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An Anatomy of the Global Trade Slowdown based on the WIOD 2016 Release

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An Anatomy of the Global Trade Slowdown based on the WIOD 2016 Release*

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Abstract

The deceleration of world trade since 2011 has been widely discussed. How much is due to a reversal of international production fragmentation? And how much is due to decreasing demand for trade-intensive goods? We present a consistent framework that quantifies their relative importance. A central concept in our approach is the global import intensity (GII) of production. This is a novel measure of fragmentation which traces the imports needed in all stages of production. We study the period before and after the great trade collapse based on an update of the world input-output database (WIOD). The increase in GII during the period 2000-2008 was due to a combination of two forces: high demand for goods and continuous international production fragmentation. Since 2011 fragmentation halted. Moreover, demand shifted to services which are less trade intensive than goods, in particular in China. We argue that lower trade ratios are likely to remain in the near future.

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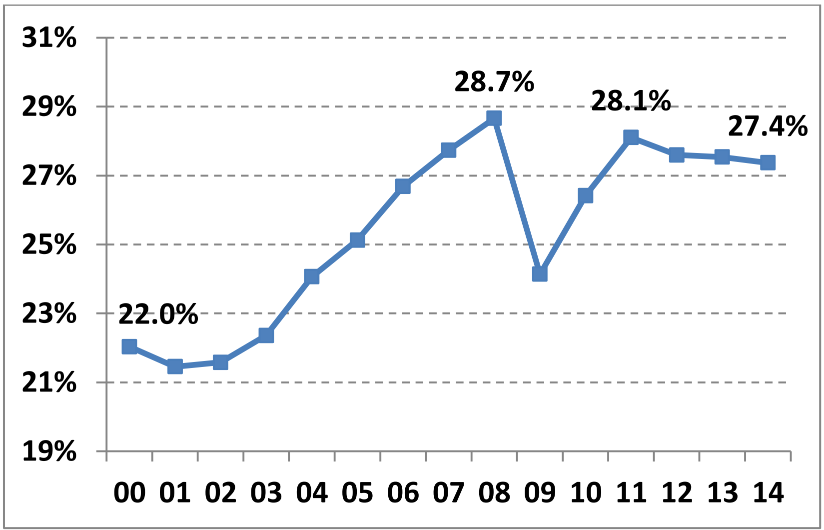
1. Introduction

The deceleration of international trade since 2011 has been widely documented and discussed.[1] It is clear that the overall weakness in global economic activity is a major determinant. But there are also indications that the relationship between trade and GDP growth is undergoing a fundamental shift. This is evidenced by the trend in import intensity of world GDP. Figure 1 shows that it grew during the 2000s, then dropped dramatically in 2008-2009 (the 'great trade collapse') and recovered afterwards. In recent years, however, trade did not keep pace with world GDP, which is reflected in a slight but prolonged decline of the import intensity. Is this declining trend only a temporary phenomenon or is it the 'new normal'?[2]

Figure 1. Import of goods and services (as percentage of world GDP)



Note: own calculations on the World Input-Output Database (WIOD), 2016 release as described in this paper. This release covers all trade between forty-three countries as well as with a "rest-of-the-world" region. Imports and GDP are in current US$.

As yet there are two competing sets of explanations for this trend break, each with different implications. The first set emphasizes changes in the composition of final demand, which contains both consumption and investment demand. Put broadly, it is argued that the global economic recession and its aftermath affected various categories of final demand to different degrees. Spending on durable investment and consumer goods declined, relative to spending on services. Durable goods are trade-intensive as they are typically produced in extensive international production networks, whereas services are mainly domestically produced. This asymmetry appeared to be a major explanation of the great trade collapse (Bems et al., 2011, 2013; Bussière et al., 2013; Eaton et al., 2016), and might also

[1] See Hoekman (2015), IMF (2016), Haugh et al. (2016) and IRC Trade Task Force (2016) for recent contributions.

[2] Import to GDP ratios have been on a steady increase since the mid-1980s, see Figure 2.1 in IMF (2016).

explain the more recent slowdown. If true, a future upturn in aggregate economic activity and renewed investment demand would fuel global trade once again.[3]

A second set of explanations focuses on the rise and possible decline of global value chains (GVCs), highlighting changes in the structure of production. It has widely been documented that production has rapidly fragmented across countries, a process starting in the 1980s and accelerating in particular in the 2000s (see e.g. Baldwin and Lopez-Gonzalez, 2015; Los et al., 2015). The rise of GVCs was reflected in an increase in trade in intermediate products (materials, parts and components), but it may have run out of steam. Possible reasons for this include changes in trade costs due to increased protection, as suggested by Evenett and Fritz (2015).[4] It might also be due to substitution of imports by domestic goods, as local production capabilities increase, as in China (Kee and Tang, 2016). Or it may be a realignment in the face of previous overshooting of fragmentation, as suggested in Harms et al. (2012) and Baldwin and Venables (2013). In addition, technological innovations, such as robotisation, may stimulate renewed localisation of production in advanced countries. In contrast to the demand explanation, these hypotheses are suggestive of a 'new normal' of a stagnating, or even declining, import intensity of world GDP.

To date, a lot of empirical evidence that speaks in favour of either of both hypotheses has been brought up (see IMF, 2016, for a recent overview). Demand-side explanations are buttressed by analyses of consumption and investment statistics at the national level, basically ignoring changes in production structures. On the other hand, production-side explanations are supported by trends found in international trade data, ignoring shifts in demand structures. This separation precludes quantification of the relative strengths of both types of change in explaining the slowdown. The main contribution of this paper is the introduction of data and a coherent modelling framework that allow for an integrated approach. We follow Bems et al. (2013) who state that: "The key to understanding how trade can fall more than GDP lies in understanding how asymmetries in expenditure changes across sectors map to international trade." (p. 376). To provide this mapping we use data from the World Input-Output Database (WIOD, Timmer et al., 2015), which combines information on demand, production and international trade. Armed with these new data and a new analytical framework, we will account for the changes in import intensity of global demand for the period 2000-2014.

[3] An alternative demand-side argument focuses on anaemic growth in Europe, observing that due to a lot of intra-EU trade, European countries have trade intensities that are higher than in many countries. Slower growth in the EU thus might explain part of the global trade intensity slow down. We show in section 4 that this effect is minor however.

[4] See IMF (2016, pp.78-81) for a review of the evidence.

Our first main finding is that the process of international production fragmentation has stalled since 2011. We measure all imports needed in any stage of production of a final good or service.[5] We refer to these as GVC imports. Note that these include the imports by the country in which the last stage of production takes place, as well as imports by other countries that are involved in earlier stages of production. Moreover, it includes imports of intermediate goods as well as intermediate services (such as supporting business services). We denote the ratio of GVC imports to the value of the final product by the term 'global import intensity' of production. This ratio is a novel measure of international production fragmentation as it is positively related to the number of stages in production as well as the probability that any link between two stages involves cross-border trade.

The trends in international production fragmentation are given in Figure 2. It shows the global import intensity (GII) of production, averaged across all goods produced in the world economy. We have data on 836 production chains of final goods, and weighted all associated GIIs by their respective final output levels. One dollar of final output of goods generated 25 dollar cent of imports worldwide in 2000, increasing to 33 dollar cent in 2008. This rapid international fragmentation of goods production dramatically reverted in 2008. This global trade collapse was followed by a gradual recovery and a return to the level of fragmentation in 2008 by the year 2011. Since then, the fragmentation process has stalled and seems even to have reverted.[6]

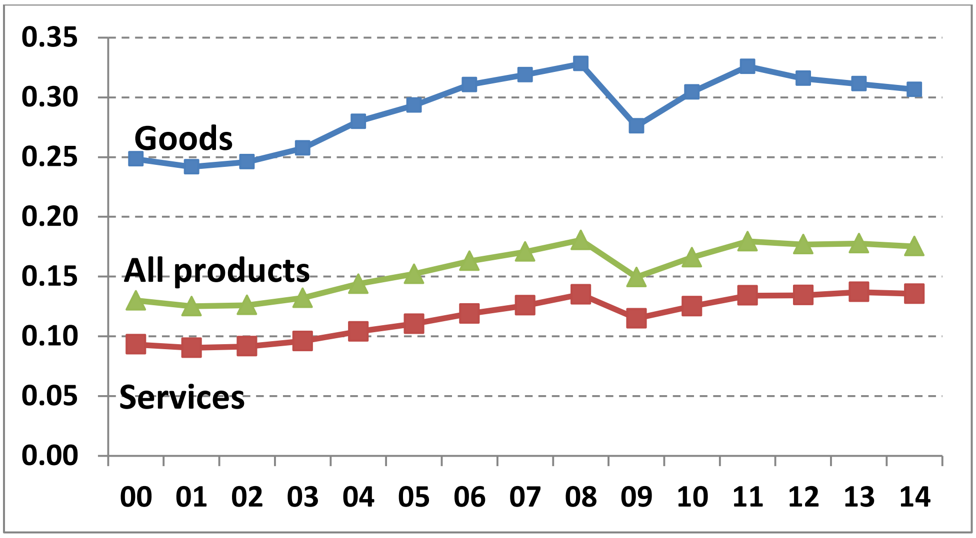
Due to the increased detail on services production and trade in the new release of the WIOD we can now also measure the international fragmentation of services production. These GIIs capture imports of goods and services needed in any stage of the production of the final service. The weighted averages for 1,628 production chains of final services are also shown in Figure 2.[7] As expected, the average global import intensity of services production is much lower than for goods, but it is clearly not negligible. The production of construction works or health services, for example, require fair amounts of imports in various stages of production, through imports of building materials or pharmaceuticals. An upward trend is found for the 2000s, but it is weaker than for goods production. In recent years fragmentation in services production seems also to halt. As final output of services accounts for a much larger share of the world economy than final output of goods, the overall averages are closer to the average GII levels for services.

[5] A final product is a good or service that is consumed or used as a capital good. An intermediate product serves as an input in production and is fully used up within an accounting period (a year in the system of national accounts). This categorisation is exhaustive and mutually exclusive.

[6] As shown in Section 4, this is a common trend across many production chains of goods and not driven by trends in just a few production processes. When excluding trade in mineral products like oil, we still find that global import intensities did not rise over the 2011-2014 period. This suggests that the results are not driven by sizable changes in relative prices.

[7] Examples of intermediate services are supporting business functions, transportation services, financial services and computer services. Final services include public services, personal services as well as health and education services.

Figure 2. International fragmentation of production of final goods and services, 2000-2014



Note: ratio of GVC imports to the output of the final products. GVC imports include imports by the country in which the last stage of production took place, as well as by all other countries involved in earlier stages of production. Goods refer to production of agricultural, mining and manufacturing final goods (836 in total). Services refer to production of all other final products in the economy (1,628). Global import intensities of production for products have been weighted by final output.

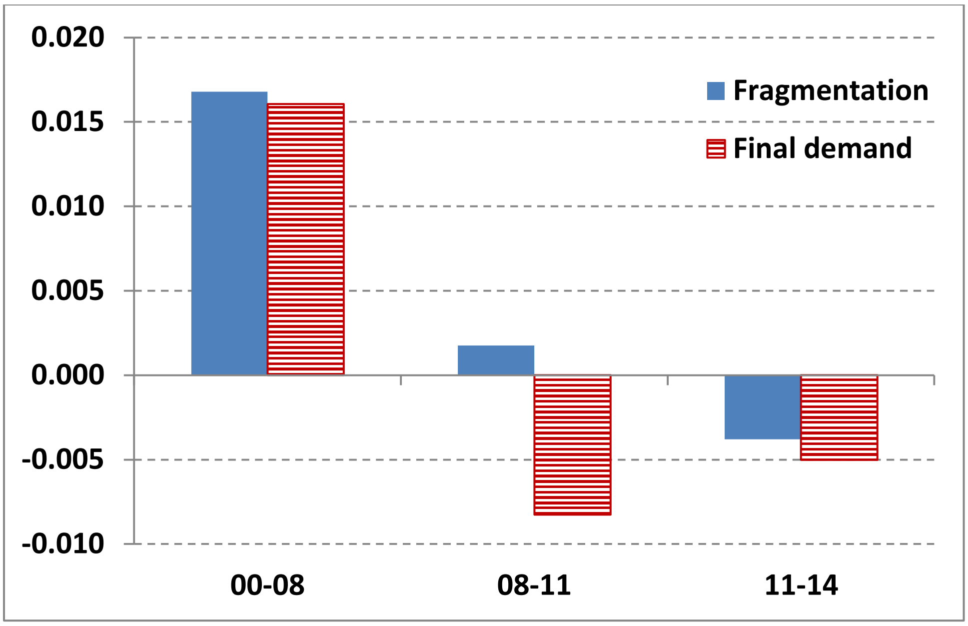
Next, we employ an input-output framework to account for the change in the import intensity of world GDP. Put simply, this intensity can increase in this framework when production processes become more internationally fragmented, or when final demand shifts to goods and services of which production processes are more import intensive. The former can be thought of as an intra-effect (within production chains), and the latter as a shift-effect (across output of production chains). By keeping global final demand for each product fixed, we find the contribution of changes in global import intensities (GIIs) of production. Conversely, we derive the contribution of changes in the product structure of global final demand by keeping GIIs constant. The main result of the decomposition is given in Figure 3. Roughly half of the increase during 2000-08 was due to international production fragmentation. Demand shifts accounted for the other half. During 2008-2011 both drivers of trade collapsed: the intra-effect became small and the shift-effect even turned negative. Since 2011, the GIIs of many products actually fell such that the intra-effect turned negative as well. During the period 2011-14 the shift and intra-effects drove down the import intensity of world GDP, each by 0.5 log points.[8]

In a final step we analyse the impact of final demand changes of individual countries. Perhaps surprisingly we find that growing Chinese demand did not have a major impact. Obviously it led to an increase in the *level* of worldwide imports, but not to the import intensity of world GDP. This is

[8] When the global import intensity of production declines (increases) over a period, the elasticity is smaller (bigger) than one.

because the import intensity of Chinese demand was barely above the world average in the early 2000s. Furthermore, it has been on the decline ever since, as demand shifted to products for which production is less import intensive, away from durables and investment goods and towards services. In addition, demand shifted to products finalised at home which in general have lower import intensities than final products purchased from elsewhere.[9] With this move to greater self-reliance, the import intensity of Chinese final demand dropped below the world average and by 2014 the level was comparable to levels in Japan and the US. When Chinese growth remains high, it will continue to lower the import intensity of world GDP.

Figure 3. Accounting for changes in global import intensity



Note: Change in ratio of imports to world GDP due to changes in production structures (as measured by changes in global import intensities of production) and due to changes in final demand structures (as measured by changes in the shares of demand for final output). All results expressed in log points. Based on Table 2 from this paper.

Our methodology is closely related to the approach of Bems et al. (2011). They relied on a demand driven model in the Leontief tradition, which provides a straightforward framework for mapping of exogenous final demand to imports flows. They used this model to account for the collapse of global trade during 2008-09. They found that the drop in final demand was magnified through vertical linkages in production: the decline in intermediate goods trade contributed 43.9 percent of the fall in total trade. We extend their approach in two ways. First, the model of Bems et al. (2011) was parameterized with data for only one year, effectively ruling out changes in production technologies. Instead, we use annual input-output tables, which enable us to attribute actual changes in global

[9] This is not self-evident as global import intensities include not only imports by China, but also by other countries in the chain.

imports to changes in demand as well as in production. Given that production structures move slowly, this is not likely to be important in measuring short-term effects of a demand shock. But it is important when analysing changes over longer periods. We follow Los et al. (2015) in tracing all intermediates needed in all stages of production of a particular final product. By singling out intermediates that are imported we can measure the GII of production. Second, in analyses of single countries one can take foreign demand as given. In a world characterised by internationally fragmented production processes, however, exports of intermediate products should be treated as endogenous. Our global model allows for this, so exports of intermediate products are not part of a country's final demand .

We argue that the GII of production is a novel indicator of international production fragmentation. It is related, but different, from a number of other indicators. It is reminiscent of the vertical specialisation (VS) measure of Hummels et al. (2001), but differs from it in two crucial aspects.[10] First, it measures the import intensity of final output and not of exports as in VS. As such, it is not informative of the participation of a specific country in international production networks. Instead, our indicator focuses on characteristics of the global value chains as a whole. If VS increases for many countries, this will be reflected in increasing GII indicators and vice versa. Second, our measure includes imports in all stages of a GVC, part of which relate to cross-border trade between third countries. VS only includes imports needed in domestic production stages. Our indicator is also related to the indicator presented in Los et al. (2015). Their indicator measures the distribution of value added across countries within a particular GVC, and as such provide evidence on the fragmentation of value creation across countries. This indicator does not focus on the physical fragmentation of production and is therefore neither sensitive to the number of stages nor to the order in which these stages take place and hence not to the associated gross trade flows. The GII indicator proposed in this paper focuses on gross trade and therefore considers such characteristics of GVCs explicitly. From a mathematical point of view, our measure is most closely related to the backward indicator proposed in Fally (2012). Like our GII, his indicator also focuses on physical characteristics of the fragmentation of production processes, but does not consider cross-border aspects of fragmentation.[11]

We do not claim that this exercise delivers a causal analysis of the drivers of global trade. We view our ex-post accounting approach as a useful organisation of the empirical facts that need to be explained. It can also be informative for the parametrization of more complex models. Eaton et al. (2016), for example, provide a multi-sector multi-country model in which trade and production are jointly determined by trade costs, preferences and productivity. In particular, our finding of changes in

[10] See Koopman et al. (2014) and Los et al. (2016) for extensions of the VS approach.
[11] Johnson and Noguera (2012) introduced the concept of value added exports. Expressed as a ratio of gross exports (known as the VAX ratio) it is sometimes interpreted as a measure of fragmentation of production. However, it measures the amount of domestic value added that is absorbed abroad. It is based on a forward linkage analysis, while our measure tracks backward linkages.

the pace of international production fragmentation highlights the importance of including endogenous development of global supply chain structures in such models.

The remainder of this paper is organised as follows. In section 2 we lay out the main accounting methodology and introduce the new measure of international production fragmentation. In section 3 we discuss the 2016 release of the World Input-Output Database (WIOD), which has been updated specifically for this analysis. We discuss the main features of the new input-output tables and delegate details on source materials to an extensive Data appendix. In section 4 we present our anatomy of the global trade slowdown. In section 5 we conclude and argue that growth in world trade in the period up to the great collapse in 2008 was due to a combination of two forces: high demand for trade-intensive products and continuous international production fragmentation. Both developments have stalled since 2011. The process of fragmentation might be reignited. Baldwin (2016) argues that much potential for further fragmentation is still unused and gains are to be made, in particular in services production. But even with a possible rebound of the world economy accompanied by increasing investment demand, trade growth might be slow. As the Chinese economy continues to mature and the import intensity of its domestic demand continues to fall (or remain below world average), global import-GDP ratios are likely to rise. From this perspective, the current slowdown in global trade should not be a major concern.

2. Methodology

The main aim of our analysis is to account for changes in global trade, focusing on two principal determinants: changes in the structure of global final demand and changes in the structure of production. We provide an ex-post accounting approach which is grounded in a demand driven model in the tradition of Leontief. This approach takes all import flows into account, including final and intermediate products trade. Importantly, it enables us to identify how much international trade is associated with the consumption (or investment) of a particular final product. This includes imports of final products by the country where the product is consumed, imports of materials, components and business services by the country where the product is finalised as well as imports needed in earlier stages of production (see Figure 4). We derive a novel measure of the import intensity of production and show how this measure can be interpreted as an indicator of international production fragmentation. This allows us to account for how changes in final demand and production structures impacted global trade over the period 2000-2014 by keeping the final demand structures constant while imputing the actual change in production structures, and vice versa. We will show that this accounting provides an exhaustive decomposition of global trade, that is, it accounts fully for the actual change in world imports by construction.

Notational preliminaries

Let *c* denote the country that is consuming a final product, and *s* the country that is supplying it. Subscript *i* indicates final products. We write demand by *c* for product *i* from *s* as $F_i(s,c)$.[12] All variables are expressed in nominal terms. In order to avoid cluttering notation, we refrain from using a time index at this stage. We can then define global final demand for product *i*:

$$F_i = \sum_c \sum_s F_i(s,c), \quad (1)$$

and world GDP

$$W = \sum_i \sum_c \sum_s F_i(s,c). \quad (2)$$

Let M_i denote the imports induced by final demand for product *i*. We denote imports of the final good by M^{Fin} and imports of intermediates that are used in any production stage of the good by M^{Int}. In an input-output framework it is assumed that the structure of production of a good is independent of the use of the good. Put otherwise, a car finalised in Germany requires a certain amount of intermediate imports, irrespective whether it will be consumed in France, Italy or domestically. Let $M_i^{Fin}(s,c)$ be the value of *i* consumed by *c* and supplied by *s*, and $M_i^{Int}(s)$ all imports related to the production of product *i* finalised in country *s*. Then, total induced imports by final demand $F_i(s,c)$ are given by:

$$M_i(s,c) = M_i^{Fin}(s,c) + M_i^{Int}(s). \quad (3)$$

It is important to note that $M_i(s,c)$ includes not only imports by country *c* from country *s*, but also trade in intermediates between any other pair of countries related to any stage of production of *i*. Therefore, even when the last stage of production is in the country of consumption itself ($M_i^{Fin}(c,c) = 0$), imports might be needed further down the production chain (in which case $M_i^{Int}(s) > 0$), such that $M_i(c,c)$ might be positive. We can now write world imports as all imports induced by final demand summed across all products:

$$M = \sum_i \sum_c \sum_s M_i(s,c)\,. \quad (4)$$

Let $m_i(s,c)$ stand for import intensity defined as:

$$m_i(s,c) = \frac{M_i(s,c)}{F_i(s,c)}. \quad (5)$$

[12] $F_i(s, c)$ could, for example, represent the value of cars finalised in Germany and consumed in Austria.

Substituting (3) in (4) and using (5) we can write global imports as

$$M = \sum_i \sum_c \sum_s \; F_i(s,c) \times \left[m_i^{Fin}(s,c) + m_i^{Int}(s)\right]. \quad (6)$$

Divide both sides of (6) by world GDP (*W*) so we can write the import intensity of world GDP as:

$$m = {}^{M}\!/_{W} = \sum_i \sum_c \sum_s \; \left(\tilde{F}_i(s,c) \times \left[m_i^{Fin}(s,c) + m_i^{Int}(s)\right]\right), \quad (7)$$

in which final demand by country *c* for a product *i* finalised by country *s* is now expressed as a share of world GDP: $\tilde{F}(s,c) = F_i(s,c)/W$.

Equation (7) shows how we can write global import intensity as a function of final demand structures and the imports induced by final demand (including imports of both final and intermediate goods). Imports of final goods can be readily obtained from international trade statistics (classified by use category) as it requires only information on the trade flow from supplier to consuming country. But this is not true for induced imports of intermediates, as it requires tracking of all stages of production. We use the standard Leontief approach to identify the flows of intermediates induced by final demand.

Measuring imports related to production

To facilitate exposition, we introduce matrix notation. The number of countries is *C* and the number of industries in each of the countries is *N*. Each country-industry creates a product that can be sold for final use and to fulfil intermediate demand. Let **F** be a matrix of final demand with dimensions (*CN*x*C*), in which the *c*th column contains the elements $F_i(s,c)$. Let **A** be a matrix of intermediate input requirements with dimensions (*CN*x*CN*). The typical element of **A**, $a_{jk}(q,r)$, stands for value of the inputs from industry *j* in country *q* required by industry *k* in country *r* to produce one dollar of its gross output. This representation thus reflects that intermediates can in principle be sourced from any other country-industry in the world.

Let **z** be a *CN* column vector with a one for final demand for product *i* finalised in country *s* and zeros elsewhere. The production of one dollar of this good will take place in the country of finalisation and the gross outputs related to this stage equal **Iz**, which is a *CN* column vector.[13] This last stage requires intermediate inputs from first-tier suppliers, some of which might be foreign. The output levels of intermediates needed in this stage are given by **Az**, which is also a *CN* vector. Some of these products might well be supplied by domestic suppliers. As we aim to measure import flows only, all domestic transaction flows have to be excluded. This can be done by first obtaining a (*CN*x*CN*) matrix of first-

[13] **I** stands for the *CN*x*CN* identity matrix.

tier supplier output levels through post-multiplying the matrix $\mathbf{A}$ by a diagonal matrix $\bar{\mathbf{z}}$, with the elements of $\mathbf{z}$ on the main diagonal.[14] Next, this matrix $\mathbf{A}\bar{\mathbf{z}}$ is multiplied elementwise by a suitably chosen 'trade selection' matrix ($\mathbf{T}^I$). The *C* blocks of dimensions *N*x*N* on the main diagonal are filled with zeros, while all other elements of $\mathbf{T}^I$ have value one. This multiplication implies that domestic transactions related to first-tier suppliers are set to zero, while exports by first-tier suppliers remain unaffected. The imports from first-tier suppliers are thus contained in an *CN*x*CN* matrix:

$$\boldsymbol{M}_z^{tier1} = \mathbf{T}^I \circ (\mathbf{A}\bar{\mathbf{z}}) \ . \tag{8}$$

The symbol ○ refers to element-wise multiplication (the Hadamard product operation). The production of intermediates delivered by the first-tier suppliers in turn requires intermediate inputs from second-tier suppliers, given by $\mathbf{A}(\mathbf{A}\mathbf{z})$. The imports from second-tier suppliers are then $\boldsymbol{M}_z^{tier2} = \mathbf{T}^I \circ (\mathbf{A}(\overline{\mathbf{A}\mathbf{z}}))$**.** Continuing this line of reasoning for higher tier suppliers, we can write the matrix with import flows needed for production of $\mathbf{z}$ as:[15]

$$\boldsymbol{M}_z^{Int} = \boldsymbol{M}_z^{tier0} + \boldsymbol{M}_z^{tier1} + \boldsymbol{M}_z^{tier2} + \boldsymbol{M}_z^{tier3} + \cdots$$

$$= \mathbf{T}^I \circ (\mathbf{I}\bar{\mathbf{z}}) + \mathbf{T}^I \circ (\mathbf{A}\bar{\mathbf{z}}) + \mathbf{T}^I \circ (\mathbf{A}\overline{\mathbf{A}\mathbf{z}}) + \mathbf{T}^I \circ \left(\mathbf{A}(\overline{\mathbf{A}^2\mathbf{z}})\right) + \ldots.$$

$$= \mathbf{T}^I \circ \{\mathbf{A}\,[\overline{(\mathbf{I}-\mathbf{A})^{-1}\mathbf{z}}]\} \, . \tag{9}$$

The total value of imports related to production of the final output vector $\mathbf{z}$ is given by summing across all bilateral trade flows in the GVC of $\mathbf{z}$ and is given by

$$m_z^{Int} = \boldsymbol{u}'\boldsymbol{M}_z^{Int}\boldsymbol{u}, \tag{10}$$

where u is a *CN* summation vector and a prime indicates transposition. m_z^{Int} is a new measure of the degree of international fragmentation in the production of the final product by the country-industry for which $\mathbf{z}$ contains a one. This measure can increase because more imports are used in any stage of production, or because new stages (with similar import requirements) are added through further fragmentation. It is zero in case the finalising country does need to import intermediates in *any* stage of production. It can be bigger than one, as imports are measured on a gross basis and double counting of value added contributions as emphasized by Koopman et al. (2014) will take place.[16]

[14] In what follows, the symbol (¯) always indicate diagonal matrices.
[15] See Miller and Blair (2009) for the mild conditions under which the summation converges.
[16] If we would have omitted the trade selection matrix $\mathbf{T}^I$ in (9), this equation would have yielded the worldwide gross output multiplier for the product for which $\mathbf{z}$ contains the value one. Fally (2012) showed that such a gross output multiplier gives the average number of stages a dollar of value added has gone through before the final product in which it is embodied is consumed.

In Table 1, we provide evidence on the empirical relevance of including not only imports in the last stage of production. In principle we have information on 2464 GVCs (56 product groups finalised in 44 countries). We aggregate and report on six major product groups using final output weighted averages across countries-of-finalisation and products within a product group.[17] Two findings stand out. First, and not surprisingly, there are large differences in global import intensities of production. They are low for services (which are mainly domestically produced and do not require much imported intermediates) and high for goods, in particular durables. Second, our preferred measure, which includes trade in all stages, shows much higher import intensities than the last-stage indicator. While the ranking across product groups is largely unaffected, import intensities appear to be affected to different extents.

We can now aggregate across all products to derive the world imports of intermediates. We replace **z** by the *CN* vector **Fu**, which contains the final demand levels for all *CN* products in the global economy, obtained by summing over all countries in which final demand is exerted and all final demand categories (including government consumption and changes in inventories). We sum across all import flows to find global import levels of intermediates associated with final demand **F** by:

$$M^{Int} = \mathbf{u}'(\mathbf{T}^{I} \circ \{\mathbf{A}\,[\overline{(\mathbf{I}-\mathbf{A})^{-1}(\mathbf{Fu})}]\})\mathbf{u}\,. \qquad (11)$$

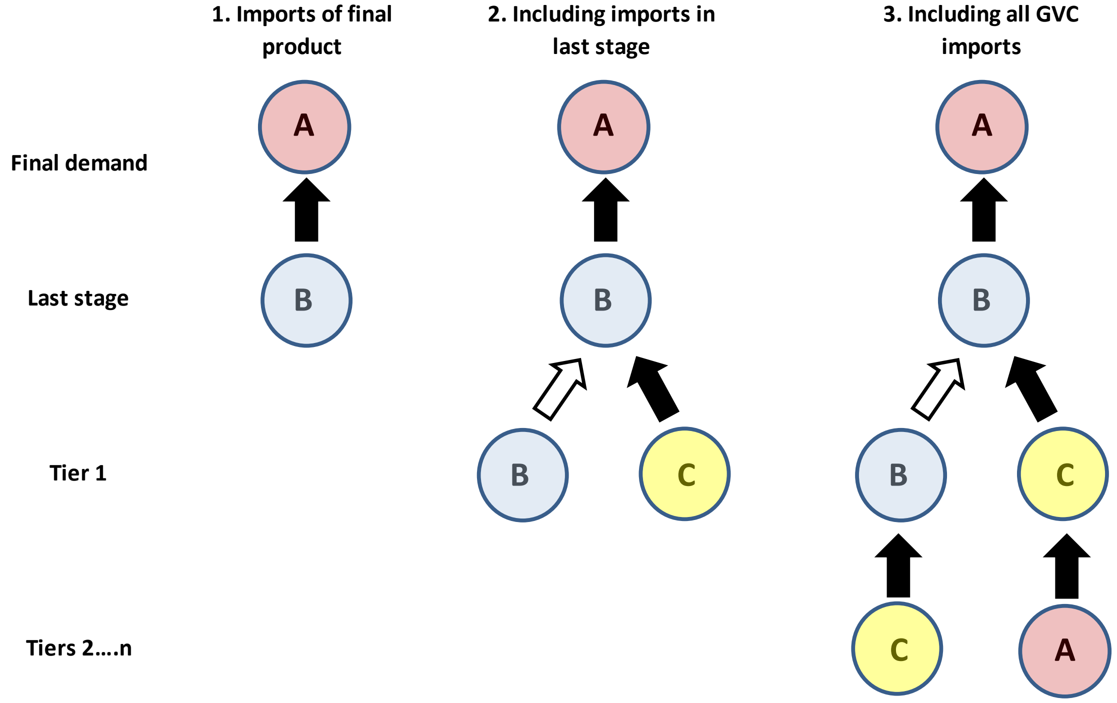
Table 1. Import intensity of production, 2007

Product group	Last stage of production	All tiers of production
Non-durable consumption goods (C-NDur)	0.136	0.288
Durable consumption goods (C-Dur)	0.181	0.401
Services consumption products (C-Serv)	0.042	0.107
Investment goods (I-Mach)	0.113	0.259
Construction (I-Con)	0.089	0.242
Other final demand	0.056	0.132

Note: Import intensity of production (per unit of gross output) based on first tier imports only and including all imports in the GVC as defined in equation (9). Final output weighted averages across countries-of-finalization and products within a product group, 2007. The product groups are based on two main final demand categories: household consumption (C) and investment (I).

[17] At the aggregate global level, this indicator is equal to total imports for intermediate use divided by world GDP.

Figure 4. Illustration of various ways to measure imports related to final demand.



Note: Black arrows indicate import flows.

Accounting for changes in global import intensity

As for intermediate imports, we can derive an expression for the imports of final products by multiplying **F** with a suitably chosen 'trade selection matrix' $\mathbf{T}^{\mathbf{F}}$ (*CN*x*C*) filled with ones and zeros such that when multiplied elementwise with **F** the elements $F_i(s,c)$ are set to zero for all *s*=*c*. Global trade in final products can now be compactly written as

$$M^{Fin} = \mathbf{u}'(\mathbf{T}^F \circ \mathbf{F})\mathbf{u} \quad . \tag{12}$$

Combining this with (11) we arrive at global imports:

$$M = M^{Int} + M^{Fin} = \mathbf{u}'(\mathbf{T}^I \circ \{\mathbf{A}\,\overline{[(\mathbf{I}-\mathbf{A})^{-1}(\mathbf{Fu})]}\} + \mathbf{T}^F \circ \mathbf{F})\mathbf{u}\,. \tag{13}$$

This equation shows how global imports are related to two key parameters. The first is the structure of final demand in terms of type of product demanded, countries of demand and countries of supply (**F**). The second is the international structure of production as described in **A**. This decomposition is exact and exhaustive and we can use it to account for changes in global import intensity over time.

Let subscripts 0 and 1 indicate the begin and end of a period. We want to decompose the change in global trade intensity *m* which is imports over world GDP. Without loss of generality we divide each element in **F** by world GDP to obtain $\tilde{\mathbf{F}}$, which represents final demand shares. The actual global import-to-GDP ratio in period 0 is then given by

$$m_{(A0,F0)} = \mathbf{u}'(\mathbf{T}^{I} \circ \left\{\mathbf{A}_0\left[\overline{(\mathbf{I}-\mathbf{A}_0)^{-1}(\tilde{\mathbf{F}}_0\mathbf{u})}\right]\right\} + \mathbf{T}^{F} \circ \tilde{\mathbf{F}}_0)\mathbf{u}, \quad (14a)$$

and in period 1 by

$$m_{(A1,F1)} = \mathbf{u}'(\mathbf{T}^{I} \circ \left\{\mathbf{A}_1\left[\overline{(\mathbf{I}-\mathbf{A}_1)^{-1}(\tilde{\mathbf{F}}_1\mathbf{u})}\right]\right\} + \mathbf{T}^{F} \circ \tilde{\mathbf{F}}_1)\mathbf{u}\,. \quad (14b)$$

These measures use the actual levels of **A** and **F** in each period. Following Dietzenbacher and Los (1998), we can construct a hypothetical global import intensity for period 1 as follows

$$m_{(A0,F1)} = \mathbf{u}'(\mathbf{T}^{I} \circ \left\{\mathbf{A}_0\left[\overline{(\mathbf{I}-\mathbf{A}_0)^{-1}(\tilde{\mathbf{F}}_1\mathbf{u})}\right]\right\} + \mathbf{T}^{F} \circ \tilde{\mathbf{F}}_1)\mathbf{u}\,. \quad (15)$$

This hypothetical intensity is created by keeping the intermediate input coefficients in **A** at the initial (period 0) levels, while letting **F** attain its period 1 level. Using this, we can write the change in the global imports-to-GDP ratio as :

$$\frac{m_1}{m_0} = \frac{m_{(A1,F1)}}{m_{(A0,F0)}} = \frac{m_{(A1,F1)}}{m_{(A0,F1)}} \times \frac{m_{(A0,F1)}}{m_{(A0,F0)}}. \quad (16)$$

The decomposition given in equation (16) relies on two hypothetical exercises. The first element on the right-hand side gives the change in global imports due to the change in GVC structures while keeping final demand structure constant (at period 1 level). The second element gives the import change due to changes in final demand structures while keeping GVC structures constant (at period 0 level). Similarly, we can construct a so-called polar case decomposition. Let

$$m_{(A1,F0)} = \mathbf{u}'\left(\mathbf{T}^{I} \circ \left\{\mathbf{A}_1\left[\overline{(\mathbf{I}-\mathbf{A}_1)^{-1}(\mathbf{F}_0\mathbf{u})}\right]\right\} + \mathbf{T}^{F} \circ \mathbf{F}_0\right)\mathbf{u}. \quad (17)$$

Then we can write:

$$\frac{m_1}{m_0} = \frac{m_{(A1,F1)}}{m_{(A1,F0)}} \times \frac{m_{(A1,F0)}}{m_{(A0,F0)}}. \qquad (18)$$

There is no theoretical ground for preferring one decomposition above the other and in the empirical analysis we report the (unweighted) geometric average of the polar cases in (16) and (18). Taking logs we can write:

$$log\,\frac{m_1}{m_0} = \frac{1}{2}\left(log\,\frac{m_{(A1,F0)}}{m_{(A0,F0)}} + log\,\frac{m_{(A1,F1)}}{m_{(A0,F1)}}\right) + \frac{1}{2}\left(log\,\frac{m_{(A1,F1)}}{m_{(A1,F0)}} + log\,\frac{m_{(A0,F1)}}{m_{(A0,F0)}}\right). \qquad (19)$$

This is our main decomposition equation. It states that the log change in the global import intensity can be fully accounted for by changes in the GVC production structure (as measured in the first part on the right hand side) and changes in final demand structures (as measured in the second part).

Further analysis of final demand structures

In subsequent analysis we will consider the contribution of changes in final demand at the country level for total global imports. We define a new matrix $\tilde{\mathbf{F}}(c)$ of dimensions *CN*x*C* in which the *c*th column has the elements $\tilde{f}_i(c,s)$ as in the original matrix $\tilde{\mathbf{F}}$ and zeros elsewhere, such that

$$\tilde{\mathbf{F}} = \sum_c \tilde{\mathbf{F}}(c)\ . \qquad (20)$$

Keeping **A** constant and allowing for the actual change in $\tilde{\mathbf{F}}(c)$ we can calculate hypothetical import levels as before:

$$m_{(A0,F(c)1)} = \mathbf{u}'\left(\mathbf{T}^I \circ \left\{\mathbf{A}_0\left[\overline{(\mathbf{I}-\mathbf{A}_0)^{-1}\left(\tilde{\mathbf{F}}(c)_1\mathbf{u}\right)}\right]\right\} + \mathbf{T}^F \circ \tilde{\mathbf{F}}(c)_1\right)\mathbf{u}, \qquad (21a)$$

and

$$m_{(A0,F(c)1)} = \mathbf{u}'\left(\mathbf{T}^I \circ \left\{\mathbf{A}_1\left[\overline{(\mathbf{I}-\mathbf{A}_1)^{-1}\left(\tilde{\mathbf{F}}(c)_0\mathbf{u}\right)}\right]\right\} + \mathbf{T}^F \circ \tilde{\mathbf{F}}(c)_0\right)\mathbf{u}. \qquad (21b)$$

We repeat this for each country and sum over all:

$$\frac{m_{(A1,F1)}}{m_{(A1,F0)}} = \frac{\sum_c m_{(A1,F(c)1)}}{\sum_c m_{(A1,F(c)0)}}\ . \qquad (22a)$$

Keeping the values in **A** at period 0 levels, we can write:

$$\frac{m_{(A0,F1)}}{m_{(A0,F0)}} = \frac{\sum_c m_{(A1,F(c)1)}}{\sum_c m_{(A1,F(c)0)}}\,. \qquad (22b)$$

Using the geometric average of these results one can decompose the overall effect of changes in final demand on global import intensity, as given in the last element of (19). We will do so to highlight the importance of particular countries in accounting for changes in the global import intensity.

The part of the change in GII attributed to final demand structure changes in (22) incorporates both the effects of changes in country shares in global final demand and effects due to other changes in the final demand structure. These relate to changes in the countries from which final products are purchased and changes in the type of products that are purchased for final use. If domestic purchases of final products are substituted by imports, the import intensity will generally increase. Substituting imports from one country by imports from another country could also impact the global import intensity, since GVC imports of a product vary across countries in which these are finalised. Changes in the product mix of final demand will also have consequences. In Figure 2, for example, we found that global import intensities of manufactures are considerably higher than for services.

In order to compute the contributions of both changes, we split the last term of (19) into eight parts, using notation that closely resembles the shorthand notation in (22).

$$\frac{1}{2}\left(log\frac{m_{(A1,F1)}}{m_{(A1,F0)}} + log\frac{m_{(A0,F1)}}{m_{(A0,F0)}}\right) = \qquad (23)$$

$$\frac{1}{2}\left(\left\{\frac{1}{4}log\left(\frac{m_{(A1,F1)}}{m_{(A1,\hat{F}0)}}\right) + \frac{1}{4}log\left(\frac{m_{(A0,F1)}}{m_{(A0,\hat{F}0)}}\right) + \frac{1}{4}log\left(\frac{m_{(A1,\hat{F}1)}}{m_{(A1,F0)}}\right) + \frac{1}{4}log\left(\frac{m_{(A0,\hat{F}1)}}{m_{(A0,F0)}}\right)\right\}\right.$$
$$\left. + \left\{\frac{1}{4}log\left(\frac{m_{(A0,\hat{F}0)}}{m_{(A0,F0)}}\right) + \frac{1}{4}log\left(\frac{m_{(A1,\hat{F}0)}}{m_{(A1,F0)}}\right) + \frac{1}{4}log\left(\frac{m_{(A0,F1)}}{m_{(A0,\hat{F}1)}}\right) + \frac{1}{4}log\left(\frac{m_{(A1,F1)}}{m_{(A1,\hat{F}1)}}\right)\right\}\right)$$

$\hat{\mathbf{F}}_0$ stands for the (*CN*x*CN*) matrix in which the country shares in global final demand are those of the initial period, but the shares of each of the *CN* products in the final demand of each country are those of the final period. Conversely, $\hat{\mathbf{F}}_1$ is the (*CN*x*CN*) matrix in which the country shares in global final demand are those of the final period, but the shares of each of the *CN* products in the final demand of each country are those of the initial period. The first part between the curly brackets (multiplied by ½) gives the contribution to changes in the global import intensity of changes in the shares of countries in global final demand, whereas the second part between curly brackets (also multiplied by ½) quantifies the GII changes that can be attributed to changes in the composition of the final demand bundles of countries.

3. Data from updated World Input-Output Database (WIOD).

To analyse recent trends in international production fragmentation and their impact on global trade, we need a consistent time-series of world input-output tables. A world input-output table (WIOT) can be regarded as a set of national input-output tables that are connected with each other by bilateral international trade flows. The combination of domestic and international flows of products provides a powerful tool for analysis of global production networks. While national tables are routinely produced by national statistical institutes, WIOTs are not, as they require integration of statistics across countries.

For this paper, we have developed an update of the World Input-Output Database (WIOD). This new 2016 release provides an annual time-series of WIOTs from 2000 to 2014 (compared to 1995-2011 in the 2013 release of WIOD). It covers forty-three countries (forty in the 2013 release), including all twenty-eight members of the European Union (as of July 1, 2013) and fifteen other major economies: Australia, Brazil, Canada, China, India, Indonesia, Japan, Mexico, Norway, Russia, South Korea, Switzerland, Taiwan, Turkey and the United States. These countries have been chosen by considering both the requirement of data availability of sufficient quality and the desire to cover a major part of the world economy. Together, the countries cover more than 85 per cent of world GDP (at current exchange rates). In addition, a model for the remaining non-covered part of the world economy is estimated, called the “rest of the world” region. It should be noted that we will not be able to account for trade between countries in this rest of the world region. This constituted 9.1 percent of world trade in 2014.[18] The new release includes data on 56 sectors and products mainly at the 2-digit ISIC revision 4 level (or groups thereof) together covering the overall economy.[19] Compared to the 2013 release the number of sectors has increased by eighteen mainly in manufacturing and in business services. This is particularly relevant for analyses of global value chains as many of the activities which are internationally fragmented are classified under these sectors.

[18] In 2014, 54% of global imports consist of trade between WIOD countries, 21% are WIOD countries’ imports from rest-of-the-world, 16% are WIOD exports to rest-of-the-world and 9% is trade between countries in the rest-of-the-world region (from UN COMTRADE 2014, reconciled data).

[19] The WIOTs have an industry-by-industry format as many applications require such a square matrix reflecting the economic linkages across industries. They are built from national supply and use tables which contain data on industries and products. The products are classified according to the CPA and cover 56 product categories following the primary outputs from our 56 sectors. Secondary outputs of industries are accounted for in the supply tables.

In order to appreciate the usefulness of the WIOD for this type of analysis it is important to understand the basic construction approach. We followed the same methodology as used in constructing the previous WIOD and this is fully described in Dietzenbacher et al. (2013). In brief, WIOTs are constructed in three steps: construction of time-series of national supply and use tables for each country (using national accounts data and benchmark supply and use tables); disaggregation of imports by country of origin and use category to generate international supply and use tables (using bilateral international trade statistics) and finally the full WIOT integrating all countries and the rest-of-the-world. Time-series consistency is of utmost important for trend analysis and this poses a major problem as national supply and use tables are only available for benchmark years and typically not revised once published.[20] This is particularly relevant as in recent years statistics are produced according to a new system of national accounts (the SNA 2008 as described in ISWGNA, 2009) which cannot be used in conjunction with statistics produced in the old SNA (the SNA1993, described in ISWGNA, 1994).[21] This problem was compounded by the introduction of a new version of the International Standard Industrial Classification of all economic activities (ISIC revision 4) around the same time, as it does not map one-to-one in the previous classification. And on top of that, national statistical institutes combined the introduction of the new SNA with a revision of the underlying data sources such that major breaks in the series arise. We deal with this problem by relying solely on national accounts data generated by NSIs according to the SNA 2008 and following ISIC rev 4.[22] These series are consistent over time as they are derived according to the same set of principles. Benchmark supply- and use tables are adjusted to match these.[23]

The primacy given to consistent National Accounts statistics sets WIOD apart from Eora, another popular database containing WIOTs.[24] Eora provides WIOTs for more countries and longer time periods. But this comes at a cost: in contrast to WIOD there is no strict hierarchy in the basic data sources. Instead, the construction philosophy underlying Eora is more mechanical: the construction of a WIOT starts from an initial situation in which all available basic information is incorporated. Conflicting pieces of information are resolved by attaching measures of reliability and letting an optimising algorithm distribute the differences across all other cells in the matrix. As a consequence, Eora tables will not necessarily adhere to national accounts statistics and an anchoring to official

[20] A positive exception to this is the time-series SUT data provided by the Bureau of Economic Analysis for the U.S. economy.
[21] Changes include adjustment of value added due to capitalization of R&D expenditures and changes in the definitions of exports and imports in the case of processing trade, see discussion in Appendix A.
[22] Most countries do publish this type of data, with, at the time of writing, the exception of China (national accounts constructed according to SNA 93 and ISIC rev 4) and of India, Japan and Russia (SNA 93 and ISIC rev 3).
[23] To be more precise, we take annual data on industry gross output and value added as well as total exports and imports and final demand categories from the latest released national accounts statistics as our starting point.
[24] Available at http://www.worldmrio.com/. See Tukker and Dietzenbacher (ed. 2013) for an extensive overview of existing global input-output databases.

statistics (including time consistency) is lost in the process. Moreover, this process creates a large number of elements in the WIOT that are widely fluctuating between years, which precludes detailed analyses. WIOTs in the WIOD are constructed within the framework of the most recent System of National Accounts and obey its concepts and accounting identities. Conflicting information (such as breaks in series of expenditures, output and value added, or differences in levels of trade according to the national accounts and international trade statistics) is resolved within this framework before an optimization routine is run. This transparency ensures a high level of data quality and maximal over-time consistency.[25]

The robustness of our findings on international production fragmentation (IPF) are tightly linked to the reliability of our up- and backdating methods, in particular of the inter-industry deliveries of goods and services. These are reflected in the intermediate input coefficients matrix **A**. This data is generally not available on an annual basis and instead we have to rely on up- and back-dating of benchmark tables. In general we have for each country data on at least two benchmark years: the most recent one for 2012 (or 2011) and the oldest one for 2008 (or earlier, see Appendix for overview by country). Possible fundamental changes in production structures in years between 2008-12 collapse are therefore likely to be well captured. For updating beyond 2012 and backdating before 2008 we have detailed annual data on international trade as well as annual gross output and intermediate input use by industry and country. Importantly, the data on imports by product and importing country (and supplying country) from bilateral trade statistics is divided into final and intermediate use based on detailed information from the BEC classification and import use tables (in so far available). These annual series basically determine the row and column sum totals of the intermediate input matrix and a RAS procedure will provide the inner elements, starting from the initial structure as given in the benchmark year. Put simply, this approach ensures that intermediate products that become more abundantly available in a country (as can be deduced from overall imports and domestic industry output of that product) are used more in all domestic industries, proportional to their initial use. Annual shifts in the shares of supplying countries from the bilateral trade statistics are subsequently applied. The updated intermediate input matrix will thus incorporate changes in various dimensions. A similar approach is used for backdating, see Temurshoev and Timmer (2012) for full technical details.

In the empirical application in section 4 we will measure final demand by the sum of private and public consumption and investment. World GDP is the sum across GDP of all countries.[26] All

[25] The Eora approach could potentially deliver the same WIOTs as in WIOD as the source data is in principle the same. This would require an explicit chosen set of reliability measures for each data source and series. In WIOD these choices are pre-determined and hence already explicit.

[26] Final demand is the sum of Final consumption expenditure by households (WIOD category CONS_h), Final consumption expenditure by non-profit organisations serving households (CONS_np), Gross fixed capital

elements in WIOT are nominal and expressed in millions of US$. Market exchange rates are used for currency conversion. Transaction values are in basic prices reflecting all costs borne by the producer. Import and export flows are accordingly expressed in "free on board" (fob) prices through estimation of international trade and transport margins.

4. Results

In this section we present main decomposition results in section 4.1. This is followed by a more detailed analysis of international production fragmentation in section 4.2, and of changes in final demand structures in section 4.3. Throughout the paper we will present results for three periods: the period up to the great trade collapse (2000-2008), the period of the global trade crisis and recovery (2008-2011) and the period of stagnation (2011-2014). By comparing 2011-14 with 2000-08 we can analyse the differences in the drivers of global trade, and compare the characteristics of each period.

4.1 Accounting for the import intensity of global final demand

Average annual growth of global imports declined from 11.4 log points during 2000-08 to only 1.4 log points during 2011-14. World GDP growth declined at the same time, but less dramatically such that the growth in global import intensity (GII henceforth) turned negative since 2008.[27] We decomposed GII growth into the two elements according to equation (19): a part accounted for by changes in GVC imports and a part accounted for by changes in world final demand structures. The first accounts for effects of changes in the global import intensities of 2,464 production chains around the world. The last accounts for shifts in demand for the output of each of these chains.[28]

Table 2 shows that both drivers contributed equally strong to growth in GII during 2000-08. Many production chains fragmented internationally and global demand shifted to products that had high import intensities such as durable goods and construction works. These changes started to contribute in particular since 2002 (see Figure 5). After the global trade collapse, GVC trade quickly picked up again. During 2008-11 it contributed positively to GII, albeit at a much lower level. Global demand however shifted to products that had a relatively low import intensity, such as non-durables and services, which contributed strongly negative. In the most recent period fragmentation had stopped

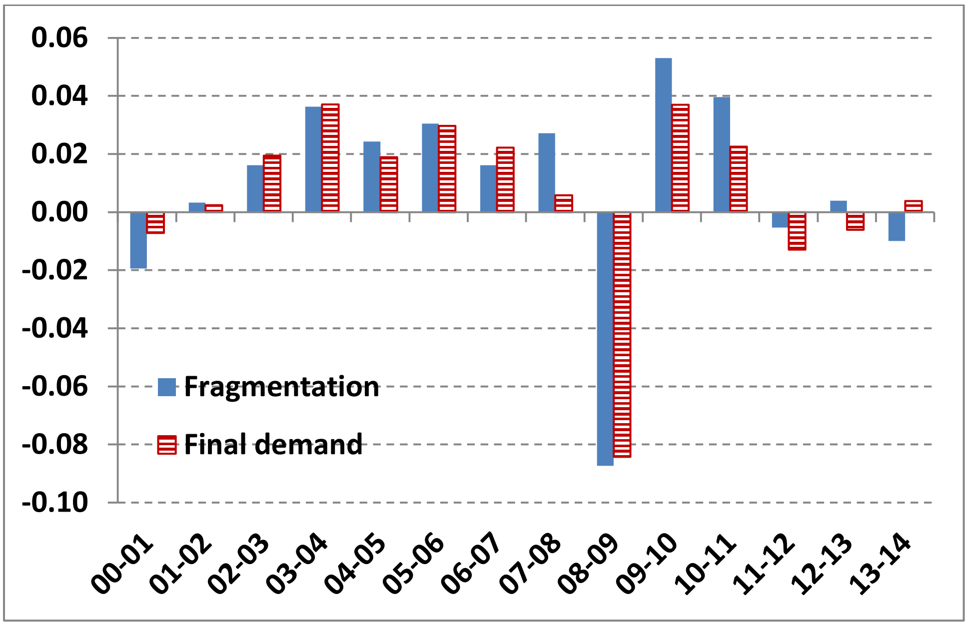
formation (GFCF), Changes in inventories and valuables (INVEN) and Final consumption expenditure by government (CONS_g). See Appendix A on how GDP of a country can be derived in the WIOT.

[27] Global import intensity growth is defined as growth of global imports minus growth of world GDP. When the global import intensity declines (increases) over a period, the import elasticity of world demand is smaller (bigger) than one.

[28] Remember that by definition, GVC trade only concerns trade in intermediates. Changes in trade in final products is picked up by the last term.

and contributions of both drivers turned on average negative. We conclude that changes in GVC trade and in global final demand structures contributed roughly equally to the decline in GII from 2000-08 to 2011-14, each accounting for 2.1 log points.

Figure 5. Decomposition of change in import intensity of global demand



Notes: Annual change (log points) in global import intensity on vertical axis. Decomposed into contribution from change in GVC imports and change in global final demand structure, see Table 2.

One might argue that our finding of trends in global fragmentation of value chains is driven mainly by trade in natural resources, such as crude oil, natural gas and mineral ores. These resources have been in high demand in the 2000s and at the same time underwent strong prices trends, with for example oil prices peaking in 2008 (from 28 US$ per barrel in 2000 to 94$ in 2008) and again in 2012 (109$, falling to 96$ in 2014). Given limited substitution possibilities, the swings in relative prices of mineral resources will be reflected in nominal trade figures. All our data is expressed in nominal US dollars and indeed, the share of natural resources in global imports trends in the same way, peaking at 13.4% in 2012 (see Appendix Table 1). It is therefore insightful to redo the analysis, but leaving out trade in products from the mining industry (WIOD Sector 4) and petroleum refining (WIOD sector 10).[29] As shown in Table 3, this dampens the decline in GII over the 2000-2014 period, but clearly does not change the overall trend. As expected the decline in GVC trade is less prominent as well, and now accounts for about one-third of the decline in GII.

[29] An alternative exercise would be to perform the decomposition on constant-price input-output tables with specific deflators for each product flow. This data is only available for a limited set of countries.

Table 2. Decomposition of change in import intensity of global demand

	00-08	08-11	11-14		(11-14) minus (00-08)
Annual growth of global imports (1)	11.4	3.8	1.4		-9.9
Annual growth of world GDP (2)	8.1	4.5	2.3		-5.8
Growth in global import intensity (3)	3.3	-0.7	-0.9		-4.2
due to fragmentation (4)	1.7	0.2	-0.4		-2.1
due to change in final demand (5)	1.6	-0.8	-0.5		-2.1

Note: Change in global import intensity decomposed into contribution from change in GVC trade and change in FD structure according to equation (19). Annual log-points times 100, period averages. Row (3) is equal to sum of rows (1) and (2) and to sum of rows (4) and (5). Numbers may not add due to rounding.

Table 3. Decomposition of change in import intensity of global demand, excluding trade in mineral resources.

	00-08	08-11	11-14		(11-14) minus (00-08)
Annual growth of global imports (1)	10.7	3.6	1.8		-8.9
Annual growth of world GDP (2)	8.1	4.5	2.3		-5.8
Growth in global import intensity (3)	2.6	-0.9	-0.5		-3.1
due to fragmentation (4)	1.0	0.1	0.0		-1.0
due to change in final demand (5)	1.6	-1.0	-0.5		-2.1

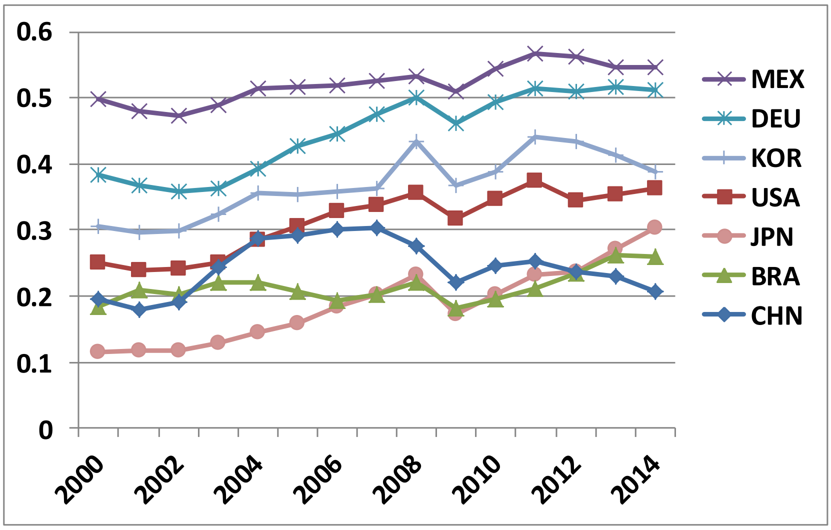
Note: as Table 2, but excluding trade in products from the mining industry (WIOD Sector 4) and petroleum refining (WIOD sector 10).

4.2 Trends in international production fragmentation

In this section we provide further details on the process of international production fragmentation that took off in the early 2000s. We present new evidence on the global import intensities (GIIs) of production of 2,464 final goods and services in the world economy. This is based on the novel indicator introduced in section 2 which measures imports by the country that is finalising the product (that is, doing the final stage of production) as well as any imports by other countries that are involved in earlier stages of the production process. By way of example, we provide the GII related to the production of final motor vehicles ("cars"). Figure 6 shows the dollar amount of imports related to the production of one dollar worth of a car, as defined in equation (9). Import intensity in GVCs of cars finalised in Mexico and Germany is much higher than for cars finalised in Japan, Brazil or China.

Fragmentation processes were strong in car manufacturing in the 2000s, irrespective of the country where the final stage of production took place. We show below that international fragmentation is common across many production processes. This stalled during the crisis and afterwards patterns vary. Notable is the *de*fragmentation trend of cars finalised in China as more and more intermediates are produced within China itself. We return to this in section 4.3.

Figure 6. Global import intensity of car manufacturing



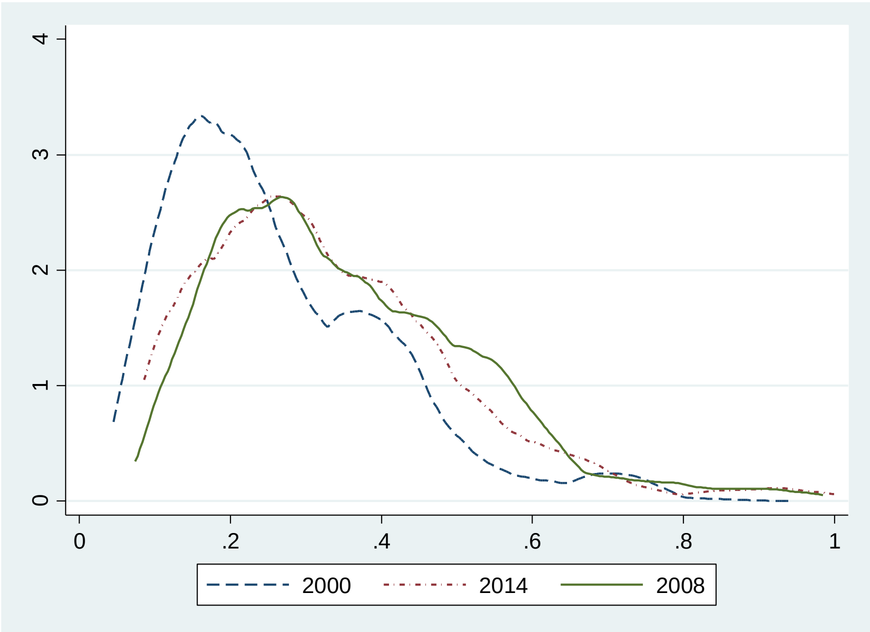
Notes: Imports needed in all stages of production of final output from WIOD industry 20 (Manufacture of motor vehicles, trailers and semi-trailers). Imports in $ per $ final output. Countries refer to the location of final stage of production (Mexico, Germany, South Korea, USA, Japan, Brazil and China).

Fragmentation of goods production

In Figure 7 we provide a kernel density plot of GIIs for 836 GVCs of goods for which we have data, namely final output from 19 manufacturing industries in 44 countries-of-finalisation. Densities are shown for the years 2000, 2008 and 2014 and observations are weighted by nominal final output values. Between 2000-2008 there was a clear fragmentation trend across the board. The GII increased in 740 out of the 836 GVCs, with an average increase of 0.089 (from 0.265 to 0.354). However, between 2008 and 2014, GII declined in 265 GVCs, and in particular in the ones with a high output value. On average GII declined by 0.020 (from 0.354 to 0.334).

As Figure 7 shows there is a wide variety in GIIs of goods production. This is partly related to the fact that production processes of some goods are 'easier' to fragment than others. For example, GIIs of food products are typically the lowest (on average 0.21) while motor vehicles, computers, refined oil and basic metals have GIIs above 0.40 (see Appendix Table 2a). Moreover, it is clear that products that are finalised in smaller countries typically have a higher GII than those finalised in bigger countries. This is because the latter have a higher variety of intermediates that can be sourced domestically. Therefore, to have a proper insight into possible trends in international production fragmentation one needs to control for these structural differences in GIIs across countries and product groups. We regress our panel dataset of GIIs on dummies for country-industry of finalisation pairs and dummies for years to isolate year-specific effects. These effects give us insights into shared trends. The total sample consists of 11,889 observations, which have been weighted by the value chains' final output values.[30] Figure 8 shows the estimated coefficients for the year dummies and the associated 95 percent confidence intervals. The dummy for 2000 has been omitted, so all point estimates have to be viewed as relative to 2000. The figure clearly reflects the across-the-board increase in GIIs. The year dummies were found to be statistically larger than zero at a 5% level of significance from 2004 onwards. The steady increases in international fragmentation continued until the onset of the crisis in 2008. The crisis induced a major dip, but this appeared to be a short-run effect as GIIs rebounded and in 2011 were higher than in 2008. The last years however see a steady decline with the level in 2014 not significantly different from the level in 2008.

Figure 7 . Global import intensity of goods production



Notes: kernel density (Epanechnikov) of global import intensities of production of 836 final manufacturing goods. Observations are weighted by nominal final output values.

Given the importance of trade in minerals, as argued before, we redo the analysis excluding imporst of mining and refined oil products. Figure 9 shows that the GII levels are now much lower in levels. But a similar trend is found however with a peak in 2008, followed by crisis and rebound by 2011. In

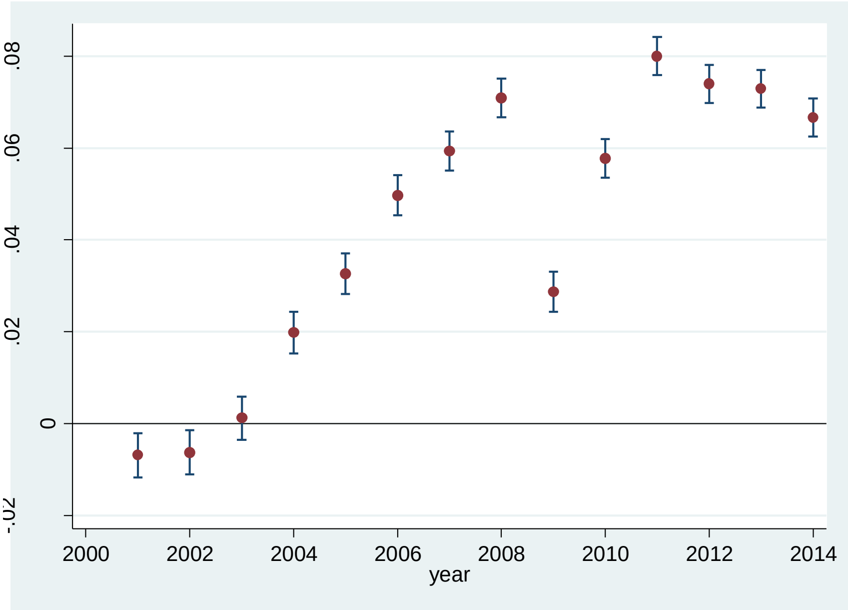
[30] We have data for 836 value chains of goods for 1995-2014. 651 observations have zero final output, or even negative output, which is possible when changes in inventories are negative. These are not taken into account.

contrast to Figure 8, in the period 2012-2014 there is no significant trend anymore and GIIs are basically constant.

Fragmentation of services production

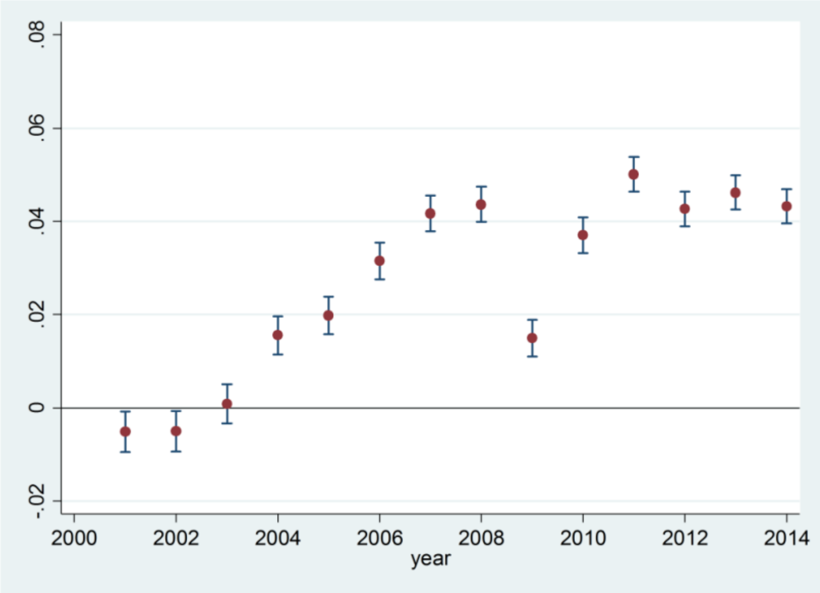
For the first time we are also able to analyse international fragmentation in the production of services. This is made possible by the increased detail in services industries in the 2016 release of the WIOD. This is important, as goods constitute only 20 per cent of world final output. As for goods, the GII for a service production will measure imports of goods and services needed in any stage of the production of the final service. Results are given in Appendix Table 2b. As expected, on average international fragmentation is rather low: public services, educational services, recreational and personal services are generally locally produced. But for many services it is clearly not negligible. For example production of construction works has a rather high GII that is comparable to some manufacturing industries. This is related to the import of building materials and imports associated with their production. Perhaps surprisingly health services also require a fair amount of imports, for example through the use of pharmaceuticals. We perform a similar regression analysis as for goods and find an upward trend in GIIs across the board in the early 2000s, but much weaker than for goods (rise in GII of less than 0.03, see Figure 10). In recent years fragmentation in services seems also to halt.

Figure 8. Trend in international fragmentation of goods production



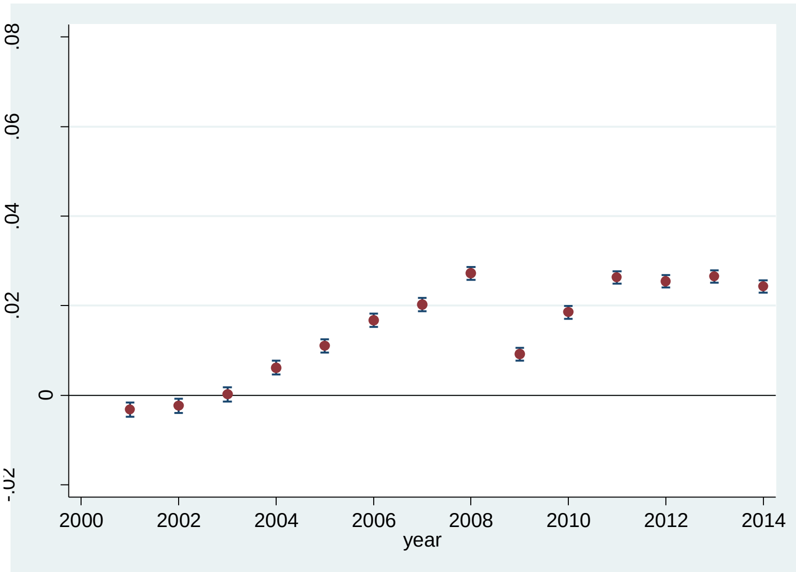
Notes: Regression of global import intensities of GVCs on dummies for country-industry of finalisation and years. The figure provides estimated coefficients and 95 percent confidence intervals for the year dummies, relative to 2000. The observations (11,889) are weighted by final output.

Figure 9. Trend in international fragmentation of goods production, excluding trade in mineral resources.



Note: as Figure 8, but excluding trade in products from the mining industry (WIOD Sector 4) and petroleum refining (WIOD sector 10).

Figure 10. Trend in international fragmentation of services production



Notes: Regression of global import intensities of GVCs on dummies for country-industry of finalisation and years. The figure provides estimated coefficients and 95 percent confidence intervals for the year dummies, relative to 2000. The observations (22,385) are weighted by final output.

4.3 Global import intensity of countries' final demand

The stalling of international production fragmentation can account for the major part of the global trade slowdown in recent years. But Table 2 also showed a comparable strong effect of changes in final demand (FD) structures. While changes in FD structures contributed 1.6 log points to the increase of global import intensity during 2000-2008, they contributed negatively (-0.5 log points) in the period 2011-2014. In this section we delve deeper into the question which countries are 'responsible' for this decline.

Clearly, the country share distribution of world GDP has changed dramatically over this period with the rise of China and other emerging economies, and the relative decline of Europe in the aftermath of the global financial crisis. Countries differ in their import intensity of final demand. These differences may arise because of for example differences in country size (smaller countries have typically less variety in the supply of domestic products and import more intermediates) or differences in per capita GDP (richer countries tend to spend a larger share of GDP on services which are generally less trade intensive). Big advanced countries like Japan and the U.S. have indeed by far the lowest global import intensities around the world. On the other hand final demand in smaller countries, in Europe as well as in other regions of the world, is generally more import-intensive. To measure the impact of final demand shifts we decompose it into the effects of changes in countries' share in world GDP and other FD structure changes, using equations (23). The decomposition results are given in Table 4 and Table 5 reports on the contribution of individual countries.

The contribution of a country can be positive because its share in global final demand is increasing (decreasing) and its import intensity is above (below) average.[31] Note that by construction of the decomposition, the contributions summed across countries (as given in the last row in Table 5) are equal to the overall contribution given in row 3 in Table 4. We find that in the period 2000-2008 final demand shifted away from Japan and the US towards many smaller countries that had higher import intensities (see Table 5). The overall net effect accounted for an increase in import intensity at the global level of 1.4 log points, almost as important as the rise in GVC trade (see Table 4). In the latest period this positive contribution no longer existed. The US share in global final demand increased again and in a reverse process, this now dragged down the import intensity at the global level.

[31] Remember that the global import intensity of a country A does not only measure imports by A itself but also imports by all other countries that were needed in the production for final demand of A.

Table 4. Alternative decomposition of change in import intensity of global demand

	00-08	08-11	11-14		(11-14) minus (00-08)
Change in global import intensity	3.3	-0.7	-0.9		-4.2
due to change in fragmentation	1.7	0.2	-0.4		-2.1
due to change in countries' share in world GDP	1.4	-0.2	0.2		-1.2
due to other changes in final demand	0.2	-0.7	-0.7		-0.9

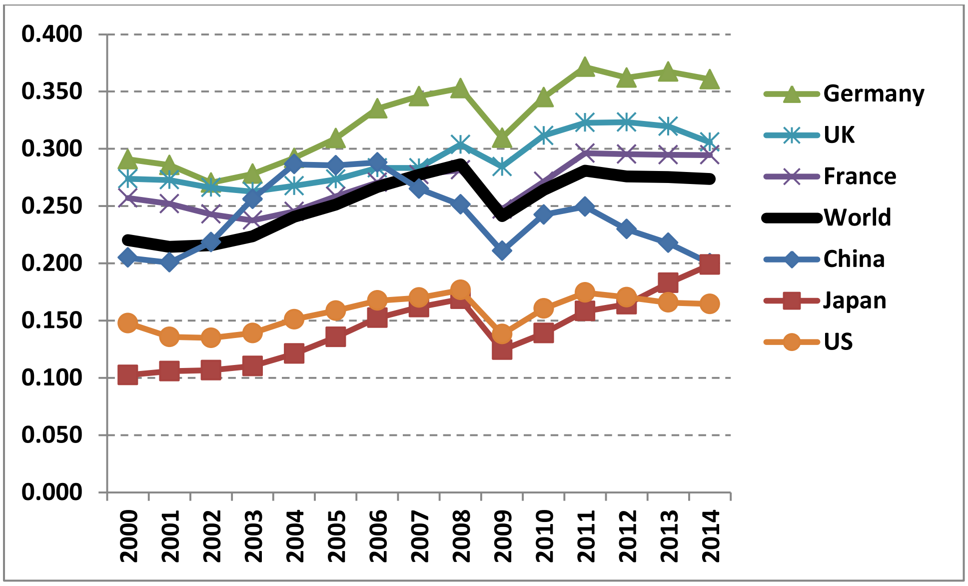
Note: Change in global import intensity decomposed into contribution from change in GVC trade and change in FD structure as in Table 2, with further decomposition of final demand according to equations (23). Annual log-points times 100, period averages.

Table 5. Contribution to change in global import intensity by change in countries' shares in global final demand.

	00-08	08-11	11-14
USA	0.495	0.361	-0.140
Rest of world region	0.259	0.182	0.210
China	-0.003	-0.105	-0.189
Japan	0.543	-0.106	0.337
Germany	-0.007	-0.049	-0.023
UK	0.008	-0.033	0.012
France	0.008	-0.001	-0.005
Brazil	-0.062	-0.183	0.078
India	-0.013	-0.029	0.000
Italy	0.007	0.008	0.006
Canada	0.007	0.004	-0.006
Russia	0.020	0.004	0.000
Australia	0.000	-0.016	0.010
Spain	0.021	0.007	0.005
South Korea	-0.001	0.001	0.006
Mexico	0.005	0.008	0.000
Indonesia	0.006	-0.007	0.001
Turkey	0.002	0.000	-0.004
Netherlands	0.011	-0.034	-0.016
Switzerland	0.001	0.009	-0.006
24 other countries	0.108	-0.181	-0.068
World (total)	1.415	-0.158	0.207

Notes: See Table 4. Country contributions have been calculated according to equations (23) using country-specific import intensities relative to the world average. Period averages are given. Countries are ordered by final output in 2014.

Figure 11. Global import intensity of final demand by country



Notes: Calculated according to equation (23)

Perhaps surprisingly is that the contribution of China in this period is also negative. China's share in global demand is growing fast, but the import intensity of her final demand is well below the world average. As shown in Figure 11, GII of Chinese final demand was briefly above world average in the early 2000s, but since then it trended downward. In 2014 it was at the level of Japan and close to the US. This is because Chinese final demand is increasingly shifting to services, but also because it requires fewer imports as more and more products are domestically produced. The share of final demand supplied by domestic industries was 88.4% in 2000, dropping to a minimum of 79.9% in 2006.[32] Since then it increased up to 82.5% in 2008 and further to 88.5% in 2014. At the same time the share of services in final demand increased steadily from 56.3% in 200, to 58.2% in 2008 and further to 63.4% in 2014 (calculations on WIOD release 2016).

Table 5 shows also that the fall in European shares of global final demand contributed as well to the decline in world GII in the last period compared to the first. But this effect was relatively minor. European countries typically have high import intensities but the decline in global demand was not big enough to have a sizeable impact on the slowdown of import intensity at the global level.

[32] It should be remembered that we analyse the import intensity of final domestic demand which excludes imports for exporting.

5. Concluding remarks

The slowdown in global trade growth since 2011 is widely documented and discussed. We present for the first time a consistent framework that allows for comparing the empirical importance of the various hypotheses. A key novel concept in this approach is the *global import intensity* (GII) of production. This measures the imports needed in any stage of production. It includes imports by the country where the final stage takes place as well as imports by any other country at earlier stages. We have updated the WIOD to investigate trends in the period 2000-2014. We find that international production fragmentation (and associated intermediate imports) contributed strongly to the rise in the GII. This was augmented by a shift in global demand towards goods and services whose production processes are highly fragmented such as consumer durables and investment products. Both contributed equally to the increase in the GII during 2000-2008. However, the process of fragmentation has stalled since 2011. In addition, global demand shifted towards services for which production processes are much less trade intensive. Both forces drove down the GII during 2011-2014.

We also found that growing Chinese demand did not have a major impact on GII of world GDP. This is because the import intensity of Chinese demand was barely above the world average in the early 2000s. Furthermore, it has been on the decline ever since, as demand shifted towards services. In addition, Chinese demand shifted to products finalised at home which in general have lower import intensities than final products purchased from elsewhere

Are the import intensity levels of the 2010s the new normal? International fragmentation has stalled, and it is unclear whether it will be restarted. The decline has multiple causes. It might be related to increasing capabilities in countries in producing upstream products for domestic use (see e.g. Kee and Tang 2016 for evidence on this for China). It might also be a reflection of increasing protection as argued by Evenett and Fritz (2015). The model by Baldwin and Venables (2013) suggest that interactions between comparative advantage and co-location forces produced a systematic tendency for overshooting. 'Reshoring' to advanced countries might be a logical consequence. More generally, activities might return to advanced economies as automation of labor-intensive tasks tilts comparative advantage once again. On the other hand, Baldwin (2016) argues that much potential for further fragmentation is still unused, in particular in services. And Los, Timmer and de Vries (2015) showed that most of the value added of goods is still produced domestically. Lastly, current world demand for trade intensive products like machinery and consumer durables is still depressed, but this might be temporary. But even with a possible rebound of the world economy, trade growth is expected to be slow. As the Chinese economy continues to mature its import intensity of domestic demand will fall. From this perspective, the current slowdown in global trade should not be a major concern.

As a final comment: we do not claim that this exercise delivers a causal analysis of the drivers of global trade. We view our ex-post accounting approach as a useful organisation of the empirical facts that need to be explained. In particular, it can be informative for the parametrization of trade prediction models. Our findings on international production fragmentation highlight the importance of including *endogenous* development of global supply chain structures in such models.

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Appendix table 1. Global imports, 2000-2014

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Shares in global imports (%) of:															
Final goods	40.3	40.9	40.9	40.3	39.5	38.7	38.1	37.7	36.2	37.4	36.6	35.5	35.3	34.9	35.4
Intermediate products (natural resources)	7.6	7.0	7.0	7.4	8.2	10.3	10.9	10.5	12.5	10.4	11.4	13.0	13.4	12.6	11.9
Intermediate products (other)	52.2	52.0	52.2	52.3	52.3	51.0	50.9	51.9	51.3	52.2	52.1	51.5	51.3	52.5	52.7
Total global imports (billion US$)	7,118	6,893	7,219	8,391	10,166	11,504	13,238	15,512	17,651	14,040	16,761	19,795	19,834	20,300	20,649
Global final demand (billion US$)	32,303	32,126	33,452	37,520	42,243	45,786	49,608	55,938	61,588	58,162	63,462	70,436	71,874	73,719	75,447
Global import intensity (%)	22.0	21.5	21.6	22.4	24.1	25.1	26.7	27.7	28.7	24.1	26.4	28.1	27.6	27.5	27.4

Note: Values in current prices. Natural resources are defined as products produced by the Mining industry (WIOD industry 4) and the Petroleum refining (industry 10). Import intensity is defined as global imports over global final demand.

Appendix table 2a. Global import intensity of production of final manufacturing goods

			Global import intensity (%)			Share in global final output (%)		
WIOD	**ISIC**	**Name**	**2000**	**2008**	**2014**	**2000**	**2008**	**2014**
5	C10-C12	food products	16.4	22.6	21.3	4.89	4.83	4.92
20	C29	motor vehicles,	32.4	43.2	41.4	2.91	2.69	2.99
19	C28	machinery n.e.c.	25.4	36.1	34.0	2.06	2.25	2.06
17	C26	computers	36.1	48.7	43.9	2.40	1.82	1.62
6	C13-C15	textiles	27.7	31.3	27.8	1.81	1.56	1.61
10	C19	refined petroleum	45.0	53.7	50.4	0.83	1.29	1.16
21	C30	other transport	29.8	37.5	37.0	0.74	0.86	1.03
18	C27	electrical equipment	28.3	39.4	37.6	0.94	0.96	0.93
22	C31_C32	furniture	22.1	28.6	28.3	1.23	1.03	0.84
11	C20	chemicals	25.5	37.2	36.1	0.79	0.82	0.76
12	C21	pharmaceuticals	22.1	30.3	32.1	0.53	0.58	0.53
16	C25	fabricated metal products,	23.9	36.9	34.4	0.60	0.58	0.51
13	C22	rubber and plastic products	29.1	41.4	39.5	0.32	0.29	0.26
15	C24	basic metals	31.4	41.2	40.6	0.14	0.26	0.21
23	C33	repair and installation	25.5	31.5	30.2	0.19	0.20	0.15
8	C17	paper and paper products	26.6	33.3	33.4	0.19	0.17	0.14
14	C23	other mineral products	23.0	29.6	29.3	0.19	0.16	0.14
7	C16	products of wood	24.5	29.0	27.8	0.13	0.10	0.10
9	C18	printed products	20.5	27.9	28.4	0.11	0.08	0.07

Note: Products ranked on share in global final output intensity in 2014.

Appendix table 2b. Global import intensity of production of final non-manufacturing products

			Global import intensity (%)			Share in global final output (%)		
WIOD	**ISIC**	**Name**	**2000**	**2008**	**2014**	**2000**	**2008**	**2014**
27	F	Construction works	17.8	25.5	24.7	10.44	12.03	12.73
51	O84	Public admin services	7.6	10.5	10.0	11.42	11.25	10.65
44	L68	Real estate services	3.2	4.2	4.1	9.15	8.64	8.67
53	Q	Health services	7.9	11.2	12.1	7.37	7.73	8.13
30	G47	Retail trade services	5.9	8.6	8.8	5.33	4.65	4.72
52	P85	Education services	6.2	8.5	8.9	3.84	4.10	4.51
29	G46	Wholesale trade services	8.7	11.7	11.1	4.38	4.54	4.33
36	I	Accommodation services	9.7	13.4	13.3	3.82	3.59	3.53
54	R_S	Other services	9.5	12.4	13.1	3.33	3.03	3.03
1	A01	Products of agriculture	11.7	15.0	13.3	2.09	2.21	2.30

Note: Top-10 non-manufacturing products in terms of global final output shares.

Appendices

Appendix A. Main methodological changes in the WIOD 2016 release compared to 2013 release

Appendix B Country sources underlying WIOT, 2016 release

Appendix A. Main methodological changes in the WIOD 2016 release

The WIOTs are built up from published and publicly available statistics from national statistical institutes around the world, plus various international statistical sources such as OECD and UN National Accounts. The 2016 WIOD is an update of the 2013 WIOD, containing the same type of data and tables and constructed according to the same methodology. However, various extensions and improvements have been integrated which will be shortly summarized in this section.

A1 Coverage

Compared to the previous version the new WIOD includes three more countries: Norway, Switzerland and Croatia. The list of the 43 countries (plus estimated rest of world) included is therefore:

- EU-28 Member States: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czechia, Germany, Denmark, Spain, Estonia, Finland, France, Greece, Hungary, Ireland, Italy, Lithuania, Luxembourg, Latvia, Malta, Netherlands, Poland, Portugal, Romania, Sweden, Slovakia, Slovenia and United Kingdom
- Australia, Brazil, Canada, China, Norway, India, Indonesia, Japan, Korea, Mexico, Russia, Switzerland, Taiwan, Turkey, USA;
- Rest-of-World (estimated)

The new version of the WIOD is structured according to the recent industry and product classification, i.e. ISIC Rev. 4 (or equivalently NACE Rev. 2). Though not all details are available for all countries it has been decided to nonetheless aim at a rather detailed industry and commodity structure which in some cases is based on additional industry-level data sources.

- The underlying supply and use tables (SUTs) cover 56 industries (see Appendix Table A1 for details). It needs however to be noted, that – due to the new SNA methodology and (sometimes major) revisions in National Accounts series and lack of one-to-one correspondence between the old and new industry classifications – cannot be simply linked together.
- The commodity dimension is according to the CPA2008 classification and covers 56 commodities which correspond to the primary products of the 56 industries listed in Appendix Table A1

A2 Improvements in the WIOD 2016

In general the construction of the WIOD 2016 follows the same methodology as the 2013 release, as described broadly in Timmer et al. (2015) and in more technical detail in Dietzenbacher et al. (2013). Two improvements have been enacted, making better use of data that has become available in recent years. First, we improved the bilateral shares estimation in trade, in particular of services trade. And second, we improved the estimation of basic price tables, using for the first time information on margins and taxes on exports

Bilateral trade shares

Whereas the previous WIOD solely relied on import data, in this version some steps have been undertaken to reconcile import flows with mirrored export flows which requires the estimation of bilateral cif/fob margins. These have been estimated similar to the approach followed in Streicher and Stehrer (2015); reconciliation procedures broadly follow the approach suggested in Fortanier et al. (2015). In addition, for initial estimates of bilateral shares by use category also information from import use tables was used when available. It should be emphasised that the bilateral product-specific cif/fob ratios are used as an initial input which are then adjusted in the course of benchmarking the trade data to the information provided in the supply (import cif) and use (export fob) data.

Trade in services data are calculated quite differently from the previous WIOD. For trade in services data the latest data available from the UN trade in services database according to BPM5 method are collected. (BPM6 data are only available for a few countries so far.) To provide a harmonized and consistent data set for bilateral services trade flows by categories a “top-down” approach is used (akin to Fortanier and Maurer, 2015). First, data for each country reporting exports to and imports from world are interpolated in case of missing years for total services trade (BoP code 200). Second, for bilateral values the mirror values are constructed and missing data are replaced by these. In those cases for which two values are reported the maximum value of these two is taken and interpolated in case of missing values. Third, as the total value of exports (of all countries to world) does not fit the value of imports (of all countries from the world), the level of imports is adjusted proportionally across countries. This provides the RAS marginal totals. Fourth, a category of ‘unallocated’ trade has been calculated (i.e. the difference between the sum over bilateral flows and flows to world) which is about 20 percent on average over the whole period (both for exports and imports). In a fifth step this is distributed using a gravity model, estimated on GDP and population of reporters and partners as explanatory variables and including country-pair fixed effects. The ‘predicted’ values are imputed in the bilateral trade matrix. Finally, this matrix is then reconciled with the marginal totals using RAS procedure. An analogous procedure is applied for each of the eleven subcategories as reported in the Appendix Table A3. The resulting bilateral trade flows at the disaggregated level are then used to split the total bilateral flows using the correspondence table to CPA provided in the Appendix table A3.

Tables at basic prices

One of the novel features of the new release of the WIOT is the availability of basic price tables for major European countries in recent releases. These tables are therefore now derived from publicly available basic price SUTs, whereas in the previous release they were estimated based on peeling off estimated margins and (net) trade and transport matrices from a table in purchasers’ prices.

Most input-output analyses require tables at basic prices, that is, goods are valued at the “ex factory” gate price: they do not include any trade and transport margin, nor taxes on the products (net of subsidies). In this way, the intermediate input coefficients in the columns of use table reflect best the technology of an industry. In that case the final demand columns indicate the consumption and investment of the goods, again reflecting their value of production, excluding the margins and (net) trade. For some purposes it can be interesting to also have information on the margins and (net) tax rates. This information is contained in so-called valuation matrices. Ideally, one would like to have tables at basic and purchasers' prices, as well as the valuation matrices.

At the time when the WIOT for the 2013 release was constructed, there were basically two types of data situations across countries. Some countries only published tables at basic prices (bp, or more precisely producer prices, as in China, Japan and US), whereas other countries only published SUTs at purchasers' prices (pp, like most EU countries). Therefore we had to strike a compromise in the construction of the WIOT, and decided to focus on constructing a basic price version as the most desirable. Consequently, we had to estimate valuation matrices for the EU countries and subtract these from the tables in purchasers' prices to arrive at tables in basic prices. Source data to estimate these was limited however, and basically restricted to one margin rate per product from benchmark tables. This rate was applied to all use categories, except exports where the rate was set to 0. This approach is defensible given that most of the margins (such as retail margins) and taxes (excise) fall on domestic use. Export margins would mainly be domestic trade and transport margins from plant to border, and possible export (net) taxes. Valuation matrices were subsequently constructed using SUT-RAS based on annual trends in total margins and total net taxes from the National Accounts (see Temurshoev and Timmer, 2011).

In recent years, most EU countries have started to produce SUTs at both purchasers' and basic prices, such that we are able to improve this procedure. Appendix A1 provides information for which countries this information has been used. The published tables in basic prices revealed that margin rates vary substantially across domestic use categories, and that exports have generally lower margins than domestic use, but still can be sizeable, and certainly are not zero. In case a table in basic prices was available we therefore changed the estimation technique, and used directly this table in basic prices as the initial guess in the SUT-RAS without needing to estimate valuation matrices. This clearly improves the quality of the constructed national SUT series at basic prices underlying the construction of international SUTs and WIOTs.

With non-zero margins on exports, we had to adjust our estimation of the international SUTs. This is because in the international bilateral trade data exports are valued free on board (fob), hence including domestic margins by the exporting country. We therefore added to the national SUTs at basic prices a new column indicating "Exports at fob" in which the entries for goods are valued at purchasers' prices, and the entries for margin products exclude margins on exported goods.[33] This information is readily available for benchmark years in the tables in purchasers' prices. For other years, we used margin rates from the nearest benchmark table to construct time series of exports in fob. When constructing the international SUTs bilateral trade shares were applied to these time series.

In the construction of the WIOT from the international SUTs a final adjustment had to be made, to transform the bilateral exports back again from fob to a basic price basis. We assumed that export margin rates are independent of the importing country, and of the product's use. (Note that this is a reasonable assumption as it concerns the margins in the exporting country. International transport margins do differ by trading country in the WIOT, see Stehrer and Streicher, 2015). The export margin rates by product (positive for goods, negative for margin products) were constructed for the national SUTs already, and applied to the exports in each row of the WIOT. This procedure ensured a WIOT at basic prices, as desired.

A3 Challenges posed by new SNA 2008 for trade in value added research

It is important to note that in the new SNA there are some major changes in the recording of trade statistics. There is a major conceptual change under item "Goods sent abroad for processing" which – in a nutshell – means that the value of goods sent abroad for processing does no longer impact on gross exports and imports because SNA2008/ESA2010 uses a change in ownership approach and is no longer based on physical movements, but on ownership principle. SNA2008/ESA2010 therefore just records the value added of the export processing service. A similar conceptual change is made in the Balance-of-Payments accounts (with their corresponding change from BPM5 to BPM6).

This has several important consequences: (i) The first consequence is of a more general nature and impacts the overall assessment of measuring "value chains". A product which is sent abroad for processing (but remains the owner of this product) is no longer recorded as exports (and consequently imports) in SNA2008/ESA2010. The net processing service is the fee charged for the processing service, i.e. recorded in the national accounts as an export of manufacturing services for the country of the processor and an import of manufacturing services for the owner of the goods. This will reduce the level of exports and imports, but will not affect the overall current account balance. It further does not change the value added figures though changes gross output and trade figures, at least in concept. (For details see Eurostat 2014a). However, it will impact trade in value added measures as value added/gross output ratios will change, although as yet is it unclear whether there will be a systematic bias (see van Rossum et al., 2014, for a case study of the Netherlands). Another problem is the

[33] Note, total exports at basic prices are equal to total exports at purchasers' prices by definition. They differ only in product shares with higher goods values, and lower margin product values, in the table at purchasers' prices compared to the basic price table entries.

differences in implementation of these international guidelines: the way individual countries compute this differs widely, in particular outside the EU (see e.g. United Nations, 2013). Also, it does not only impact goods, but also trade in services such as management services and wholesaling.

This causes an inconsistency with the international goods trade statistics which will continue to show the gross value of the exports for processing and returning imported processed goods, as it is based on the physical movement of goods, rather than the economic ownership of the goods (see UN/ESA 2011). Though it is recommended that these items are included as supplementary items in the National Accounts Statistics, namely in the external goods and services account, it has to be seen whether such information becomes actually available. As yet, it is not being collected by any international organisation in a systematic way. As the construction of WIOTs requires bilateral trade information it is assumed that bilateral trade shares (calculated from the trade in goods and services data) are also valid for the processed exports. This proportionality is to be doubted (e.g. Germany is likely to have a higher share of processing trade with Czech Republic than with say France), but a solution must await further data information.

A4 How to derive GDP from the WIOT

An important characteristic of the WIOTs is that they obey the national accounting identities. In particular, GDP as calculated from the expenditure side should be equal to GDP calculated from the production side. Below we indicate how one derive GDP of a country in a WIOT and how one can verify the accounting identity to hold.

GDP from expenditure side

The expenditure approach measures GPD by aggregating over all expenditure categories and the trade balance:

$$GDP_{EXP} = C + I + G + (EXP - IMP)$$

Where

- C is private consumption. In the WIOT this is Final consumption expenditure by households (CONS_h) plus Final consumption expenditure by non-profit organisations serving households (CONS_np).
- I is Investment, or gross capital formation: in the WIOT this is Gross fixed capital formation (GFCF) plus Changes in inventories and valuables (INVEN)
- G is Government consumption, in the WIOT this is Final consumption expenditure by government (CONS_g)

- For these columns include the values on all adjustment rows for the columns in the WIOT (*taxes less subsidies on products, Cif/ fob adjustments on exports, Direct purchases abroad by residents, Purchases on the domestic territory by non-residents*)
- EXP is total Exports, including the negative of the value for *Purchases on the domestic territory by non-residents*
- IMP is total Imports, including the total of the *International Transport Margins* for the country and the value for *Direct purchases abroad by residents*

GDP from production side

In the production approach GDP is given by:

$$GDP_{INC} = VA + TXSP$$

Where

- VA is the total of *Value Added* for the country (summed across all industries) and
- $TXSP$ is the total of *taxes less subsidies on products* for both Intermediate Use and Final Demand columns. NB It is important to note that for some countries for which there are (net) taxes on exports, these need to be added as well. Net taxes on exports are not givne in the WIOT, but can be found in the International SUT for the country.

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Appendix Table A1 – Industries in WIOD release 2016 (according to ISIC Rev. 4)

Nr.	**Industries**	
1	A01	Crop and animal production, hunting and related service activities
2	A02	Forestry and logging
3	A03	Fishing and aquaculture
4	B	Mining and quarrying
5	C10-C12	Manufacture of food products, beverages and tobacco products
6	C13-C15	Manufacture of textiles, wearing apparel and leather products
7	C16	Manufacture of wood and of products of wood and cork, except furniture; etc.
8	C17	Manufacture of paper and paper products
9	C18	Printing and reproduction of recorded media
10	C19	Manufacture of coke and refined petroleum products
11	C20	Manufacture of chemicals and chemical products
12	C21	Manufacture of basic pharmaceutical products and pharmaceutical preparations
13	C22	Manufacture of rubber and plastic products
14	C23	Manufacture of other non-metallic mineral products
15	C24	Manufacture of basic metals
16	C25	Manufacture of fabricated metal products, except machinery and equipment
17	C26	Manufacture of computer, electronic and optical products
18	C27	Manufacture of electrical equipment
19	C28	Manufacture of machinery and equipment n.e.c.
20	C29	Manufacture of motor vehicles, trailers and semi-trailers
21	C30	Manufacture of other transport equipment
22	C31_C32	Manufacture of furniture; other manufacturing
23	C33	Repair and installation of machinery and equipment
24	D	Electricity, gas, steam and air conditioning supply
25	E36	Water collection, treatment and supply
26	E37-E39	Sewerage; waste collection, treatment and disposal activities; materials recovery; etc.
27	F	Construction
28	G45	Wholesale and retail trade and repair of motor vehicles and motorcycles
29	G46	Wholesale trade, except of motor vehicles and motorcycles
30	G47	Retail trade, except of motor vehicles and motorcycles
31	H49	Land transport and transport via pipelines
32	H50	Water transport
33	H51	Air transport
34	H52	Warehousing and support activities for transportation
35	H53	Postal and courier activities
36	I	Accommodation and food service activities
37	J58	Publishing activities
38	J59_J60	Motion picture, video and television programme production, sound recording and music publishing activities; etc.
39	J61	Telecommunications
40	J62_J63	Computer programming, consultancy and related activities; information service activities
41	K64	Financial service activities, except insurance and pension funding
42	K65	Insurance, reinsurance and pension funding, except compulsory social security
43	K66	Activities auxiliary to financial services and insurance activities
44	L	Real estate activities
45	M69_M70	Legal and accounting activities; activities of head offices; management consultancy activities
46	M71	Architectural and engineering activities; technical testing and analysis
47	M72	Scientific research and development
48	M73	Advertising and market research
49	M74_M75	Other professional, scientific and technical activities; veterinary activities
50	N	Rental and leasing activities, Employment activities, Travel services, security and services to buildings
51	O	Public administration and defence; compulsory social security
52	P	Education
53	Q	Human health and social work activities
54	R-S	Creative, Arts, Sports, Recreation and entertainment activities and all other personal service activities
55	T	Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use
56	U	Activities of extra-territorial organisations and bodies

Appendix Table A2 - Benchmark supply and use tables used in WIOD release 2016

ISO	Country	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
AUS	Australia			X					X		
AUT	Austria				X	X	X	X	X		
BEL	Belgium				X	X	x				
BGR	Bulgaria				X	X	X	X			
BRA	Brazil						X	X	X	X	
CAN	Canada					X	X	X			
CHE	Switzerland				X			X			
CHN	China			X					X		
CYP	Cyprus				X	X					
CZE	Czech Republic	X	X	X	X	X	X	X	X		
DEU	Germany				X	X	X	X			
DNK	Denmark	X	X	X	X	X	X	X			
ESP	Spain				X	X	X				
EST	Estonia				X	X	X	X			
FIN	Finland				X	X	X	X			
FRA	France				X	X	X	X	X		
GBR	United Kingdom	X	X	X	X	X	X				
GRC	Greece	X	X	X	X	X	X	X			
HRV	Croatia						X				
HUN	Hungary				X	X	X	X	X		
IDN	Indonesia	X					X				
IND	India			X							
IRL	Ireland				X	X	X	X			
ITA	Italy				X	X	X	X	X		
JPN	Japan	X	X	X	X	X	X	X			
KOR	Korea	X					X				
LTU	Lithuania				X	X	X				
LUX	Luxembourg	X	X	X	X	X	X	X	X	X	
LVA	Latvia				X	X	X				
MEX	Mexico				X				X		
MLT	Malta				X		X				
NLD	Netherlands			X	X	X	X	X	X		
NOR	Norway	X	X	X		X	X	X	X	X	
POL	Poland				X	X	X				
PRT	Portugal		X	X	X	X	X	X			
ROU	Romania				X	X	X	X			
RUS	Russia										
SVK	Slovak Republic				X	X	x	X			
SVN	Slovenia				X	X	x	X	X		
SWE	Sweden				X	X	x				
TUR	Turkey										
TWN	Taiwan	X	X	X	X	X	X	X			
USA	United States	X	X	X	X	X	X	X	X	X	X

Legend

SUTs available in SNA2008 and ISICRev4

SUTs available in SNA1993 and ISICRev4

SUTs available in SN1993 and ISICRev3

Appendix Table A3 – Services trade classification (BOP categories) and mapping to CPA

CPA_Code	Code	BOP code	BOP desc
CPA_D35	1	205	Transportation
CPA_H except H53	1	205	Transportation
CPA_E	1	249	Transportation
CPA_I	2	236	Travel
CPA_N79	2	236	Travel
CPA_H53	3	245	Communications services
CPA_J61	3	245	Communications services
CPA_F	4	249	Construction services
CPA_K65	5	253	Insurance services
CPA_K64, K66	6	260	Financial services
CPA_J62_J63	7	262	Computer and information services
CPA_J58	8	266	Royalties and license fees
CPA_G, L, M, N except N79	9	268	Other business services
CPA_J59_J60	10	287	Personal, cultural, and recreational services
CPA_S, R, T	10	287	Personal, cultural, and recreational services
CPA_O, P, Q	11	291	Government services, n.i.e.

Appendix B Data Sources by Country

(with help from Reitze Gouma, Oliver Reiter, Mahdi Ghodsi and Simona Jokubauskaite)

In this and following section a country-by-country description of the sources used is provided and the idiosyncratic assumptions made to derive national SUTs are summarised. National classifications had partly to be mapped into the new WIOD industry and product classifications.[34] In this section we discuss the data situation for EU Member States and non-EU Member States separately.

B.1 Sources and methods for EU Member States

General approach

Supply and use tables (SUTs): The official benchmark supply and use tables for the European countries are taken from EUROSTAT. The EUROSTAT tables provide data at basic prices (in some cases at purchasers' prices only) at the level of 64 industries and 64 products and are used directly with a minimum of adjustments.

The years for which tables are available from Eurostat and used for WIOT differ from country to country (see Section 3). For most European countries the first year for which a benchmark SUT is available that follows the new SNA08 concepts is 2010. To also use benchmark tables prior to the global economic crisis starting in 2008 an SNA93 table for 2008 is used (for most countries), which are available in the same product and industry dimensions (i.e. NACE Rev. 2). Unfortunately these SNA93 tables are not available in basic prices for all countries, therefore in order to estimate a basic price table for 2008 this has been estimated following the same approach as in the previous version of the WIOD, where valuation matrices are estimated for the use table using the SUTRAS procedure, which are deducted from the use table at purchasers' prices to arrive at a basic price table. For some countries this procedure is also applied for the use table according to SNA08.

External Time-series: External Time-series for SNA08 National Accounts (NA) output data by ISIC Rev. 4 industry are taken from EUROSTAT. Time series for aggregate NA data by expenditure categories are also taken from EUROSTAT. Data on the adjustment items *Final consumption expenditure of non-resident households on the territory* and *Final consumption expenditure of resident households abroad* are taken from OECD National Accounts.

External National Accounts time series on intermediate use by industry and final demand categories are adjusted by deducting taxes less subsidies on products (TXSP) from the NA values, using ratios from the benchmark use table at basic prices. Below we indicate for each country, specific adjustments made.

[34] **An** accompanying EXCEL file can be provided documenting the concordance and bridge tables for those countries where this was not straightforward

Austria

SUTs

- SNA93 2008 tables are used. A use table at basic prices is not available for 2008, therefore this has been derived by converting the SNA93 product by product IO table to a use table at basic prices.
- SNA08 tables at basic prices are available from EUROSTAT for the years 2010-2012.

External time-series

- External NA output data by industry and final consumption expenditure are taken from EUROSTAT.

Belgium

SUTs

- There is no 2008 SNA93 use or IO table at basic prices for Belgium. Therefore 2008 basic price tables were estimated using SUTRAS based on SNA93 data.
- The 2010 SNA08 tables were taken from FPB, since EUROSTAT does not provide the use tables at basic prices for Belgium. The tables from FPB do provide a use table at basic prices, however the adjustment rows for imports and exports as well as the adjustments for *Direct purchases abroad by residents* and *Purchases on the domestic territory by non-residents* were missing. These values are taken from the EUROSTAT tables. Overall the FPB tables are not exactly the same, but very close to the EUROSTAT tables.
- The FPB supply table only provides one additional row with total margins for each industry. Therefore the basic price supply table had to be adjusted, to include the margins on the proper margin rows. A fixed product distribution of the margins is used for each industry, derived from the total use at basic prices minus the total supply at basic prices that excludes the margins.

External time-series

- External NA output data by industry and final consumption expenditure are taken from EUROSTAT. For 2014 the output data at the A64 industry level is not completely filled, but totals at the EUROSTAT A21-sector level are available. The 2013 shares of the detailed A64 industries in their A21-sector aggregate are used to distribute the unallocated output to the industries at the A64 level for 2014.

Bulgaria

SUTs

- SNA08 2011 purchaser price use tables and basic price supply tables are available from EUROSTAT.
- Basic price use tables are calculated by estimating valuation matrices based on the purchaser price use table and deducting them from the purchaser price table using SUT-RAS.

External time series

- External NA output data by industry and final consumption expenditure is taken from EUROSTAT. For 2014 there is no data on gross output or value added data on the A64 level. Value added growth rates at the national level are used to estimate the missing values.

Croatia

SUTs

- SNA08 2010 basic price tables are available from EUROSTAT.

External time series

- External NA output data by industry and final consumption expenditure is taken from EUROSTAT. For 2014 there is no data on gross output or value added data on the A64 level. Value added growth rates at the national level are used to estimate the missing values. Data on sectors H51 and H53 is only available on aggregate; Slovenian industry shares are used to split the aggregated data.

Cyprus

SUTs

- SNA93 2009 purchaser price use tables and basic price supply tables are available from EUROSTAT.
- Basic price use tables are calculated by estimating valuation matrices based on the purchaser price Use table and deducting them from the purchaser price table using SUT-RAS.

External time series

- External NA output data by industry and final consumption expenditure is taken from EUROSTAT. For 2014 there is no data on gross output or value added data on the A64 level. Value added growth rates at the national level are used to estimate the missing values.

Czech Republic

SUTs

- SNA08 tables at basic prices are available from EUROSTAT for the years 2005 and 2010-2012

External time-series

- External NA output data by industry and final consumption expenditure are taken from EUROSTAT. From 2011 onwards there is an inconsistency in the data for the adjustment items from OECD (*Final consumption expenditure of non-resident households on the territory* and *Final consumption expenditure of resident households abroad*) and the value for *Final consumption expenditure of households on the territory*. The differences are distributed proportionately across the adjustment items.

Denmark

SUTs

- A full time series of SNA08 SUTs in basic prices is available from EUROSTAT for 2005-2012.

External time-series

- External NA output data by industry and final consumption expenditure are taken from EUROSTAT.

Estonia

SUTs

- SNA08 basic price tables are available for the years 2010 - 2011 from EUROSTAT.

External time series

- External NA output data by industry and final consumption expenditure is taken from EUROSTAT.

Finland

SUTs

- SNA93 2008 tables are used. A use table at basic price is not available for 2008, therefore we derived it by converting the SNA93 industry by industry IO table to a use table at basic prices.
- SNA08 tables at basic prices are available from EUROSTAT for the years 2010-2011

External Time-series

- External NA output data by industry and final consumption expenditure are taken from EUROSTAT.

France

SUTs

- SNA93 2008 tables are used. A use table at basic price is not available for 2008, therefore we derived it by converting the SNA93 product by product IO table to a USE table at basic prices.
- SNA08 tables at basic prices are available from EUROSTAT for the years 2010-2012

External time-series

- External NA output data by industry and final consumption expenditure are taken from EUROSTAT. For 2014 the output data at the A64 industry level is not completely filled, but totals at the EUROSTAT A21-sector level are available. The 2013 shares of the detailed A64 industries in their A21-sector aggregate are used to distribute the unallocated output to the industries at the A64 level for 2014.

Germany

SUTs

- SNA93 2008 tables are used. A use table at basic prices is not available for 2008, therefore we derived it by converting the SNA93 product by product IO table to a USE table at basic prices.
- There are no SNA08 use tables at basic prices available for 2010-2011, only IO tables at basic prices. Therefore we converted the product by product IO tables to USE tables at basic prices, following the same method as for the SNA93 2008 table.

External time-series

- External NA output data by industry and final consumption expenditure are taken from EUROSTAT.

<u>Greece</u>

SUTs

- SNA08 basic price tables for the year 2010 are taken from EUROSTAT.

External time series

- External NA output data by industry and final consumption expenditure is taken from EUROSTAT.

<u>Hungary</u>

SUTs

- SNA93 2008 tables are used. A use table at basic price is not available for 2008, therefore it has been derived by converting the SNA93 product by product IO table to a USE table at basic prices.
- SNA08 tables at basic prices are available from EUROSTAT for the years 2010-2012

External time-series

- External NA output data by industry and final consumption expenditure are taken from EUROSTAT.

<u>Ireland</u>

SUTs

- There is no 2008 SNA93 Use or IO table at basic prices for Ireland. Therefore 2008 basic price tables were estimated using SUTRAS based on SNA93 data.
- SNA08 tables at basic prices are available from EUROSTAT for the years 2010-2011
- There is no information in the SUTs on the split of several industries and products. The values for the cells have been recovered using information from row and column totals that were available and applying GRAS technique.

External Time-series

- External NA output data by industry and final consumption expenditure are taken from EUROSTAT. There is quite a large statistical discrepancy between output from the production side and from the expenditure side (about 1.3% of VA on average, but with a maximum of 4.2% in 2002). This difference is distributed over the final consumption categories.
- The SNA08 ISIC Rev. 4 output data has missing data for detailed industries of Agriculture and for manufacturing industries C19 (*coke and refined petroleum*) and C20 (*chemicals and chemical products*). In the SNA93 data this information is available, so we have used the shares from these data to distribute the SNA08 data over these industries. The SNA93 data is only available up to 2012, therefore the shares for 2013 and 2014 are kept constant at the 2012 level.
- For Ireland there is output for Industry U (*Activities of extraterritorial organisations and bodies*). This causes problems with SUTRAS because there is no output reported for this industry in the benchmark SUTs, therefore the output for this industry is allocated to industry O (*Public administration and defence; compulsory social security*)
- Intermediate use for industry T (*Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use*) is reported in the output data, which is not the case in the Use tables. Therefore VA values for this industry have bene set equal to GO.

Italy

SUTs

- There is no 2008 SNA93 Use or IO table at basic prices for Italy. Therefore 2008 basic price tables were estimated using SUTRAS based on SNA93 data.
- SNA08 tables at basic prices are available from EUROSTAT for the years 2010-2012

External time-series

- External NA output data by industry and final consumption expenditure are taken from EUROSTAT. For 2014 the output data at the A64 industry level is not completely filled, but totals at the EUROSTAT A21-sector level are available. The 2013 shares of the detailed A64 industries in their A21-sector aggregate are used to distribute the unallocated output to the industries at the A64 level for 2014.

Latvia

SUTs

- SNA08 2010 purchaser price use tables and basic price supply tables are available from EUROSTAT.
- Basic price use tables are calculated by estimating valuation matrices based on the purchaser price Use table and deducting them from the purchaser price table.

External time series

- External NA output data by industry and final consumption expenditure is taken from EUROSTAT. For 2014 there is no data on gross output or value added data on the A64 level. Value added growth rates at the national level are used to estimate the missing values. NA data on sector C19 is confidential, it can however be calculated by deducting all other manufacturing sectors data from the aggregated manufacturing sector data

Lithuania

SUTs

- SNA08 basic price tables for 2010 are available from EUROSTAT.

External time series

- External NA output data by industry and final consumption expenditure is taken from EUROSTAT. For 2014 there is no data on gross output or value added data at the A64 level. Value added growth rates at the national level have been used to estimate the missing values.

Luxembourg

SUTs

- SNA08 purchaser price use tables and basic price supply tables are available from EUROSTAT for the years 2000 - 2014.
- Basic price use tables are calculated by estimating valuation matrices based on the purchaser price Use table and deducting them from the purchaser price table.

- Both use and supply table contain a large number of confidential columns (C17, C18, C20, C21, C22, C23, C24, C25, C26, C27, C28, C29, C30, C31_32, C33, H50, H51, H52, H53, L68, M72, N77, N78 and N79). Belgian production structures for those industries are applied and scaled to fit with NA data.

External time series

- External NA output data by industry and final consumption expenditure is taken from EUROSTAT. The same industries that have confidential data in the SUTs are also do not report disaggregated A64 Gross Output or Value Added data. C17 and C18 are reported as C17_C18, C20 and C21 as C20_C21 and similar. Again Belgian data are used to compute shares for those sectors and break the aggregated sectors down to disaggregated A64 industry sector data.

Malta

SUTs

- SNA08 basic price tables for the year 2010 are available from EUROSTAT.

External time series

- External NA output data by industry and final consumption expenditure is taken from EUROSTAT.

Netherlands

SUTs

- There is a 2008 SNA93 industry by industry IO table, however, it is not consistent with the available supply table in terms of supply and use by product at basic prices. Therefore 2008 basic price tables were estimated using SUTRAS based on SNA93 data.
- SNA08 tables at basic prices are available from EUROSTAT for the years 2010-2012

External time-series

- External NA output data by industry and final consumption expenditure are taken from EUROSTAT. For the Netherlands there is output for Industry T (*Services of households as employers; undifferentiated goods and services produced by households for own use*). This causes problems with SUTRAS because there is no output for this industry reported in the benchmark SUTs, therefore the output for this industry is allocated to industry S96 (*Other personal services*).

Poland

SUTs

- There is no 2008 SNA93 Use or IO table at basic prices for Poland. Therefore 2008 basic price tables were estimated using SUTRAS based on SNA93 data.
- SNA08 tables at basic prices are available from EUROSTAT for the year 2010

External time-series

- External NA output data by industry and final consumption expenditure are taken from EUROSTAT. From 2011 onwards there is a mismatch between the GDP by expenditure data from

EUROSTAT and the adjustment items from OECD (*Final consumption expenditure of non-resident households on the territory* and *Final consumption expenditure of resident households abroad*). Since the *Final Consumption Expenditure by Households* is set equal to *Final Consumption Expenditure by Households on the domestic territory*, the values for the domestic concept have been adjusted to be consistent with the adjustment items.

- The SNA08 ISIC Rev.4 output data has missing data for industries H51 (*Air transport*) and H53 (*Postal and courier activities*). In the SNA93 data this information is available, so the shares from these data are used to distribute the SNA08 data over these industries.
- The SNA08 data is only available from 2003 onwards, therefore the SNA93 ISIC Rev. 4 data are used to back-cast the series at the detailed A64 industry level.
- For 2013 the SNA08 data is not available at the A64 industry level, but totals at the EUROSTAT A21-sector level are available. The 2012 shares of the detailed A64 industries in their A21-sector aggregate are used to distribute the unallocated output to the industries at the A64 level for 2013.
- For 2014 the SNA08 data is not available at the A64 or the A21 industry level. Therefore quarterly GDP data at the A10 level has been used to extrapolate the series for Value Added to 2014. The 2013 Gross Output to Value Added ratios are used in order to estimate Gross Output data for 2014 at the A64 industry level.

Portugal

SUTs

- SNA08 purchaser price use tables and basic price supply tables are available for 2010 and 2011 from EUROSTAT.
- Basic price use tables are calculated by estimating valuation matrices based on the purchaser price Use table and deducting them from the purchaser price table.

External time series

- External NA output data by industry and final consumption expenditure is taken from EUROSTAT. For 2014 there is no data on gross output or value added data on the A64 level. Value added growth rates at the national level are used to estimate the missing values.

Romania

SUTs

- SNA08 basic price tables for the years 2010 - 2011 are available from EUROSTAT.
- The supply table of Romania is, in effect, a diagonal matrix. This makes the SUTRAS procedure inefficient and (quite often) even impossible. The Bulgarian supply matrix is used as a drop-in replacement for the Romanian supply table.

External time series

- External NA output data by industry and final consumption expenditure is taken from EUROSTAT.

Slovak Republic

SUTs

- SNA08 basic price tables for the years 2010 are available from EUROSTAT.

External time series

External NA output data by industry and final consumption expenditure is taken from EUROSTAT.

Slovenia

SUTs

- SNA08 basic price tables for the years 2010 are available from EUROSTAT.

External time series

- External NA output data by industry and final consumption expenditure is taken from EUROSTAT.

Spain

SUTs

- There is no 2008 SNA93 Use or IO table at basic prices for Spain. Therefore 2008 basic price tables were estimated using SUTRAS based on SNA93 data.
- SNA08 tables at basic prices are available from EUROSTAT for the year 2010

External time-series

- External NA output data by industry and final consumption expenditure are taken from EUROSTAT. From 2011 onwards there is an inconsistency in the data for the adjustment items from OECD (*Final consumption expenditure of non-resident households on the territory* and *Final consumption expenditure of resident households abroad*) and the value for *Final consumption expenditure of households on the territory*. The difference is distributed proportionately across the adjustment items.
- For 2014 the output data at the A64 industry level is not completely filled, but totals at the EUROSTAT A21-sector level are available. The 2013 shares of the detailed A64 industries in their A21-sector aggregate are used to distribute the unallocated output to the industries at the A64 level for 2014.

Sweden

SUTs

- SNA93 2008 tables are used. A use table at basic price is not available for 2008, therefore we derived it by converting the SNA93 product by product IO table to a use table at basic prices
- SNA08 tables at basic prices are available from EUROSTAT for the year 2010
- The tables give numbers for the aggregate of the following industries:
  - C20 + C21, these data are split using Gross Output shares from EUROSTAT's Structural Business Statistics (SNA93 data in the ISIC Rev. 3 classification)

    - H52 + H53. We left the aggregate values in the rows and columns for H52, as no shares are available to make the split.
    - M72 + M73: these data are split using Gross Output shares the SNA08 2010 supply table.
- The tables give total supply for industries and products that do not match the sum of the product rows and industry columns. This difference stems from unknown secondary production for the following missing products:
    - CPA_C20 + CPA_C21.
    - CPA_H52 + CPA_H53.
    - For the product group CPA_G there is no product split, but the totals are reported in one row.
    - Information by industry is available and used. Also we assume all product output to have been produced in the own industry, such that GRAS could be used to estimate the missing cells.
- In the use table, in order to estimate the industry totals, the supply table GO shares are applied to distribute the unallocated total intermediate use by industry. For the product totals the same was done using the distribution of total supply at basic prices to allocate the unallocated total intermediate use by product from which the interior of the use table has been estimated.

External time-series

- External NA output data by industry and final consumption expenditure are taken from EUROSTAT. For 2014 the SNA08 data is not available. For value added sector data is available at the A21 level. The 2013 shares of the detailed A64 industries in their A21-sector aggregate are used to distribute the unallocated output to the industries at the A64 level for 2014. Gross Output is estimated using the 2013 ratios of Gross Output over Value Added.
- For industries C20, C21, H52, H53, M71, M72 output data is missing. This is resolved, consistent with the treatment in the SUTs.

<u>United Kingdom</u>

SUTs

- There is no 2008 SNA93 Use or IO table at basic prices for the United Kingdom. Therefore 2008 basic price tables were estimated using SUTRAS based on SNA93 data.
- SNA08 tables at basic prices are available from EUROSTAT for the year 2010
- The supply tables contain confidential elements. The values for the cells have been recovered using information from row and column totals that were available and applying GRAS technique.

External time-series

- External NA output data by industry and final consumption expenditure are taken from EUROSTAT. For 2014 there is no data on Gross Output. Therefore the 2013 gross output to value added ratios has been used to estimate gross output by industry for 2014.

B2 Sources and methods for non-EU Member States

Australia

SUTs

- Supply and use tables for 2007 and 2012 at basic prices from Australian Bureau of Statistics ABS (accessed February 2016, link). The SUTs follow SNA 2008 and the detailed product and industry classifications are in ISIC rev. 4 (see link).

External time-series

- GDP by economic activity - one digit sectors in ISIC rev. 4 - and GDP by expenditure from ABS for the period from 2000 to 2014 (accessed February 2016, see Table 2 and Table 5 in link). Additional industry detail by using (interpolated) shares from the 2007 and 2012 SUTs. Gross output is estimated based on the output to value added ratio in the SUTs.

Notes

- Industries M69 to M74 and N78 to N82 are not further disaggregated.

Brazil

SUTs

- Supply and use tables for 2010-2013 at purchasers' prices from Brazil's statistical office IBGE (accessed January 2016, link). These SUTs follow SNA 2008 and product and industry classifications are in ISIC rev. 4 (see link).

External time-series

- GDP by expenditure from IBGE; consistent with SUTs for 2010-2013 (accessed January 2016, link). To back- and up-date the time series we used trends from GDP by expenditure data from the UN national accounts statistics (accessed January 2016, see link).
- Gross output and value added from IBGE; consistent with SUTs for 2010-2013 (accessed January 2016, link). The series are backdated using trends from gross output and value added series from IBGE for 2000-2010 (downloaded in January 2016 from link). These series follow SNA 1993 and are in ISIC rev. 3 (see here). Updating to 2014 using trimestral national accounts data from IBGE (downloaded in January 2016 from link).
- Wholesale and retail trade are split using information from the Pesquisa Anual de Comercio.

Notes

- Industries A02 to A03; E36 to E37; H52 to H53; K64 to K66; M72 to M74; N78 to N79; Q86 to Q87; R90 to R93; and S94 to S96 are not further distinguished.

Canada

SUTs

- Supply and Use tables for 2009-2011 at basic prices and aligned with SNA 2008 and in ISIC rev. 4 from the detailed tables at Cansim, Statistics Canada (Accessed February 2016, link).

External time-series

- Gross output and value added data for 2009-2011 consistent with SUTs (Accessed February 2016, link). The series are backdated using output and value added data from the input file of the time series SUTs underlying the WIOTs, release October 2012. Update to 2014 using GDP by economic activity by broad sectors from the UN National accounts statistics (accessed February 2016, see link).
- GDP by expenditure data from the OECD National accounts statistics (accessed February 2016, see link).

Notes

- Industries C31 to C33 and D35 to E36 are not further distinguished.

China

SUTs

- We use input-output tables (commodity-by-commodity) at a detailed 120+ product level for benchmark years 2002, 2007, and 2012 at producer prices and conform SNA 1993. These are combined with less detailed Supply and Use tables for China for 2002, 2007, and 2012. Both sources are published by the National Bureau of Statistics.
- We take the input-output tables as the starting point for two reasons. First, limited product and industry detail in the supply and use tables makes a good concordance with WIOT difficult. The input-output tables are, on the contrary, much more detailed and allow a better match. Second, the NBS considers its input-output tables of higher quality than the published supply and use tables. From the published supply tables, we use the secondary production information (only available for industry: mining, manufacturing industries, and public utilities) in constructing the supply block for WIOD. Row and column totals in the supply block are from the IOTs, but the distribution is obtained from the official supply table. The procedure to obtain consistency with the row and column totals is the so-called RAS-procedure.
- Tables for 2002 and 2007 use the CSIC 2002, whereas the 2012 table is in CSIC 2011. Industry concordance with the international industry classification system, is provided in the concordance table (see Excel file). The CSIC 2011 in principle follows the International Standard Industrial Classification of all economic activities (ISIC) Rev. 4.
- No detail is available in the input-output tables to split distributive trade services. We use sales data shares from the China *First Economic Census* 2004 to split it into wholesale and retail trade.
- At the national bureau of statistics, the national accounts division is separate from the input-output division and information from the input-output tables is not necessarily consistent with the national accounts. The China IOTs have a column titles “errors”. Personal correspondence indicated that if the error gets larger than five percent of total supply, the additional error is moved to “changes in inventories and valuables”. In the SUTs and IOTs, the tables are balanced using this variable such that: Intermediate Inputs + Final Demand + Error = Gross Output + Import. We distributed the error in each variable in the Final Demand Section using the share of each variable in the Final Demand. (Note: In some cases, the total Final Use (Final Demand) is zero. In such cases, we put the error into changes in inventory and valuables.)

External time-series

- UN NA by expenditure, 2000-2014 (accessed January 2016, see link)

- Output and value added series by industry from *the China Industry Productivity* (CIP) database 3.0 for the period from 2000 to 2010 (Wu and Ito, 2015, accessed January 2016 see link). The CIP database distinguishes 37 industries in ISIC rev. 4. To obtain further industry detail, the series are disaggregated using shares from the input-output tables.
- Purchases by non-residents on the domestic territory and purchases abroad by residents is not separately reported in the national accounts. These are taken from the item 'travel' in de the balance of payment as published in the China Statistical Yearbooks (accessed April 2016, see link). The BoP estimates follow the international Balance of Payments manual version 5.
- Gross output and value added series are updated to 2014 using:
    - 2011-2013 industry trends in revenues and value added for manufacturing from various issues of the China Statistical Yearbook (SYB) (accessed January 2016, see link)
    - 2011-2012 using trend by broad sectors in value added from SYB
    - 2013-2014 using trend by broad sectors in value added from quarterly national accounts (accessed January 2016, see link)

Notes

- Industries C31 to C33; G45 (partly in G46 and partly in G47); J58 to J61; K65 to K66; M71 to M73; N77 to N79; S94 to S96 and T are not further disaggregated.

India

SUTs

- Supply and use table for 2007 at basic prices from NSO (see link). SUT follows SNA 1993.

External time-series

- Value added and gross output time series from India KLEMS for the period from 2000 to 2011 (available at link). Additional industry detail from using shares of the IOT. Series are updated using NA statistics on gross output and value added by detailed industries from the NSO for the period from 2011 to 2013 and broad sectors from 2013 to 2014 (Accessed April 2016 at mospi.nic.in; access requires registration).
- GDP by expenditure from NAS 2015, NSO (Accessed April 2016 at mospi.nic.in; access requires registration).

Notes

- Industries C31 to C33; E36 to E39; H53, J58 to J61; M71 to M75, N78 to N82; Q86 to Q87; R90 to S96 are not further disaggregated.

Indonesia

SUTs

- Input-Output tables for 2000, 2005, and 2010 at producer prices from the national statistical office, Badan Pusat Statistik (BPS). The 2000 and 2005 tables were scanned from published documents, the 2010 table was accessed on March 2016 (see link). The 2010 IOT follows SNA 2008 and is in ISIC rev. 4. The 2000 and 2005 tables follow SNA 1993.
- No information on net taxes is available, so the estimated time series SUTs are at producer prices.

External time-series

- Value added by industry is in ISIC rev. 4 from BPS for the period from 2010 to 2014 (accessed March 2016, see link). C17 to C18; C20 to C21; C25 to C27; C29 to C30; G46 to G47; H53, J58 to J63; M and N; Q86 to Q88; R and S are split using shares from the 2010 IOT.
- Value added is backdated using industry trends from BPS for 2000-2010. These series follow SNA 1993 and are in ISIC rev. 3.
- Gross output is estimated using the gross output to value added ratios from the IOTs.
- GDP by expenditure in SNA 2008 from BPS for 2010 to 2014. Series are backdated using trends from the OECD national accounts statistics.

Notes

- Industries C31 to C33; E36 to E39; M69 to M74; N78 to N82; R90 to R93; S94 to S96 are not further disaggregated.

Japan

SUTs

- Supply and use tables at producer prices; output and value added by detailed industries from JIP Database 2014, available for the period from 2000 to 2011 (accessed January 2016, see link). Supply tables were delivered upon request by the JIP team. The JIP database is compiled following the 1993 SNA. The 108 activities distinguished are mapped to ISIC rev. 4 products and industries. Whenever present, negative values for gross fixed capital formation in the use tables, in the intermediate use blocks, and final consumption expenditure were set to zero.

External time-series

- The output series are updated to 2014 using output indices by broad sectors from Japan's statistical office (accessed January 2016, see link). The intermediate input series are updated using value added trends by broad sectors from the OECD National Account Statistics (accessed January 2016, see link).
- GDP by expenditure from OECD, 2000 to 2014 (accessed January 2016, see link).

Notes

- Industries C31 to C33; K65 to K66; M69 to M72; N77 to N82; R90 to R93; S94 to S96 are not further disaggregated

Mexico

SUTs

- Supply and use tables at basic prices for 2008 and 2012 (Accessed March 2016, see link). The SUTs align with SNA 2008; are very detailed and matched to ISIC rev. 4 industries and products.

External time-series

- Gross output and value added series at the same level of industry detail from INEGI for 2003 to 2014 (Accessed March 2016, see link). Backdating to 2000 using the input file of the time series SUTs underlying the WIOTs, release October 2012.
- Wholesale and retail trade is split using shares from the 5-year economic census (years 2004/2009/2014).

- GDP by expenditure data from INEGI for 2003 to 2014 (Accessed March 2016, see link). Backdating to 2000 using the input file of the time series SUTs underlying the WIOTs, release October 2012.

Notes

- Industries L68 and N77; M73 to M75 are not further disaggregated.

Norway

SUTs

- No basic price tables are available for Norway, and purchases price tables are used, transformed to basic prices using the SUT RAS procedure (see Dietzenbacher et al, 2013)
- The 2008 ESA95/SNA93 tables were taken from SSB (Statistics Norway). SNA08 tables for 2010-2011 are available from EUROSTAT. SNA08 tables for 2012-2013 are available from SSB
- In the tables from Statistics Norway (SSB) (2008, 2012-2013) values for the industries C19-C21 have been grouped in the column of C21. We use the EUROSTAT tables and RAS technique to fill this up.
- In order to estimate the missing values by industry column in the Use tables for each year, we use the GO shares by industry from the supply table in the respective year.
- In order to estimate the missing values by product row in the EUROSTAT Use tables for 2010 and 2011 we use the product distribution for total supply from the supply table.
- Small negatives values in the use table are set to zero

External time-series

- External NA output data by industry and final consumption expenditure are taken from EUROSTAT. From 2011 onwards there is a mismatch between the GDP by expenditure data from EUROSTAT and the adjustment items from OECD (*Final consumption expenditure of non-resident households on the territory* and *Final consumption expenditure of resident households abroad*). Since the *Final Consumption Expenditure by Households* is set equal to *Final Consumption Expenditure by Households on the domestic territory*, the values for the domestic concept have been adjusted to be consistent with the adjustment items.
- The SNA08 ISIC Rev. 4 output data for industries C19, C20 and C21 are grouped. The output is split using the GO shares from the SUTs.
- For 2014 the output data at the A64 industry level is not completely filled, but totals at the EUROSTAT A21-sector level are available. The 2013 shares of the detailed A64 industries in their A21-sector aggregate are used to distribute the unallocated output to the industries at the A64 level for 2014.

Russia

User warning: Given the paucity and outdated nature of the publicly available Russian statistics, we do not advise users to make analysis of the Russian economy based on this data. There is still no official Supply and Use table available (a 2011 SUT was announced for November 2015 but has still not been released), which means that we have to rely on an outdated table for 1997. We have included Russia in this version of the WIOD only for analyses of international trade with Russia. The trade data is relatively more complete and up to date.

SUTs

- Supply and use table at basic prices in 2007 from the estimated time series SUTs underlying the WIOTs, release October 2012 (which is based on extrapolation of an 1997 table). Tables are in SNA 1993, ISIC Rev. 3. 59 products and 35 industries are distinguished and these are mapped to ISIC rev. 4 products and industries.

External time-series

- Output and value added data from the input file of the time series SUTs underlying the WIOTs, release October 2012. The series are updated using economic activity by broad sectors from OECD National Account Statistics (accessed January 2016, see link).
- Expenditure data for 2000 to 2014 from OECD National Account Statistics (accessed January 2016, see link).

Notes

- Industries A01 to A03; C17 to C18; C20 to C21, C24 to C25; C26 to C27; C29 to C30; C31 to C33; D35 to E39; H52 to H53; J58 to J673; K64 to K66; M69 to N82; Q86 to Q87; R90 to T are not further disaggregated

South Korea

SUTs

- Supply and use tables at basic prices for 2005 and 2010 from the Bank of Korea (accessed April 2016, see link). The 2010 SUT follows SNA 2008 and is in ISIC rev. 4. The products and industries in the 2010 table were mapped to the 64 products and industries in the new WIOTs. Only wholesale and retail trade needed to be split for which we used shares from the Korea KLEMS database (accessed April 2016, available at link). The 2005 SUT follows SNA 1993; is in ISIC rev. 3 and has less detail. We split industries using shares from the 2010 SUT.

External time-series

- Output and value added series are based on the Bank of Korea's National Account Statistics (BoK NAS; accessed April 2016, see link). These series are in SNA 2008 and ISIC rev. 4. Output and value added of wholesale and retail trade was split using shares from the Korea KLEMS database. Further industry detail for value added series, where needed, was obtained using shares from the 2010 use table. For gross output the ratio from BoK NAS was applied to more disaggregated industries where necessary.
- Exports and imports by product were extrapolated from 2010 to 2013 based on updated SUTs for 2011-2013 from the BoK (accessed April 2016, see link).

Notes

- Industries C31 to C33; N78 to N79; S96 and T are not further disaggregated

Switzerland

The data for Switzerland has been constructed in close cooperation with from Rütter Soceco AG and we are grateful to Carsten Nathani for advice and help. The underlying data construction work is described in: Nathani, C., Hellmüller, P., Schwehr, T. (2016): Adaptation of Swiss data for the World Input-Output Database. Technical report. Rütter Soceco, Rüschlikon.

SUTs

Supply and use tables at basic prices for 2008 and 2011 were supplied to us by Rütter Soceco AG and are described in Nathani, C., Hellmüller, P., Schwehr, T. (2016). The SUTs follow SNA 2008 and employ the ISIC rev. 4 industry classification.

External Time-series

- Gross output, value added and GDP by expenditure in SNA 2008 and ISIC rev. 4 from Bureau of Federal Statistics (BFS) for 2000 to 2014 (accessed September 2016, see link). Industries A01 to A03 and C19 to C20 were split using shares delivered by Rütter Soceco AG. Industries H49 to H51 are split using shares from the OECD Stan database.
- Note: industries E36 to E39; J58 to J60; M69 to M71 and M73; N77 to N82; R90 to R93; and S94 to S96 are not further distinguished.
- An additional adjustment was made to the output in the Public administration and defense; compulsory social security (O) and Education (P) industries, at the suggestion of Rütter Soceco AG. In the National Accounts Industry O includes a large portion of Education. This has been reallocated to the Education industry, using shares provided by Rütter Soceco AG.

Taiwan

SUTs

- There are two detailed commodity by commodity (168*168) IO tables for 2006 and 2011, available from National Statistics Taiwan (DGBAS, see link)
- We treat the tables as USE tables and symmetric supply tables are generated by attributing the entire product output to one corresponding industry. The mapping tables can be found in the Excel file.
- In the resulting use tables total private consumption is allocated to household consumption, even though it also includes Final consumption expenditure by non-profit organisations serving households (NPISH).

External time-series

- SNA08 external NA output data by industry and final consumption expenditure are taken from DGBAS. The sum of value added tax and net import duties are treated as taxes on products. There are no time series available on the adjustments for *Direct purchases abroad by residents* and *Purchases on the domestic territory by non-residents.*
- For a number of industries only aggregate data is available. These have been split using GO and VA shares from the IO table. This concerns the following industries:
    - G45 and G46 (*Wholesale trade*)
    - J58 (*Publishing services*)and J59_J60
    - M69_M70, M71, M72, M73, M74_M75
    - N78, N79, N80-N82 (*Administrative and support service activities*)
    - S95, S96 (*Other service activities*)

Turkey

SUTs

- Supply and use tables at basic prices for 2002 from TurkStat (Accessed May 2016, see link). Tables are in SNA 1993, ISIC Rev. 3. 59 products/industries are distinguished and these are mapped to ISIC rev. 4 products and industries.

External time-series

- National accounts data of value added data by one digit sectors (A to T) for 2000 to 2014 from TurkStat (Accessed May 2016, see link). This data is in SNA 2008, ISIC Rev. 4. Value added shares from the 2002 use table are applied to arrive at the same industry detail as in the 2002 SUT. Gross output data is based on the ratio of output to value added from the 2002 use table.
- Expenditure data for 2000 to 2014 from TurkStat (Accessed May 2016, see link).

Notes

- Industries C20 to C21; C31 to C33; H52 to H53; J58 to J61; M69, M71, M73 to M75; N77 to N82, Q86 to Q87; R90 to R93; S94 to S95 are not further disaggregated

United States

- Beginning with 2007, the benchmark input-output tables are fully integrated with the annual industry accounts and the national income and product accounts. The Bureau of Economic Analysis (BEA) provides a benchmark make and use tables for 2007 (389 industries) and annual time-series tables for 1997-2014 for 71 industries (see link). While the benchmark tables are available both in producer and purchasers' prices, the annual Use tables are available only in producer prices. There is no information to transform these to basic prices, so the **intermediate and final use block are in producer prices**.
- Note that the reported export values in the SUTs are exclusive of "**re-exports",** defined as foreign merchandise entering the country as imports and then exported in substantially the same condition as when imported.
- The make-use framework of the BEA has some idiosyncrasies from an international perspective. Recently, they also provide supply and use tables as supplemental estimates which adhere better to international conventions, in particular regarding the treatment of (net) taxes (see "Supply-Use Tables for the United States", by Jeffrey A. Young, Thomas F. Howells III, Erich H. Strassner, and David B. Wasshausen in September 2015 *Survey of Current Business*). As we aim for basic price tables, and these use tables are only at purchasers' prices they do not provide a useful (no pun intended) alternative. However, we will us the value added block from these tables as they include a presentation of **value added in basic prices**, which is missing in the use tables according to the BEA make-use system. All the tables we use are before redefinitions ('Redefinitions' pertain to the secondary products of a multi-product industry and modifying the classification of industries from a NAICS to an I-O basis).
- The **bridge table** from the 71 SUT industries to the WIOD is given in the Excel file. Some BEA industries and products had to be split to get appropriate WIOD products and industries. This splitting has been done using detailed time-series data on gross output by industry, also available from the BEA website. These are consistent with the SUTs.
- **Imports** in the original US tables were provided in the use tables as negative entries. These were moved into the supply table, after changing the sign. The imports are valued at their foreign port value, and hence they exclude any transport and insurance fees (which can be considered as f.o.b.

valuation). The negative entries for wholesaling and some transportation services are treated as a **cif/fob adjustment** and set to zero. The resulting inconsistency between the supply and use table are corrected by subtracting the difference from exports in the use table, where also we consider the same value as cif/fob adjustment.

- The **Rest of the world adjustment** in the Make table is only small and is clubbed with public administration. In the Use table, this line is only reported combined with **non-comparable imports.** The imports consist of *Purchases of residents abroad* and intermediate uses. The intermediate use of this is allocated to N77 *Rental and leasing activities*. The exports of this item are allocated to *Domestic purchases by non-residents*. The personal consumption of this item is split into *Domestic purchases by non-residents* and *Purchases of residents abroad.* The latter can be implicitly derived.
- Whenever there were negative entries in the intermediate blocks in some industries/products (e.g. product secondary raw materials, which includes scrap, had negative entries), these are set to zero, and are added to inventories and taxes on production to keep consistency.

Rest of the World

In the World Input Output Tables (WIOTs) the Rest of the World (RoW) is included as if it is a separate country just like the other 43 countries included in WIOD. The estimation of the Input-Output data for regular countries is based on the Supply and Use tables. For the RoW this information is not available, therefore we apply an estimation method that is described step by step in this section.

External data for the Rest of the World

External National Accounts (NA) data is downloaded from the UN National Accounts for all countries in the world. These annual data give information on Value Added (VA) by broad sector and GDP by expenditure category of Final Demand (FD) in nominal US dollars. The data is aggregated for all countries not explicitly included in the WIOD, to come up with the RoW totals. The UN VA data by broad sectors needs to be broken down to the WIOD industry level. For this we assume that the VA industry distribution in the broad sectors in each year, is the same as the aggregate VA distribution of the following set of WIOD countries: Brazil, India, China, Indonesia, and Mexico. We employ the Gross Output (GO) to Value Added ratio for each industry of this same set of WIOD countries, to estimate GO by industry for the RoW. The totals for Intermediate Use (II) by producing-industry are derived as the difference between GO and VA for each industry. Finally for each WIOD trading partner, trade shares of RoW Imports from WIOD countries, by end use, either II or FD, are available for manufacturing industries, from bilateral trade data.

Estimation of an IO table for the Rest of the World

The external RoW data gives the totals for II, VA and GO by industry and FD by category. In order to estimate an IO-table for the RoW we take the following steps:

A. We distribute the RoW NA totals of II and FD by producing-industry using the aggregate distribution of the WIOD countries Brazil, India, China, Indonesia, and Mexico. This gives an initial IO matrix of II and FD by producing-industry for which GO by producing-industry is not necessarily the same as GO by using industry. In order to balance this RoW IO-table and make it consistent with the information from the international SUTs, as well as the NA data for RoW adjustments have to be made.

B. In the RoW IO-table total RoW GO can be calculated by summing over II, FD, Exports (EX) and deducting Imports (IMP):

$$GO = II + FD + EX - IMP$$

From the International SUTs RoW IMP from WIOD-countries and RoW EXP to WIOD countries are known. The resulting RoW trade balance will generally be different than the trade balance from the National Accounts, so this identity will not hold using external data for GO, II, and FD in combination with the trade data from the International SUTs.

In order to be consistent with the output totals from the National Accounts we calculate the following residual:

$$GO_{res} = GO - II - FD - EX + IMP$$

The residual is then distributed by producing-industry using the RoW IMP distribution $[GO_{res}]$.

C. From the International SUTs it is known for the RoW for each producing-industry how much it exports to the WIOD countries and by which industries the products are used. In order to leave these data unchanged the totals of these exports by producing-industry are deducted from external GO by producing-industry prior to balancing the table. At this stage imports are included in the RoW IO-matrix, so IMP by producing-industry is added to GO by producing-industry. Finally we exclude the GO residual by producing-industry calculated in B. from GO by producing-industry, to avoid spreading these adjustments throughout the RoW table. This leaves an adjusted vector of GO by producing-industry.

$$[GO_{adj}] = [GO] + [IMP] - [EXP] - [GO_{res}]$$

D. The initial RoW IO table at A. is then balanced using GRAS, applying the external II and FD data as column totals and the $[GO_{adj}]$ as row totals.

E. This results in a balanced IO-table for the RoW. The GO residuals by producing-industry $[GO_{res}]$ are added to RoW changes in inventories.

Splitting RoW imports by using-industry

From the International SUTs it is known how much the RoW imports from WIOD countries by producing-industry, but not whether it is used for II or FD. Furthermore a further split is required obtain imports by using-II-industry and using-FD-category. As mentioned in the first section, end-use shares are available for producing-industries of manufactured goods by trading partner. For the remaining producing-industries by WIOD trading partner for which these trade shares by end-use are not available, these shares are calculated by using the aggregate of the exports to WIOD countries Brazil, India, China, Indonesia, and Mexico. This gives RoW imports by, trading partner, producing-industry, and total end use (II and FD). In order to further break down these exports by using-II-industry and using-FD-category we apply the distribution of using-industries in II and using-categories in FD from the RoW IO-table at section 2. Hence, we apply a proportionality assumption between imported and domestically produced products. We exclude Changes in Inventories from this procedure, therefore no trade for this category is calculated. Lastly we deduct the aggregate of the RoW imports by producing industry from the RoW IO-table to obtain the domestic RoW blocks for II and FD.