Coke, refined petroleum and nuclear fuel	34t35	Transport equipment
24	Chemicals and chemical products	36t37	Manufacturing n.e.c.

Table 1 National supply-use and input-output tables used for constructing of WIOD

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Australia		SUT (106c * 106i)							SUT (233c * 53i)	SUT (233c * 53i)			
Austria	SUT (59c * 59i)		SUT (59c * 59i)		SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)		
Belgium	SUT (59c * 59i)		SUT (59c * 59i)		SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)			
Brazil						SUT (110c * 55i)	SUT (110c * 55i)	SUT (110c * 55i)	SUT (110c * 55i)	SUT (110c * 55i)	SUT (110c * 55i)	SUT (110c * 55i)	
Bulgaria						SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)			
Canada			SUT (BP) (473c*122i)	SUT (BP) (473c*122i)	SUT (BP) (473c*122i)	SUT (BP) (473c*122i)	SUT (BP) (473c*122i)	SUT (BP) (473c*122i)	SUT (BP) (473c*122i)	SUT (BP) (473c*122i)	SUT (BP) (473c*122i)	SUT (BP) (473c*122i)	
China		SUT(PR) (40c * 40i) & IO(PR) (124c * 124c)						SUT(PR) (42c * 42i) & IO(PR) (122c * 122c)					SUT(PR) (42c * 42i) & IO(PR) (135c * 135c)
Cyprus*						SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	
Czech Republic	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)		
Denmark		SUT (59c * 59i)			SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)		
Estonia			SUT (59c * 59i)		SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	
Finland	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	
France	SUT (59c * 59i)		SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	
Germany	SUT (59c * 59i)		SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	
Greece						SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	
Hungary				SUT (59c * 59i)	SUT (59c * 59i)			SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	
India				SUT(FC) (115c * 115i)					SUT(FC) (130c * 130i)			SUT(FC) (130c * 130i)	
Indonesia	IO (172c * 172c)					IO (175c * 175c)					IO (175c * 175c)		

Table 1 National supply-use and input-output tables used for constructing of WIOD (continued)

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Ireland						SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)			SUT (59c * 59i)		
Italy	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)		
Japan	IO(PR) (108i * 108i)					IO(PR) (108i * 108i)							
Korea	IO(PR) (402c*402i)					IO(PR) (404c*404i)					IO(PR) (403c*403i)		
Latvia													
Lithuania		SUT (59c * 59i)		SUT (59c * 59i)					SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)		
Luxembourg	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	
Malta						SUT (59c * 59i)	SUT (59c * 59i)						
Mexico									SUT (79c * 79i)				
Netherlands	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	
Poland		SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)						SUT (59c * 59i)		
Portugal	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	
Romania						SUT (59c * 59i)			SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	
Russia	SUT (110c *59i)												
Slovak Republic	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	
Slovenia						SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	
Spain	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	
Sweden	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	
Taiwan		IO (596c*160i)					IO (610c*160i)					IO (554c*165i)	
Turkey		SUT(PR) (97c*97i)		SUT (97c*97i)				SUT (59c*59i)					
United Kingdom	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)	SUT (59c * 59i)				
USA	SUT(PR) (130c * 130i)	SUT(PR) (66c * 65i)	SUT(PR) (66c * 65i)	SUT(PR) (66c * 65i)	SUT(PR) (66c * 65i)	SUT(PR) (66c * 65i)	SUT(PR) (66c * 65i)	SUT(PR) (66c * 65i)	SUT(PR) (66c * 65i)	SUT(PR) (66c * 65i)	SUT(PR) (66c * 65i)		

Note: All tables are at purchasers' prices unless otherwise indicated (PR stands for producer prices, FC for factor cost and BP for basic price), i stands for industry dimension and c for commodity. * Cyprus SUTs based on Greece.

Appendix Table 1 Industries and columns in Use table

Columns in USE Table		
Code	**NACE**	**Description**
1	AtB	Agriculture, Hunting, Forestry and Fishing
2	C	Mining and Quarrying
3	15t16	Food, Beverages and Tobacco
4	17t18	Textiles and Textile Products
5	19	Leather, Leather and Footwear
6	20	Wood and Products of Wood and Cork
7	21t22	Pulp, Paper, Paper , Printing and Publishing
8	23	Coke, Refined Petroleum and Nuclear Fuel
9	24	Chemicals and Chemical Products
10	25	Rubber and Plastics
11	26	Other Non-Metallic Mineral
12	27t28	Basic Metals and Fabricated Metal
13	29	Machinery, Nec
14	30t33	Electrical and Optical Equipment
15	34t35	Transport Equipment
16	36t37	Manufacturing, Nec; Recycling
17	E	Electricity, Gas and Water Supply
18	F	Construction
19	50	Sale, Maintenance and Repair of Motor Vehicles Retail Sale of Fuel
20	51	Wholesale Trade and Commission Trade, Except of Motor Vehicles
21	52	Retail Trade, Except of Motor Vehicles ; Repair of Household Goods
22	H	Hotels and Restaurants
23	60	Inland Transport
24	61	Water Transport
25	62	Air Transport
26	63	Other Supporting and Auxiliary Transport Activities; Activities of Travel Agencies
27	64	Post and Telecommunications
28	J	Financial Intermediation
29	70	Real Estate Activities
30	71t74	Renting of M&Eq and Other Business Activities
31	L	Public Admin and Defence; Compulsory Social Security
32	M	Education
33	N	Health and Social Work
34	O	Other Community, Social and Personal Services
35	P	Private Households with Employed Persons
36		Financial intermediation services indirectly measured (FISIM)
37		**Total**
38		Final consumption expenditure by households
39		Final consumption exp. by non-profit organisations serving households
40		Final consumption expenditure by government
41		**Final consumption expenditure**
42		Gross fixed capital formation
43		Changes in inventories and valuables
44		Gross capital formation
45		Exports
46		**Final uses at purchasers' prices**
47		**Total use at purchasers' prices**

Appendix Table 2 Products and rows in Supply table

Code	CPA	Description
1	1	Products of agriculture, hunting and related services
2	2	Products of forestry, logging and related services
3	5	Fish and other fishing products; services incidental of fishing
4	10	Coal and lignite; peat
5	11	Crude petroleum and natural gas; services incidental to oil and gas extraction excluding s
6	12	Uranium and thorium ores
7	13	Metal ores
8	14	Other mining and quarrying products
9	15	Food products and beverages
10	16	Tobacco products
11	17	Textiles
12	18	Wearing apparel; furs
13	19	Leather and leather products
14	20	Wood and products of wood and cork (except furniture); articles of straw and plaiting mate
15	21	Pulp, paper and paper products
16	22	Printed matter and recorded media
17	23	Coke, refined petroleum products and nuclear fuels
18	24	Chemicals, chemical products and man-made fibres
19	25	Rubber and plastic products
20	26	Other non-metallic mineral products
21	27	Basic metals
22	28	Fabricated metal products, except machinery and equipment
23	29	Machinery and equipment n.e.c.
24	30	Office machinery and computers
25	31	Electrical machinery and apparatus n.e.c.
26	32	Radio, television and communication equipment and apparatus
27	33	Medical, precision and optical instruments, watches and clocks
28	34	Motor vehicles, trailers and semi-trailers
29	35	Other transport equipment
30	36	Furniture; other manufactured goods n.e.c.
31	37	Secondary raw materials
32	40	Electrical energy, gas, steam and hot water
33	41	Collected and purified water, distribution services of water
34	45	Construction work

Appendix Table 2 Products and rows in Supply table (continued)

35	50	Trade, maintenance and repair services of motor vehicles and motorcycles; retail sale of a
36	51	Wholesale trade and commission trade services, except of motor vehicles and motorcycle
37	52	Retail trade services, except of motor vehicles and motorcycles; repair services of persor
38	55	Hotel and restaurant services
39	60	Land transport; transport via pipeline services
40	61	Water transport services
41	62	Air transport services
42	63	Supporting and auxiliary transport services; travel agency services
43	64	Post and telecommunication services
44	65	Financial intermediation services, except insurance and pension funding services
45	66	Insurance and pension funding services, except compulsory social security services
46	67	Services auxiliary to financial intermediation
47	70	Real estate services
48	71	Renting services of machinery and equipment without operator and of personal and house
49	72	Computer and related services
50	73	Research and development services
51	74	Other business services
52	75	Public administration and defence services; compulsory social security services
53	80	Education services
54	85	Health and social work services
55	90	Sewage and refuse disposal services, sanitation and similar services
56	91	Membership organisation services n.e.c.
57	92	Recreational, cultural and sporting services
58	93	Other services
59	95	Private households with employed persons
60		**Total**
61		Cif/ fob adjustments on exports
62		Direct purchases abroad by residents
63		Purchases on the domestic territory by non-residents
64		**Total intermediate consumption/final use at purchasers' prices**
65		Compensation of employees
66		Other net taxes on production
67		Operating surplus, gross
68		**Value added at basic prices**
69		**Output at basic prices**