World Input-Output Database Project

Background material for the Final WIOD Conference:

Causes and Consequences of Globalization

Groningen (The Netherlands), April 24-26, 2012

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SEVENTH FRAMEWORK PROGRAMME

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How has the increase in Chinese exports of textile products affected the employment of low skilled workers in German retail trade? What would be the effects of a change in the European Union's agricultural policy on global CO2 emissions? Economic and environmental policies are designed at a detailed level of industries and products, while production is characterized by an interdependent structure. Due to globalization, these interdependencies cross borders and the inclusion of trade is more than ever essential. Analyzing policy issues therefore requires an all-encompassing database. Its construction is at the heart of this project and the following three aspects are crucial.

- Input-output (IO) tables provide a description of the interdependent production structure. Taking the reach of internationalization into full consideration requires a worldwide set of national IO tables (covering at least 80% of world GDP) that are fully linked through bilateral trade data.

- Taking the dynamics of internationalization into account requires a time series (1995-2006) of such linked IO tables, in current and constant international prices.

- Taking the effects of internationalization into consideration requires that other relevant information is appended. These so-called satellite accounts include labour data for different skill types, investment flows, and environmental and resources data.

The first part of the project constructs such a unique database. The second part of the project applies the database to analyze the international interaction of socio-economic and environmental objectives from a policy perspective. These are applications that use the database by directly employing IO and econometric techniques, and applications that use large-scale models that employ the database. The project builds on several previous, EU-sponsored projects and is carried out by Europe's leading experts in IO theory, data construction, interindustry models, and policy applications.The following institutes participated:

- University of Groningen (The Netherlands)
- Institute for Prospective Technological Studies (Spain)
- Wiener Institut für Internationale Wirtschaftsvergleiche (Austria)
- Zentrum für Europäische Wirtschaftsforschung (Germany)
- Österreichisches Institut für Wirtschaftsforschung (Austria)
- Konstanz University of Applied Sciences (Germany)
- The Conference Board Europe (Belgium)
- CPB Netherlands Bureau for Economic Policy Analysis (The Netherlands)
- Institute of Communication and Computer Systems (Greece)
- Central Recherche SA (France)

In addition we were happy to have the collaboration of the OECD (France).

More information on the WIOD-project can be found at www.wiod.org.

New Measures of European Competitiveness. A Global Value Chain Perspective on Manufacturing

(University of Groningen)

This note is a summary of a longer paper written by Marcel P. Timmer, Abdul Azeez Erumban, Bart Los, Robert Stehrer and Gaaitzen de Vries. This paper can be found at the WIOD website: www.wiod.org

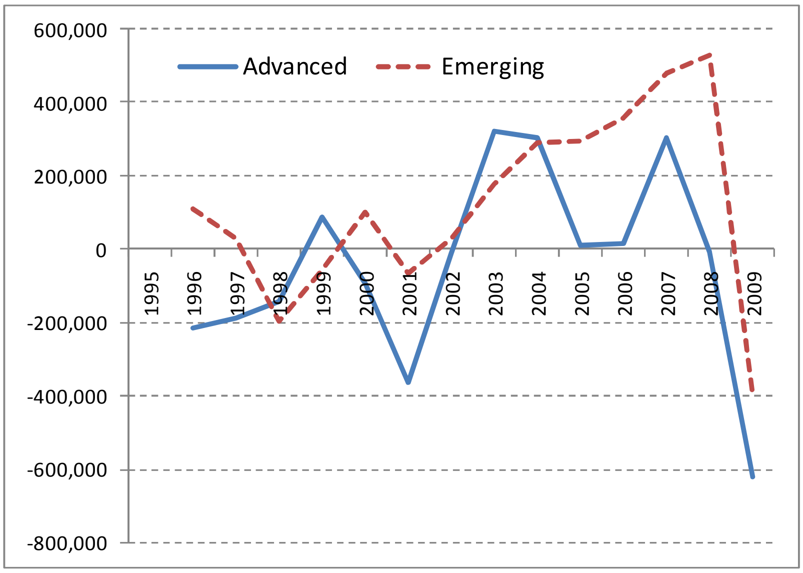
Increasing fragmentation of production requires a new metric of competitiveness

International competition increasingly plays itself at the level of tasks within firms, rather than at the level of products. This creates new challenges for the way in which competitiveness of nations is analysed. We introduce a new metric that allows us to analyse the value that is added in various stages of regionally dispersed production processes. It is defined as the income generated in a country by carrying out activities related to the production of manufacturing goods in any stages of the production process, abbreviated by the term *GVC income*. Compared to traditional competitiveness indicators like a country's share in world exports, this new metric has three advantages. First, it indicates to what extent a country can compete with other nations in terms of *activities* related to global manufacturing, rather than competing in manufacturing *products* as measured by exports. These activities take place in manufacturing industries, but also in services industries. Second, it measures the share of a country in internationally contested markets. It is a reflection of an economy's strength to compete in both domestic and global markets. Third, income and employment effects of trade in tasks for separate groups of workers (such as low- and high-skilled) can also be determined in the same unified framework.

Growth in GVC income in advanced countries is slow, while accelerating in emerging countries since 2002.

We identify the emergence of global production networks by tracing the flow of goods and services across industries and countries as described in a world input-output table. Using a decomposition technique introduced by Leontief, we slice the value of manufacturing expenditure up into incomes for labour and capital in various countries. These are the incomes of factors that are directly and indirectly needed for the production of the final consumption goods. The empirical analysis is based on a new database, called the World Input-Output Database (WIOD), which combines national input-output tables, bilateral international trade statistics and data on production factor requirements. We find that the effects of the fragmentation process have been very uneven within and across regions. Growth in GVC income in advanced countries is slow, while accelerating in emerging countries since 2002 (see Figure 1).

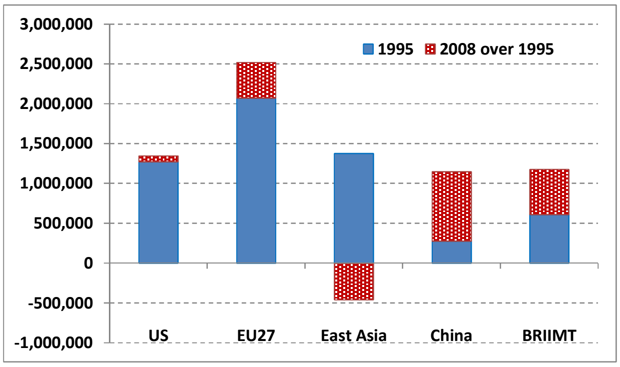
Figure 1 GVC income (annual change in million 1995 US$)

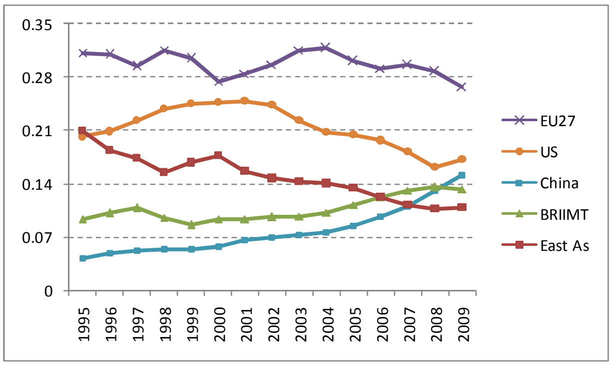


Note: Advanced includes EU-15, Japan, Korea, Taiwan, Australia, Canada and the U.S. Emerging includes all other countries in the world. National currencies converted to US$ with official exchange rates, deflated to 1995 prices with the US CPI.

Source: World Input-Output Database (WIOD).

Figure 2 Regional GVC income in 1995 and 2008.





(a) In million 1995 US$ **(b) Shares in world GVC income**

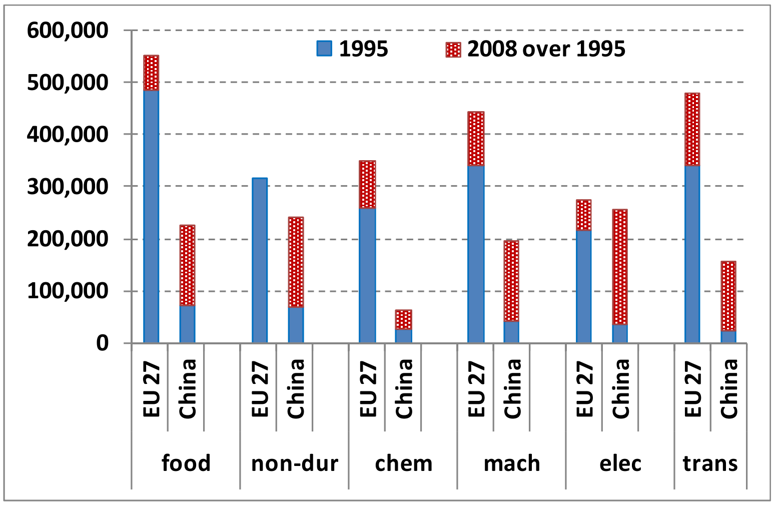
Note: East Asia includes Japan, South Korea and Taiwan. BRIIMT includes Brazil, Russia, India, Indonesia, Mexico and Turkey. Source: World Input-Output Database (WIOD).

Competitiveness of Europe is steady

The decline of the advanced nations is particularly due to the demise of East Asia which share has been declining rapidly since the mid-1990s. After an initial rise, the US share also started to decline after 2002 (see Figure 2). In contrast, the EU GVC income share has been relatively stable, only slowly declining over the period from 1995 to 2008. In 2009 it still had the largest share in world GVC income. China is responsible for the major part of the increase of the emerging countries' share, accelerating after its WTO ascension in 2000. In 2007 it overtook the share of East Asia. In 2009, the Chinese GVC income share was higher than that of Brazil, Russia, Indian, Indonesia, Mexico and Turkey (BRIIMT) combined. And it was almost equal to that of the

US. European competitiveness is particularly strong in durable goods. GVC income shares in production of non-electrical machinery and transport equipment are high (between 30 and 35%). For electrical machinery, the European share is much lower (about 20%), being overtaken by China (see Figure 3).

Figure 3 GVC income by products, 1995 and 2008



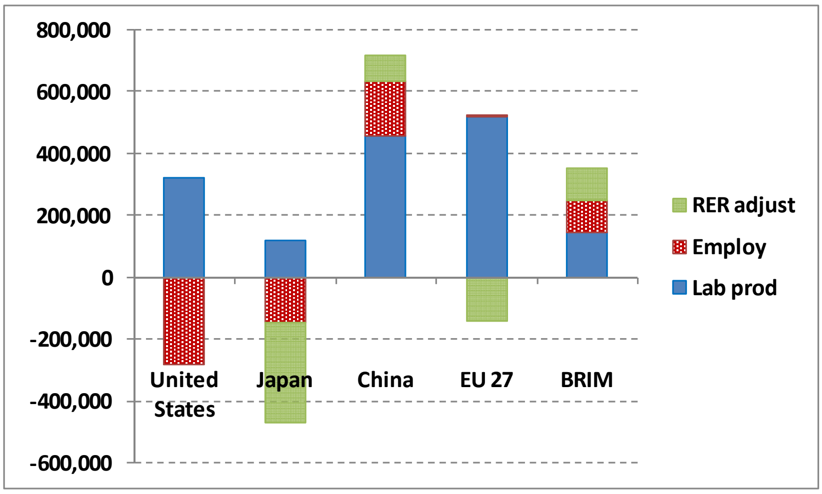
Note: In million 1995 US$. Food manufacturing products (from ISIC rev.3 industries 15 & 16), Non-durable products (17 to 20, 36, 37); Chemical products (23 to 26), Machinery & metal products (27 to 29); Electrical machinery products (30 to 33); Transport equipment (34, 35).

Source: World Input-Output Database (WIOD).

European GVC income supported by growth in labour productivity

Increasing competitiveness can be achieved through increasing the number of workers in GVC activities and improving their productivity. We decompose changes in GVC income into changes in the number of workers involved and change in the GVC income per worker. The latter is akin to standard measures of labour productivity as it measures the real value added per worker in GVC production, adjusting for differences in real exchange rates. We find that the sources of GVC income growth vary widely across countries, see Figure 4. In Japan and the US improvements in labour productivity are cancelled out by declines in GVC employment. GVC income in the EU increases due to strong productivity growth, but employment growth is negligible. While GVC employment growth was strong in Germany and Spain it was negative in France and in particular in the UK. In China, Brazil, India and Mexico, employment in GVCs is growing strongly. China additionally benefits from strong labour productivity growth.

Figure 4 Change in GVC income between 1995 and 2008.

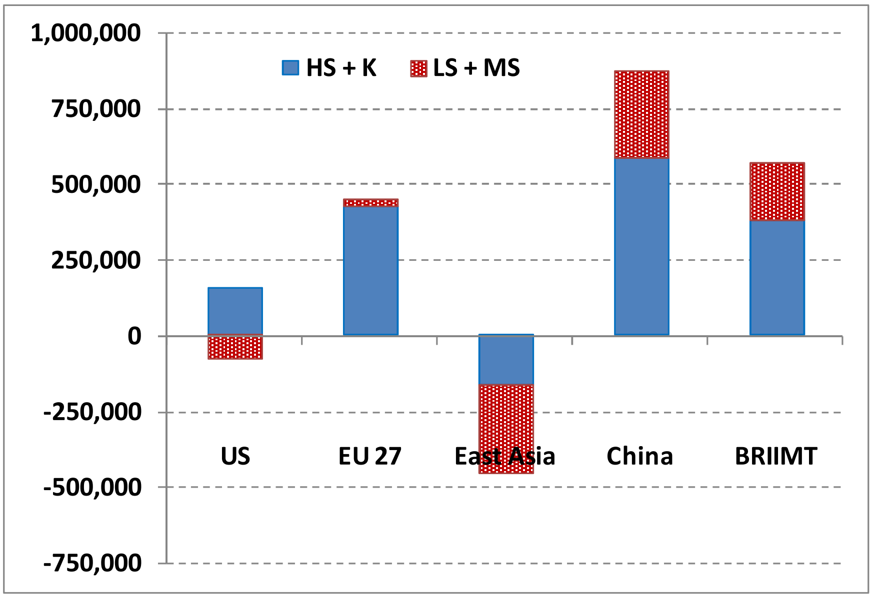


Note: Change in GVC income earned in non-food manufacturing between 1995 and 2008 (in mi1995 US$) split into change in labour productivity (Lab prod), change in number workers (Employ) and change in real exchange (RER).

Increasing fragmentation is benefiting high-skilled workers and capital

Our income data on labour and capital allows us to study which production factors have benefitted from the changes in the regional distribution of global value added. We decomposed value added into four parts: income for capital and income for labour, split into low-, medium- and high-skilled labour. High-skilled labour is defined as workers with college degree or above. Medium skilled workers have secondary schooling and above, including professional qualifications, but below college degree, and low-skilled have below secondary schooling. An estimate for the income of self-employed workers is included in labour compensation. The income for capital is the amount of value added that remains after subtracting labour compensation. It is the gross compensation for capital, including profits and depreciation allowances. Being a residual measure it is the remuneration for capital in the broadest sense, including tangible, intangible, mineral resources, land and financial capital. In all regions, the compensation for capital and high-skilled labour is increasing relative to medium-and low-skilled labour (see Figure 5). In advanced regions, the increasing importance of capital and high-skilled labour is a reflection of the increased investment in so-called intangible assets that are becoming increasingly important for growth in advanced nations.

Figure 5 GVC Income by production factor, change between 1995 and 2008.



Note: In million 1995 US$. GVC income earned by high-skilled labour and capital (HS+K) and by medium- and low-skilled labour (MS+LS).

Source: World Input-Output Database (WIOD).

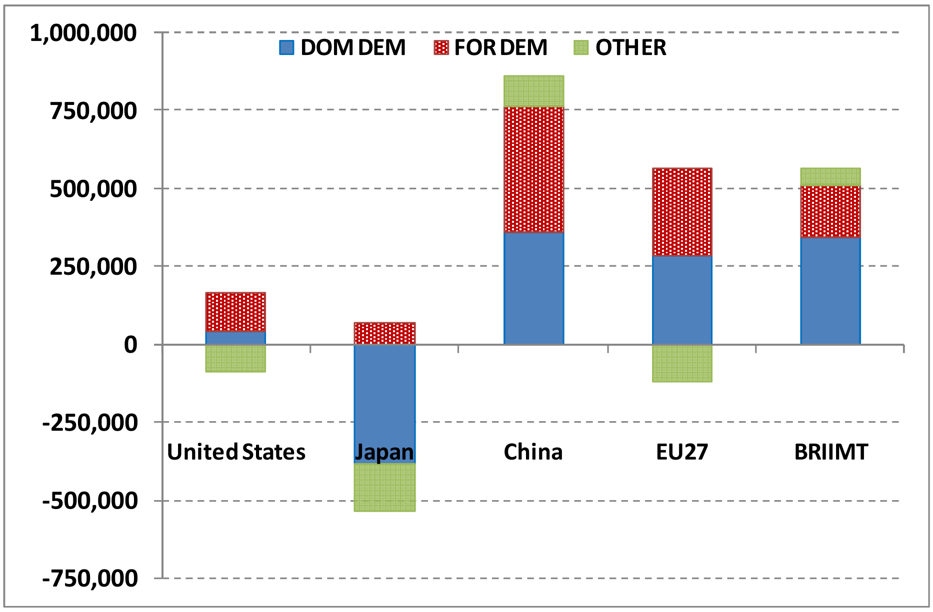
Employment in services activities for global manufacturing increased

An increasing number of jobs involved in the global production of manufacturing products is to be found outside manufacturing industries. This share is growing. In Europe, the number of manufacturing workers involved in manufacturing GVCs declined whereas the number of workers in services increased. In 2008, almost half of all jobs related to global manufacturing production are found in non-manufacturing sectors. A similar shift can be seen in other advanced regions.

Foreign demand important source of growth for Europe

The WIOD also allows decomposition from the demand side. A demand side perspective opens up the possibility to investigate the impact of changing global demand structures on a country's GVC income. We decompose the change in a country's GVC income (K) into a part related to changing domestic demand (Cdom), changing foreign demand (Cfor) and changes in the structure of global production (A). The latter basically indicates to what extent a country has improved its GVC income by serving global demand through exporting intermediate products that are used in production by other countries. Advanced countries all lost GVC income due to the changes in the organisation of global production (indicated by OTHER in the figure). Basically, a strong process of substitution took place in which domestically produced intermediates were substituted for by imported intermediates. This source of GVC income hence contributed negatively. In addition, domestic demand was increasingly served by imports. In the EU domestic demand suffered less from import substitution and it contributed strongly to GVC income growth. The opposite is found for the emerging countries which benefitted from strong domestic demand growth and from the changes in global production by serving the global demand for intermediates. China benefitted in particular from serving foreign final demand. This source contributed to almost halve of its GVC income increase.

Figure 6 Sources of change in GVC income (in million 1995 US$), 1995-2008.



Note: change in global income decomposed into change due to changes in domestic demand (DOM DEM), in foreign demand (FOR DEM) and reorganisation of global production (OTHER).

International integration of production: factor trade and employment effects

(The Vienna Institute for International Economic Studies - WIIW)

Production is becoming more and more globalised

The internationalisation of production has been one of the key driving forces of EU integration. This on-going process has been the underway since the 1990s when Eastern European countries rapidly integrated into the European economy, a process which resulted in the enlargement of the EU in 2004 and 2007. This process has taken place at a time when overall international economic integration has gained momentum within other regions (with the signing of the NAFTA agreement and the emergence of Asian production networks) as well as between regions (which is seen most clearly with the emergence of China). These developments have led to increasing interlinkages across economies and particularly in a few key sectors such as electronics and the transport equipment industry.

World input-output table covers all inter-regional direct and indirect flows

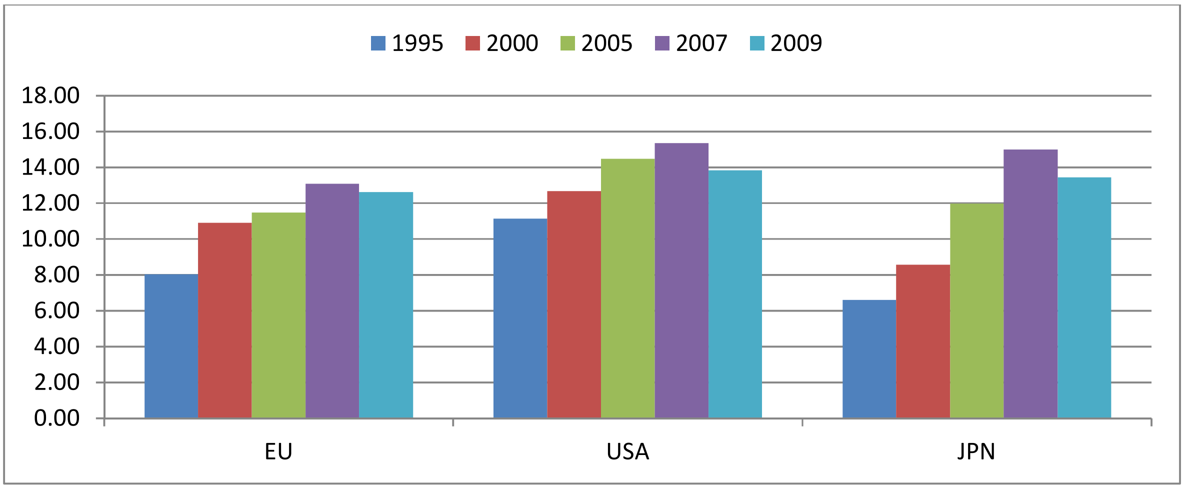
The strength of these interlinkages is measured using indicators of vertical specialisation. Such indicators are based on input-output tables which also provide information on the imports of intermediates by industry. The WIOD database also splits up these imports by source countries thus allowing one to properly account for inter-country and inter-industry flows of goods for the 41 countries (including rest of the world) and 35 industries covered. Taking account of these inter-regional trade flows generalises the most widely used indicator of vertical specialisation in the literature introduced by Hummels et al. (2001).

Import content of exports is increasing significantly, but falling over the crisis

Based on such an indicator, which gives information on the "direct and indirect import content of exports" as a proportion of the total output needed to produce these exports, the rising importance of international production is clearly observable.

Figure 1 demonstrates the strong increase in this indicator over the period 1995-2007 for the major advanced economies (i.e. the EU, the USA and Japan). For EU-extra trade the foreign content increased from 8% in 1995 to 13% in 2007. Even stronger increases are seen for Japan (from 6.5% to 13%). Interestingly, the share is still relatively low for the EU when compared with the other two countries. A second striking finding is that this share decreased over the crisis period (2007-2009) in all countries by 1-2 percentage points. For the EU member states these shares range from 20% in Great Britain to more than 40% in Hungary and Luxembourg with the simple average across EU member states being about 30% indicating the rising importance of production integration.

Figure 1 – Share of direct and indirect import content of exports in %



Source: WIOD database

Geographic sourcing structure of import content of exports shifted to emerging markets

These foreign components of a country's exports are sourced from various suppliers. Since 1995 the geographic sourcing structure has changed significantly for EU members due to the European integration process and the increasing importance of emerging economies, most notably China. Figure 3 provides information on the foreign component of exports by region comparing the EU-15 and EU-12 to the USA and Japan. Differentiating intra-EU sourcing between the EU-15 and the EU-12 indicates a strong within-EU integration process of the latter group which increased from 4.5% in 1995 to almost 10% in 2009. With respect to extra-EU sourcing the emergence of China is clearly visible. The share of China increased from 5.7% to almost 25% mostly at the expense of Japan (12.5% to 5.7%) and the USA (24% to 15%). During the crisis (2007-2009) the shares of all source countries of the EU, with the exception of China, declined or remained constant; with respect to intra-EU sourcing it turns out that intra-EU15 sourcing slightly declined as well, while the share of EU12 countries increased.

Vertical specialisation is closely linked to inter-country value added flows

The concept of vertical specialisation is closely linked to calculations of the value added content of trade (i.e. *domestic* value added embodied in a country's exports and foreign value added embodied in a country's imports) and trade in value added (i.e. a country's value added embodied in other countries consumption) as outlined in Stehrer (2012). The foreign value added content of the EU's exports is increasing in line with the increasing vertical specialisation (for details see Foster-Stehrer-deVries, 2012).

Macroeconomic imbalances remain but differ by factor of production

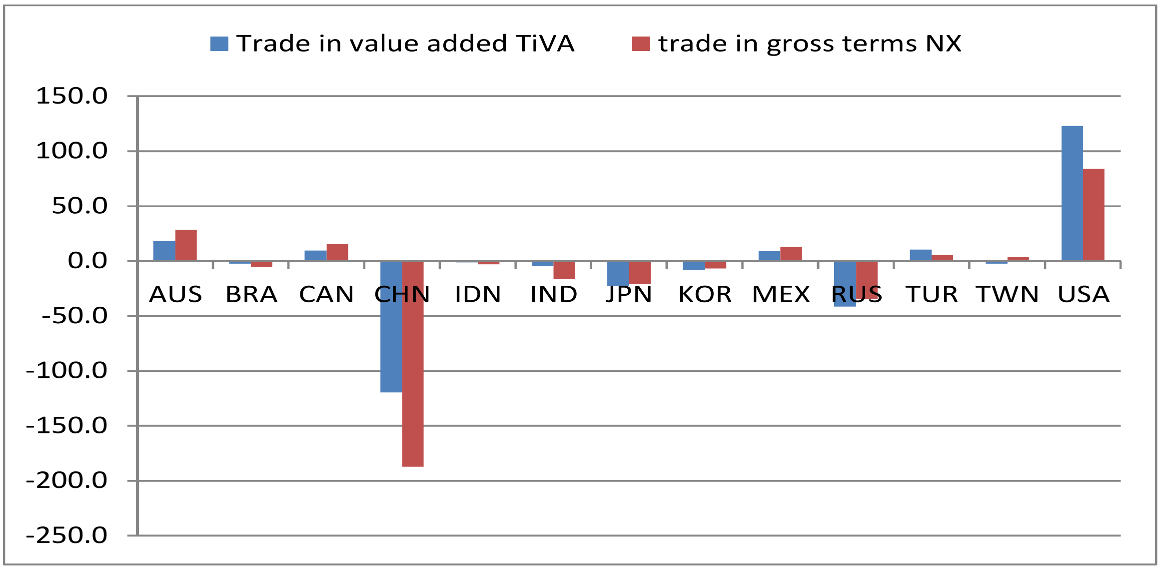
In a mirror perspective, countries are also themselves part of other countries supply chains, i.e. other countries' source for intermediates. Though a country's overall trade balance does not change, the WIOD dataset allows for the calculation of trade imbalances by factor of production.

Results reveal that the advanced economies tend to be net importers of capital in value terms and net exporters of high-educated labour. This result is triggered by the relatively high capital intensity of assembly production in the emerging economies combined with low wages in these countries, while advanced economies tend to export high-tech goods which are skill-intensive. In physical terms, the advanced economies are net importers of low-skilled labour in particular, which is due to low labour productivity in the emerging and developing economies (for details see Foster-Stehrer-deVries., 2012, and Stehrer, 2012).

Bilateral net trade in value added differs from trade balance in gross terms

In a bilateral context the trade balances when measured in value added terms might differ from trade balances when measured in gross terms. Whereas the EU-27 trade balance with the US in value terms was slightly larger than in gross terms the deficit with China was significantly lower. Differences for other countries are less strong (see Figure 2).

Figure 2 – Bilateral trade balances, 2008



Source: WIOD database

Scale effect of offshoring offsets productivity effect

The increasing internationalisation of production triggers fears of potential employment losses in advanced economies. Econometric analysis allows for the splitting of the effects of increased production sharing into a productivity and a scale effect; the former due to the fact that less domestic labour is needed to produce a particular level of output and the latter due to firms becoming more competitive due to offshoring activities. Results when considering total employment tend to suggest that while there has been a negative technology effect of both narrow (i.e. relocation of a sectors' activities into the same sector of another country) and broad offshoring (i.e. offshoring of activities to other countries in any sector) the overall effect of offshoring has been neutral. The negative technology effects tend to be more prevalent in manufacturing industries than in services industries. This implies that the positive scale effect of offshoring offsets the negative effect technology effects. Results for the different employment types (low-, medium- and high-skilled) are largely similar to those for total employment with a negative technology effect usually offset by a positive scale effect, resulting in an overall neutral impact of offshoring (see Foster-Pöschl-Stehrer, 2012, for details).

Offshoring triggers changes in the wage structures by squeezing medium-skilled labour

A further concern is that although offshoring does not impact strongly on the levels of employment in general it might trigger changes in the relative wages of labour by skill types. Examining the effects of offshoring on the wage bill shares by education (see Foster-Stehrer-Timmer-deVries, 2012) suggests that both narrow and broad offshoring have tended to reduce the cost shares of all types of employment in total variable costs, and that they have tended to impact on medium-skilled workers to a greater extent than low- and high-skilled workers. Results on the elasticities of the cost shares with respect to offshoring are found to be somewhat more mixed – reflecting the fact that medium-skilled workers tend to make up the largest shares in total variable costs – but in the majority of cases the elasticities are found to be largest in the case of medium-skilled labour. Results for manufacturing offshoring also tend to suggest that offshoring has impacted upon medium-skilled labour to a greater extent than the other types of labour in the majority of cases. Overall, the results would seem to suggest that in the recent years, offshoring has impacted upon all types of labour, with medium-skilled labour being squeezed to a greater extent by foreign offshoring (see also Stehrer-Stöllinger, 2012, for a discussion on offshoring effects by occupational categories).

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Use of WIOD to analyse the impact of trade: employment generation vs. emissions responsibilities

(Institute for Prospective Technological Studies, IPTS)

In the last decades the world has witnessed a rapid and profound process of globalization that has favoured the flow of goods, services and production factors around the world. This phenomenon becomes clear when we look at the statistics of international trade. According to the World Trade Organization, between 1995 and 2010, the world trade volume tripled in nominal terms to exceed €14 trillion (30% of world GDP).

The term globalization is usually associated to different economic concepts such as liberalization, specialization, outsourcing or competitiveness that contribute to shape the distribution and division of production and consumption activities across world regions.

The consequences of the growth in international trade can be observed in many dimensions of modern societies. For instance, by exporting goods and services countries can obtain economic benefits, such as the creation of new jobs. On the other hand, exporting countries have to tackle the environmental consequences of producing those same exported goods.

This relation between increasing trade flows, employment generation and environmental degradation seems to be especially relevant for the problem of climate change. In the last years, a group of emerging economies has led employment generation worldwide, while increasing significantly their emissions of greenhouse gases (GHG). At the same time, developed countries have stabilized their GHG emissions. It has been argued that both of these trends are partly related to, the increasing exports of developing countries and their growing market share in developed economies. However, while job creation is a national or local benefit, GHG impacts are shared globally.

This triangle formed by trade, employment and emissions connects with the outstanding political debate about how to evaluate the relative contribution of different countries to climate change. The Kyoto Protocol establishes that each country would be responsible for the emissions generated within its national territory ("producer responsibility"). According to this approach, countries could accomplish national emission reduction targets by displacing emissions to other countries.

Recently, some developing countries are reluctant to participate in climate change mitigation alleging that, besides their per capita emissions are lower, a great part of their emissions are generated when producing exports and that this should be taken into account when allocating the responsibilities for the emissions. By using this so-called "consumer responsibility" approach, each country would be responsible for all the emissions embodied in its final demand, regardless where they have been generated. However, supporters of this method of responsibility allocation often avoid the fact that together with the potential environmental repercussions, the exporting countries may also obtain economic and job creation benefits from those same exports.

The World Input-Output Database (WIOD) has the merit of containing a time series of socioeconomic and environmental accounts (including resources use and air emissions) for the 27 Member States of the European Union (EU), as well as for the main world economies. This information is especially useful to analyze the evolution of the links between trade, employment and environment. As example, this database has been used to calculate the employment and greenhouse gas (GHG) emissions generated by exports and imports of the world's main economies, and to analyze to what extent trade drives the evolution of employment and emissions.

How many employments and GHG emissions are generated by international trade?

Key observations
There is a need for reducing emissions embodied in international trade • In 2008, 23% of worldwide GHG emissions were linked to international trade, thus emissions embodied in international trade should not be ignored when assessing the options for reducing global GHG emissions; • when doing that, one should also bear in mind that 20% of world employment is generated by international trade.
The EU occupies a central position in the global exchange of employments and emissions • in the year 2008, the EU ranked 3rd in employment embodied in exports and 2nd in GHG embodied in exports; • was the region that generates the largest amount of employment abroad through imports (165 million jobs, 28% of the total employment generated by international trade) and was the largest GHG emissions importer around the world (2.4 GtCO2e[1], 25% of traded emissions); • almost 40% of the employment and the emissions generated by EU imports were located in China (55 million jobs and 0.7 GtCO2e); • the EU was the region with the largest emission deficit: 1.5 GtCO2 (Figure 3). This deficit was equivalent to 30% of the emissions generated within the EU.
China and USA could be encouraged to play an important role in reducing the emissions embodied in international trade: • China is the country that has contributed most to the growth in GHG emissions. Between 1995 and 2008, more than 40% of the increase in global GHG emissions took place in China; • in 2008, 20% of the change in Chinese emissions was linked to international trade, and China exports 34% of its national emissions. China was the world largest net exporter of emissions, with a surplus of 2.1 $GtCO_2e$ (25% of its total emissions); • in terms of employment, China was the country that benefitted most from the increase of international trade, 29% of Chinese total employment was linked to exports; • in 2008, USA ranked 2nd in terms of GHG emissions and had the second largest emissions trade deficit.

Employment

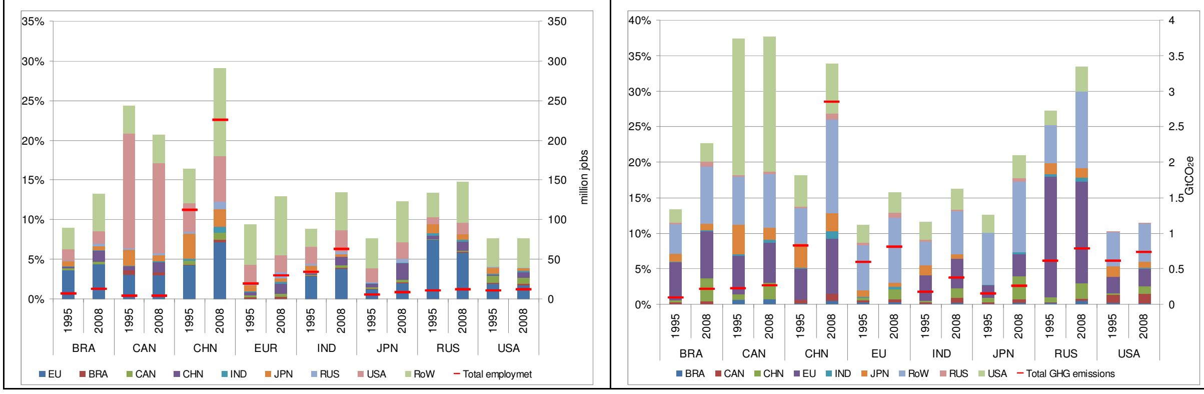
According to the analysis derived from the WIOD, in 2008 international trade generated 20% of the total employment in the world (605 million jobs), growing form 14% in 1995 (334 million jobs). Figure 1 (a) depicts for the main world economies the number of jobs embodied in exports for the years 1995 and 2008 (red mark, right hand side axis) and the percentage it represents over total employment (bars, left hand side axis). It also includes information on the destination country of exports. In 1995, exports contributed to generate 9.5% (19 million jobs) of the total EU employment, while in 2008 it reached 13% (around 30 million jobs). USA and China were the countries that largely contributed to generate employment in the EU. These two countries were responsible for 17% and 10% of the employment embodied in EU exports.

When compared to other countries, however, the EU export-related employment share is lower than that of the world average. For instance, China doubles the European figures. In terms of employment, China is the country that benefitted most from the increase of international trade: between 1995 and 2008, the number of workers devoted to exports doubled (from 112 million to 225 million) and the share of total employment generated by exports increased from 16% to 29%. Almost 25% of these jobs were attributable to EU exports. In India 14% (63 million of jobs) of total employment was devoted to exports, of which 28% were related to EU imports.

[1] Giga tonnes of CO_2 equivalents, 1 $GtCO_2e = 10^9$ tCO_2e)

Figure 1: Share of employment and GHG emissions embodied in exports over total employment and number of jobs embodied in exports, 1995 and 2008.

(a) Employment (%, million jobs)	(b) GHG emissions (%, GtCO2e)



BRA: Brazil; CAN: Canada; CHN: China; EU: European Union; IND: India; RoW: Rest of the World; RUS: Russia; USA: United States of America; World: World total.

The EU is the leading geographical area in creating jobs elsewhere through imports. In 2008, almost 28% (165 million jobs) of the total employment generated by international trade was due to EU imports. China and India were the countries that most benefitted from EU imports, being the number of jobs generated in these countries 55 million and 18 million, respectively. USA generated 20% of the employment embodied in trade while China, 7%.

GHG emissions

The increase in the volume of goods traded around the world has also impacted the GHG emissions. Between 1995 and 2008, the volume of global GHG emissions linked to trade almost doubled, passing from 4.8 $GtCO_2e$ (16% of total emissions) to 9.6 $GtCO_2e$ (24% of total emissions). Figure 1(b) shows for each country the GHG emissions embodied in exports for the years 1995 and 2008 and the percentage it represents over total emissions. It also includes information on the destination country of exports. In 2008, the EU exported 0.8 $GtCO_2e$ (16% of its domestic emissions) compared with 0.6 $GtCO_2e$ in 1995. The EU was the world's second area in terms of emissions embodied in exports (8.5% of the worldwide emissions embodied in international trade), being USA and China the main destinations of EU exports of GHG.

China is the country with the highest growth in embodied emissions in exports. Between 1995 and 2008, Chinese exports of GHG increased by a factor of 3.5, from 0.8 $GtCO_2e$ to 2.8 $GtCO_2e$. In 2008 China exported 225 $GtCO_2e$, which is 30% of its total emissions and 34% of the total GHG emissions embodied in international trade. The EU and USA were the destination regions for respectively 23% and 21% of the Chinese exports of GHG emissions. Finally, USA is the third country with highest GHG exports (0.8 GtCO2e).

On the other side, the EU turned out to be the main destination for the global emissions generated by international trade. In 2008, the EU imported 2.4 $GtCO_2e$, almost 25% of total emissions exported around the world. 28% of the EU imported emissions came from China while 14% were imported from Russia. The EU is followed by the USA in terms of GHG embodied in imports (1.7 $GtCO_2e$), China (0.7 $GtCO_2e$) and Japan (0.6 $GtCO_2e$).

The emission trade balance is defined as the difference between exported and imported emissions. This indicator allows analyzing to what extent a country is a net exporter or importer of emissions. If the emissions embodied in the exports of one country are larger than those embodied in its imports the country will be a net emission exporter and, therefore, it will have an emission surplus. Otherwise, the country will be a net importer and will show an emission deficit. In 2008, the EU is the region with the largest emission deficit: 1.5 $GtCO_2e$. This deficit is equivalent to 30% of the emissions generated within the EU. The emission trade balance of USA shows a deficit of 1 $GtCO_2e$ (16% of its national emissions) and the emission deficit of Japan is 0.4 $GtCO_2e$ (32% of its emissions). On the contrary, China is the world largest net exporter of emissions, with a surplus of 2.1 $GtCO_2e$ (25% of its total emissions).

To what extent are changes in employment and GHG emissions attributable to international trade?

Key observations
The drivers of the change in employment and GHG emissions in main economies • the evolution of both variables is mainly driven by the growth in the level of domestic final demand; • trade plays a secondary but relevant role; • technological change contributes notably to offset the effects of domestic final demand and trade on employment and emissions.

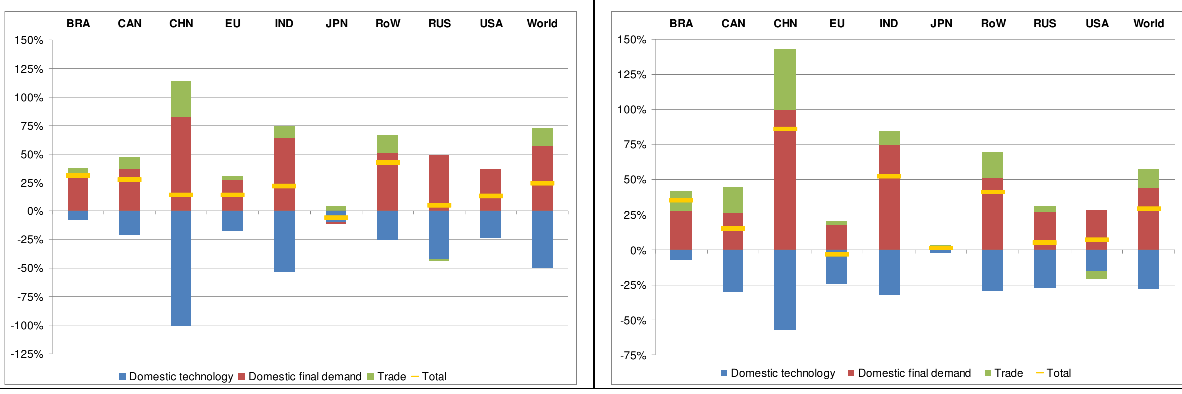
Employment

The increasing level of connectivity across world economies has derived in a rising dependence of employment to international trade, to the point that trade has become one of the main drivers for jobs generation. An analysis of the drivers of job and GHG emission changes carried out with WIOD shows that between 1995 and 2008, employment grew by 24% worldwide (577 million jobs) (Figure 2(a)), from which changes in international trade contributed to generate 383 million of jobs (+16% compared to 1995). However, the growth in domestic final demand (i.e. excluding exports) and not trade was the main driver for the increase in employment (1381 million jobs, +58% compared to 1995).

On the other hand, the increase in labour productivity due to technological change reduced employment by 1187 million people (-50% compared to 1995), offsetting to some extent those positive effects of trade and final demand. In the EU, as in most of the main world economies, international trade also contributed to the generation of employment, but its role was secondary in importance compared with the domestic final demand component. Between 1995 and 2008, total employment increased in the EU by 14% (28 million jobs), and changes in trade patterns contributed to generate 6.7 million jobs (+3% compared to 1995). China is the country where international trade created the highest number of jobs (211 million, +31%), followed by India (36 million, +10%).

Figure 1. Main drivers of the change in employment generation and GHG emissions, 1995-2008. (%)

(a) Employment | (b) GHG emissions



BRA: Brazil; CAN: Canada; CHN: China; EU: European Union; IND: India; RoW: Rest of the World; RUS: Russia; USA: United States of America; World: World total.

GHG emissions

In 2008, the world's GHG emissions totalled 39.3 $GtCO_2e$. China was the country that emitted most (21%, 8.4 $GtCO_2e$), followed by USA (16%, 6.4 $GtCO_2e$), the EU (13%, 5.2 $GtCO_2e$), Russia (6%, 2.3 $GtCO_2e$) and India (6%, 2.3 $GtCO_2e$). These five regions account for more than 60% of global GHG emissions. Between 1995 and 2008, the world GHG emissions increased by 29%, releasing additional 8.9 $GtCO_2e$. Country data reveals that China is the country that most contributed to this increase (3.8 $GtCO_2e$), followed by India (0.8 $GtCO_2e$), USA (0.4 $GtCO_2e$) and Brazil (0.24 $GtCO_2e$). In the EU, the emissions of GHG slightly decreased by 0.3% (-0.17 $GtCO_2e$).

The change in the domestic final demand was the main driver for the growth in global GHG emissions, contributing to an increase of 41% (12.7 $GtCO_2e$) compared to 1995 (Figure 2(b)). Changes in international trade caused a growth of 12% (3.7 $GtCO_2e$) in GHG emissions, while technological change contributed to reduce the emissions by 24% (7.3 $GtCO_2e$). In the EU, as it occurred in most of the countries, changes in domestic final demand were the main driver for the increase of emissions (0.9 $GtCO_2e$, +18% compared to 1995). International trade had a positive net effect in the EU of 0.17 $GtCO_2e$: while the increase in imports reduced the emissions by 0.2 $GtCO_2e$, the growth in exports increased the emissions by 0.37 $GtCO_2e$. Changes in domestic technology contributed to reduce the emissions by 1.3 GtO_2e (-24% compared to 1995). China is the country with the highest increase in GHG emissions due to trade (2.1 $GtCO_2e$), although the main driver for the growth in the emissions was also the domestic final demand.

Trade Performance in Internationally Fragmented Production Networks: Concepts and Measures

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This note is meant to bring discussions about the measurement of the value added content of trade forward. Comments and suggestions are welcome.

Abstract
In this note, we outline two perspectives on the value added content of international trade. We distinguish two perspectives: the “direct trade flow (DTF)” perspective and the “global value chain (GVC)” perspective. We argue that both have their particular interpretations. The direct trade flow perspective is useful to analyse the domestic value added content of exports. The GVC perspective is useful for analysing the importance of foreign demand for income generation in the domestic economy. In addition, the GVC perspective can be used to trace the development of global production networks.

1. Introduction

The fragmentation of production across national boundaries is a defining feature of the modern international economy. This calls for new measures to analyse trade patterns. Figures on gross exports do not give much information anymore about the actual value added by the exporting country: if a country has to import a large amount of intermediate inputs to assemble its export products, the value added is much less than the gross export value. In the end, it is the domestic value added content that matters, as this amounts to the compensation for domestic labour and capital due to demand from abroad.[2]

Recently, following a well-known article by Hummels et al. (2001), various measures linking value added and exports have been proposed in the literature. In this note, we discuss the two main perspectives: the “direct trade flow” perspective and the “global value chain (GVC) income” perspective. The results obtained by the computations associated with these perspectives should be interpreted differently. The choice for one specific perspective should depend on the particular policy question at hand.

The expositions are based on a single hypothetical example of a simple trade network, depicted in Figure 1. It depicts the flows of three types of intermediate inputs (mining products, business services and manufactured steel) that are used by the car industry to manufacture final products. These final products are produced in two countries (A and C). In this hypothetical case, A sells cars to consumers in A itself and in B. C’s car industry sells on its domestic market and to D. It is

[2] It is important to stress from the outset that throughout this note, we consider both trade in goods and services. Financial flows, such as repatriation of profits, are not considered. It is the value added that crosses industry and country borders embodied in products that we try to measure.

important to note that 1000 dollars of value added are created in this system (400 in A, 300 in B and 300 in C). These 1000 dollars are reflected in the total value of the sales to consumers, in the bottom row. [3]

The flow of gross exports and imports is given in Table 1. The conventional bilateral trade balances (based on gross exports and imports) for this system are given in Table 2.

Table 1: Gross exports from country in row to country in column

To / From	A	B	C	D	Total
A		400	0	0	400
B	200		400	0	600
C	0	100		100	200
D	0	0	0		0

Table 2: Gross trade balances (bilateral, surpluses/deficits for countries in rows)

	A	B	C	D	Total
A		200	0	0	200
B	-200		300	0	100
C	0	-300		100	-200
D	0	0	-100		-100

2. The "direct trade flow" (DTF) perspective

The first approach to studying links between value added and trade in the context of increasing production fragmentation aims to measure the *domestic value added (DVA) content of exports*.[4] Since the value of gross exports equals the value of imported intermediate inputs plus domestic value added in these exports, this approach is in fact equivalent to computing the vertical specialization index introduced by Hummels et al. (2001), multiplying this index by gross exports and subtracting the result from the gross export figure.[5] The Hummels et al. measure of vertical

[3] Please note that real-world global trade networks are much more intricate than the simplified example that is used for illustrative purposes in this note. These networks are much less "linear". It is much harder to denote an industry as "upstream" or "downstream", because of feedback loops (such as the business services industry in C using C's business services as an intermediate input). These loops often also have an international dimension, which complicates the computations outlined in the sections below.

[4] In launching a new initiative, OECD-WTO (2012) labeled this approach 'trade in value added', a label that usually refers to a different concept (see Section 3).

[5] In most input-output tables, the value added block does not only contain a row for value added (at basic prices), but also additional rows for "taxes minus subsidies on products", "direct purchases abroad by residents", etc. In these

specialization is defined as the value of imports required to produce one unit of exports. The higher this vertical specialization index, the lower the domestic value added content of a unit of exports.

A typical question would be: how much DVA is contained in exports from C to B? In the case described this would be 100, as all value of the exports is created in C itself. This is because C's business services industry does not use any imported intermediate inputs. More complex is the question how much of B's DVA is contained in exports from B to C. B is using imported intermediates (from A and C) and hence the value added by B to its exports is less than its gross export value. Gross exports of steel by B are 600. Of this value, 300 is added by B, so exports of domestic value added by B amount to 300. If we assume that the DVA content of a single product produced in a single country does not depend on the country of destination, then B exports 100 of DVA to A (200/600*300) and 200 to C (400/600*300).[6] Note that this concept relates to direct trade flows between countries: the DVA that is contained in products that leave a port in B and arrive at a port in C.

This calculation can also be done for multiple products. For example, A exports mining products and cars to B: how much of A's value added is contained in A's exports to B? In the case described above, the answer would be 200+100=300, i.e. the value added in A's mining exports to B's steel industry, plus the value added by A's car industry to produce cars sold to consumers in B. To arrive at 100 for the second part, we assume again that value added per dollar of output is identical for A-cars sold in A and A-cars sold in B. The results for all bilateral trade flows are given in Table 3. Combining Tables 1 and 3 we can derive the value added content of exports (as a share of gross exports), see Table 4.[7]

By considering the difference between exports of value added from A to B and exports of value added from B to Aare equal to imports of value added from B to A, we can derive value added in net trade between these countries. The full set of bilateral value added in net trade figures is documented in Table 5. These numbers are difficult to interpret, however. Take the example of country D. D has a gross trade deficit of 100, but in value added terms using this direct trade flow perspective its deficit is substantially smaller. The reason is that in this approach only the value added by the direct exporter (country C) is considered and not the value added in the production stages further upstream. In this case the value added by B's steel industry and A's mining industry is not taken into account.[8] We thus conclude that the direct trade flow perspective is useful for examining domestic value added content of export flows, but should not be used to examine the value added content of imports or of net trade.

Table 3: Value added in exports, DTF perspective

To	A	B	C	D	Total

cases, the value of gross exports equals the sum of the value of imported intermediate products, value added at basic prices and these additional cost components.

[6] DVA contents in products can vary across countries of destination. For China and Mexico, for example, we know that goods produced for exports have a different domestic value added content than goods for domestic use (Hummels et al., 2001, Koopman et al, 2008, Yang et al., 2009, and Johnson and Noguera, 2012)

[7] Since D does not export anything, the DVA contents of its exports are not defined.

[8] In the recent literature, the direct trade concept is used in the recent literature on testing the Heckscher-Ohlin-Vanek (HOV) theorem (e.g. Trefler and Zhu, 2010), which relates empirical trade patterns to differences in national endowments of production factors. To this end, production factor contents (in physical terms rather than in terms of their compensation) in net trade are considered. For the purposes of testing the HOV theorem, all factor contents in net trade must be considered, including factors deployed in third countries. In this context, the factor contents of C's exports to D (and consequently, D's imports from C) would also contain factor inputs in A's mining and in B's steel industries.

From					
A	(100)	300	0	0	300
B	100	(0)	200	0	300
C	0	100	(166.7)	33.3	133.3
D	0	0	0	(0)	0

*The values between parentheses (in the shaded cells) indicate domestic value added that does not cross a border. If these numbers would also be included in row-wise sums, domestic value added of the exporting country would be obtained.

Table 4: Value added content in exports (%), DTF perspective

To / From	A	B	C	D	Total
A		75%	0	0	75%
B	50%		50%	0	50%
C	0	100%		33.3%	66.7%
D	-	-	-		-

Table 5: Value added in net trade (bilateral, surpluses/deficits for countries in rows), DTF perspective

	A	B	C	D	Total
A		200	0	0	200
B	-200		100	0	-100
C	0	-100		33.3	-66.7
D	0	0	-33.3		-33.3

We would like to stress that the domestic value added content of exports can be measured on the basis of a national input-output table (giving a detailed account of the values of domestic interindustry flows, plus a vector or matrix of the use of imported intermediate inputs by using industry).[9] The bilateral measures require a split of the exports by country of destination but still do not require a full world input-output table.

Koopman et al. (2010) do not only compute value added in exports. They also decompose this value into three components: value added contained in exports that (i) end up in final products in the importing country (i.e., value added in B's steel exports to A that get embodied in A's cars sold on the domestic market), (ii) end up in final products used in the exporting country (i.e. value added in B's steel exports to A that get embodied in A's cars exported to B itself), and (iii) end up in third countries (i.e., value added in B's steel exports to C that get embodied in C's cars sold to consumers in D). For this type of calculations, a full world input-output table is needed. Some pitfalls should be avoided. An example of such a pitfall is including part of the value added in A's mining industry twice, when computing A's DVA in exports to B. This problem emerges when A's mining products exports are unduly considered as exports of final products, because this approach fails to take into account that exported cars contain some value added generated in the mining industry.

3. The global value chain (GVC) perspective

The direct trade flow perspective focuses on the value added content of particular trade flows originating from a country. In contrast, the GVC perspective takes final consumption of goods in a country as a starting point and traces the value that has been added by different countries in the various production stages. In this perspective, the *exports of value added* is defined as the amount of value added produced in a given source country that is ultimately *embodied* in final products absorbed abroad (Johnson and Noguera, 2011; Bems et al., 2011).

The hypothetical example depicted in Figure 1 can serve as an illustration. The value added in C business services is embodied in cars sold to consumers in all four countries considered. Although there are no products physically crossing the "border" between C and A, C still exports value added to A, according to this concept. This is due to the fact that the C business services industry adds value that ends up in cars driven by A consumers.[10] If e.g. demand for cars in A is dropping this will have a negative effect on the value added generated (and hence income) in C although there is no direct trade link between the two. This simplified example shows that the GVC perspective requires world input-output tables: without information about the production structure of B and information about the countries to which C supplies, it would be impossible to arrive at the value added generated in B that is consumed in A.

The exports in value added of C to D can be computed in a stepwise fashion. First (assuming identical value added to output ratios for C cars sold in C itself and in D as before), 33.3 dollars of value added C car industry value added end up with D consumers (1/6th of 200). Next, value added generated further upstream in C should be considered. As mentioned above, the value added in C business services is finally embodied in cars purchased in all four countries. How much of this value added can be attributed to the cars sold in D? For each dollar of output of the C car industry, 2/3 dollars of B steel are needed (output of C's car industry equals the 400 dollar

[9] See Dietzenbacher (2012), who proves that it does not matter for vertical specialization indices whether national input-output tables or international input-output tables are used.

[10] Note that this is analogous to the well-known concept of 'carbon footprints': if factories in country A emit pollutants associated with the production of intermediate inputs required for consumption in country B, these are considered part of country B's carbon footprint.

of intermediate inputs plus 200 dollars of value added it creates itself).[11] For each dollar of B's steel in its turn, 1/6 dollars of C business services are needed. Each of these contain 1 dollar of C's value added. Hence, we have that the 100 dollars of cars sold in D require 100 · (2/3) · (1/6) · 1 = 11.1 dollars of C's business services value added. Hence, the total C exports in value added to D amount to 33.3 + 11.1 = 44.4 dollars.

The bilateral exports of value added are given in Table 6. Note that although A does not deliver directly to either C or D, there is an export of value added from A to these countries, indirectly through B. This indicates the basic difference between the DTF and the GVC perspective. Although there is no direct trade flow from A to D, any change in final demand in D will have an impact on the value added generated in A. This is picked up in the GVC approach, but not in the DTF approach as described above.

Table 6: Exports of value added (GVC perspective)

To / From	A	B	C	D	Total
A	(133.3)	133.3	111.1	22.2	266.6
B	50	(50)	166.7	33.3	250
C	16.7	16.7	(222.2)	44.4	77.7
D	0	0	0	(0)	0

*The values between parentheses (in the shaded cells) indicate domestic value added that does not cross a border. If these numbers would also be included in row-wise sums, domestic value added of the exporting country would be obtained.

Based on Table 6 we can define imports of value added by A from B as the exports of value added from B to A. By subtracting the imports from the exports, net trade in value added is derived, see Table 7. Comparing the results in Table 7 to those for conventional trade balances in Table 2 shows that the values summed over countries-of-destination are identical for the two indicators. B, for example, remains a net exporter and the extent to which its exports exceed imports does not change. This is a fundamental property of the GVC concept (see Johnson and Noguera, 2012) and makes it a useful indicator for analysing net trade in value added.

Table 7: Net trade in value added (bilateral, surplus/deficits for countries in rows) (GVC perspective)

	A	B	C	D	Total
A		83.3	94.3	22.2	200
B	-83.3		150	33.3	100

[11] These input coefficients (defined as the values of intermediate inputs required per value unit of output) are contained in the well-known input coefficients matrices directly derived from input-output tables.

C	-94.3	-150		44.4	-200
D	-22.2	-33.3	-44.4		-100

The bilateral trade patterns in value added terms are different from those in gross terms, however. In the example, B has a surplus with D if the trade in value added concept is used, while it has neither a surplus nor a deficit in conventional gross trade terms. B's trade surplus with C is reduced significantly when considering trade in value added. A comparison of the results for trade in value added (Table 3) and value added in trade (Table 2) shows that the two concepts are very different, and not only in conceptual terms.

Trade in value added indicators are important when studying the domestic effects of global macroeconomic shocks such as the 2008 crisis (e.g. Bems et al., 2011) as well as for measuring income elasticities in a country to consumer demand in other countries. The GVC perspective is also useful when one wants to study how much various countries contribute to the value of a particular product, say a mobile phone produced in China as it allows one to trace the value added in all stages of production. Hence, it can be seen as an indicator of revealed competitiveness. Timmer et al. (2012) define *GVC income* as the income generated in a country by carrying out activities related to the production of manufacturing goods in any stage of the production process. Compared to traditional competitiveness indicators like a country's share in world exports, this new metric has three advantages. First, it indicates to what extent a country can compete with other nations in terms of *activities* related to global manufacturing, rather than competing in manufacturing products as measured by exports of *products*. These activities take place in manufacturing industries, but also in services industries. Second, it measures the share of a country in internationally contested markets. It is a reflection of an economy's strength to compete in both domestic and global markets. Third, income and employment effects of trade in tasks for separate groups of workers (such as low- and high-skilled) can also be determined in this unified framework. Timmer et al. (2012) argue that this approach leads to insightful conclusions about international competitiveness of countries in a world characterized by internationally fragmented production networks.

5. Concluding remarks

In this note we highlighted two perspectives on the value added content of trade. By outlining the basic ideas behind these methods, illustrating these by means of a simplified example and giving very brief accounts of potential uses of these concepts, we hope this note adds to the understanding of the concepts, in particular among non-specialists. Since both perspectives boil down to a specific decomposition of value added (GDP) as generated in a country to trading partners and to itself, it is very important that the input-output data used to compute the indicators accurately reflect national GDP levels and their division over industries. The basic philosophy behind the WIOD database (i.e., start from National Accounts data and treat these as hard constraints in the treatment of trade data that are not always in line with these) suits this purpose very well.

We hope that in future discussions a common language is being developed to avoid further confusion. Therefore we propose to always indicate the perspective taken when measuring value added trade. The terms "direct trade flow" (DTF) and "Global value chain" (GVC) perspective will hopefully serve this purpose.

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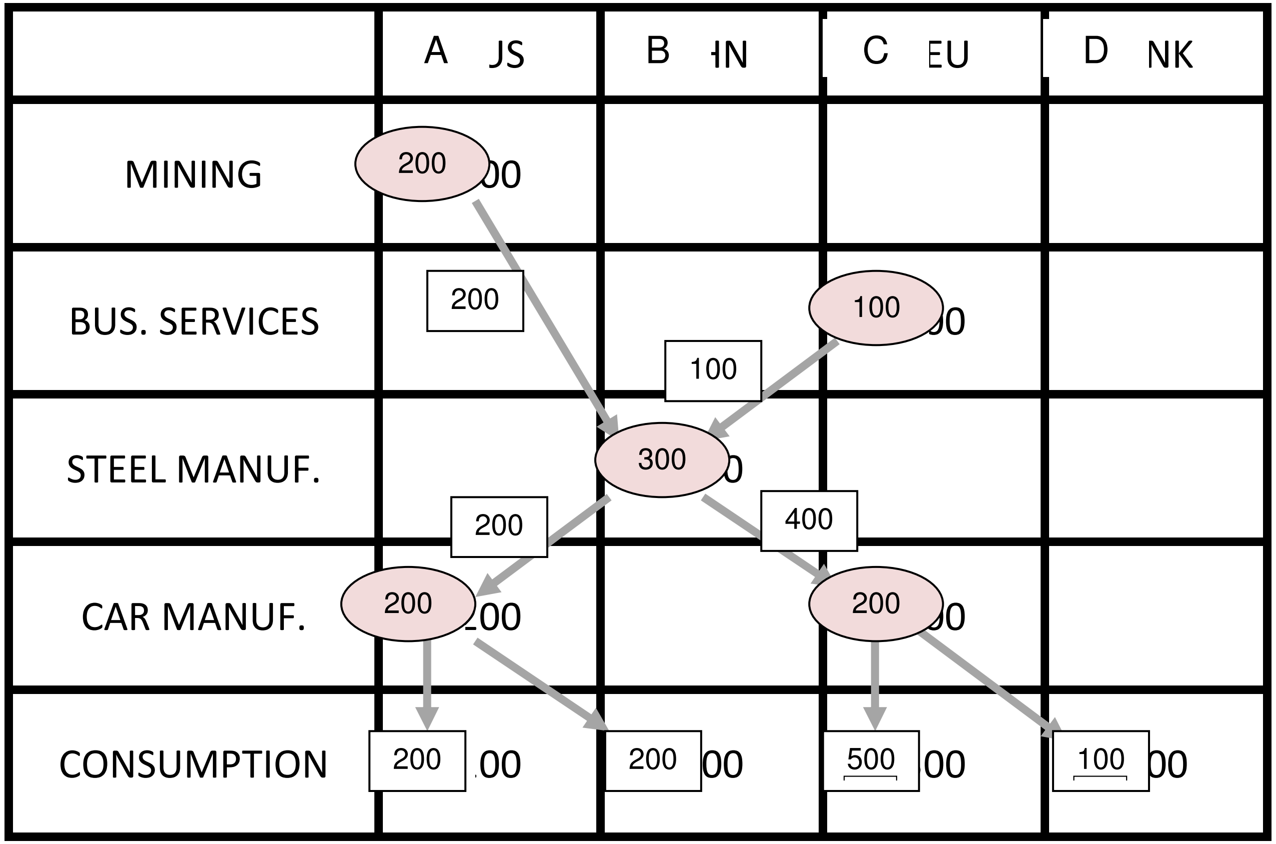
Figure 1: Stylized Network of Fragmented Production Chains



Values in rectangular boxes refer to the value of the transactions among industries and between industries and consumers as indicated by arrows.
Values in shaded ellipses indicate value added created in the industry to which the cell refers.

The World Input-Output Database (WIOD) - Contents

On April 16, 2012, the World Input-Output Database will be opened for the general public. This database has been developed to analyse the effects of globalization on trade patterns, environmental pressures and socio-economic development across a wide set of countries. The database covers 27 EU countries and 13 other major countries in the world for the period from 1995 to 2009. Broadly, it consists of time series of

World Tables (annual, 1995-2009)

- International Supply and Use table at current and previous year prices, with use split into domestic and import by country (35 industries by 59 products)
- World input-output table at current prices and at previous year prices (35 industries by 35 industries)
- Interregional Input-Output table for 6 regions (35 industries by 35 industries)

National Tables (annual, 1995-2009)

- National supply and use tables at current and previous year prices (35 industries by 59 products)
- National Input-Output tables in current prices (35 industries by 35 industries)

Socio-Economic Accounts (annual, 1995-2009)

- Industry output, value added, at current and constant price (35 industries)
- Capital stock, investment (35 industries)
- Wages and employment by skill type (low-, medium- and high-skilled) (35 industries)

Environmental Accounts (annual, 1995-2009)

- Gross energy use by sector and energy commodity
- Emission relevant energy use by sector and energy commodity
- CO2 Emissions modeled by sector and energy commodity
- Emissions to air by sector and pollutant
- Land use, Materials use and Water use by type and sector

List of countries in WIOD-database

European Union			**North America**	**Asia and Pacific**
Austria	Germany	Netherlands	Canada	China
Belgium	Greece	Poland	United States	India
Bulgaria	Hungary	Portugal		Japan
Cyprus	Ireland	Romania		South Korea
Czech Republic	Italy	Slovak Republic	**Latin America**	Australia
Denmark	Latvia	Slovenia	Brazil	Taiwan
Estonia	Lithuania	Spain	Mexico	Turkey
Finland	Luxembourg	Sweden		Indonesia
France	Malta	United Kingdom		Russia

Downloadable at http://www.wiod.org/database/index.htm