# TRADE IN VALUE-ADDED: CONCEPTS, METHODOLOGIES AND CHALLENGES (JOINT OECD-WTO NOTE)

1. With the globalization of production, there is a growing awareness that conventional trade statistics may give a misleading perspective of the importance of trade to economic growth and income and that "what you see is not what you get" (Maurer and Degain, 2010). This reflects the fact that trade flows are measured gross and that the value of products that cross borders several times for further processing are counted multiple times. Policymakers are increasingly aware of the necessity of complementing existing statistics with new indicators better tuned to the reality of global manufacturing, where products are "Made in the World".[1]

2. Gross recording of trade flows is not an issue by itself; as a matter of fact, they are essential when the focus is on the (increasing) interconnectedness of economies or the study of supply-chains, and global production networks. But it can be misleading, as is often the case, when one crudely relates gross flows of exports, say, with domestic value-added and national income, or its components such as profits or wages, and by extension, employment. For example, an exported good may require significant intermediate inputs from domestic manufacturers, who, in turn, require significant intermediate imports, and, so, much of the revenue, or value-added, from selling the exported good may accrue abroad to reflect purchases of intermediate imports used in production, leaving only marginal benefits in the exporting economy.

3. An often-cited case study that clearly illustrates the issue relates to the production of an Apple iPod (Dedrick *et al*, 2010). The study showed that of the $144 (Chinese) factory-gate price of an iPod, less than 10% contributed to Chinese value added, with the bulk of the components (about $100) being imported from Japan, with much of the rest coming from the US and Korea.[2] Many other studies present similar evidence. For example a recent WTO report calculated that the US-China trade balance in 2008 would be about 40 per cent lower if estimated in value-added terms. Similar results are provided in other studies such as a report from the USITC[3], which also shows a 50 per cent reduction in the EU15-China trade balance, and the Japan-China trade balance switching from a surplus in gross terms to a deficit in value-added terms.

4. In relatively closed economies, or indeed those where imports are typically goods or services for final (as opposed to intermediate) use, the assumption that a certain amount of exports generates an equivalent amount of benefits to the producing economy is relatively robust. But this characterises a world that, to some extent, no longer exists. Recent decades have seen an acceleration in the globalisation of production processes as trade costs have fallen - driven by technological progress and trade policy reforms.

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1 See for example the proceedings of a meeting organized in the French Sénat in 2010 (Sénat-WTO, "Measuring international trade in value added for a clearer view of globalization", Paris, 15 October 2010)

2 . See Box 1 for an illustration with the iPhone 4.

3 Koopman et al. 2011

As this "fragmentation of production" (Jones and Kierzkowski, 2001) has grown, so too has the potential for gross flows of trade to mislead. Innovations such as the container ship and the Internet have revolutionised trade and supply chain management in several ways; similarly, services trade liberalisation has reduced regulatory barriers in key sectors of the global logistics chain (transport, finance, telecommunications, etc.) and facilitated foreign direct investment.

**Box 1. Who bites the Apple? The iPhone example revisited**

Several studies have illustrated the concept of value-added trade using Apple's emblematic devices: first the iPod (Linden *et al.* 2009) and then the iPhone (Xing and Detert, 2010) and the iPad (Linden *et al.*, 2011). All these hi-tech products are assembled in the People's Republic of China and so make a significant contribution to China's exports. But Chinese value-added represents only a small share of the value of these electronic devices that incorporate components from Germany, Japan, Korea and other economies that manufacture intermediate inputs. Based on estimates provided by iSuppli and Chipworks, the table below illustrates this by identifying those countries that provide intermediate inputs into the iPhone 4.

| Country | Components | Manufacturers | Costs |
|---|---|---|---|
| Chinese Taipei | Touch screen, camera | Largan Precision, Wintek | $ 20.75 |
| Germany | Baseband, power management, transceiver | Dialog, Infineon | $ 16.08 |
| Korea | Applications processor, display, DRAM memory | LG, Samsung | $ 80.05 |
| United States | Audio codec, connectivity, GPS, memory, touchscreen controller | Broadcom, Cirrus Logic, Intel, Skyworks, Texas Instruments, TriQuint | $ 22.88 |
| Other | Other | Misc. | $ 47.75 |
| | | **Total** | **$ 187.51** |

However, this does not tell the full story. The table only shows the value of the intermediate inputs produced by the firms but they themselves will no doubt have used intermediate imports in their production or sourced intermediate goods from domestic suppliers who in turn would have used intermediate imports. Identifying these flows is equally important, particularly, in the context of the example above, because some of those imports may have originated in China. Moreover, while the country indicated is the country where the firms producing the components are headquartered, these inputs are often produced in other countries. Infineon, for example, has several factories in China. Chinese value-added may therefore not only be limited to the final assembly costs.

To fully decompose the value added of the iPhone, and ascribe it to individual countries therefore, one cannot rely on a list of component suppliers. Information on all of the suppliers and their suppliers, and their suppliers' suppliers, and so on, is needed. What is needed therefore is a dataset that is able to link production processes within and across countries; in other words a set of international input-output tables with bilateral trade links (a global input-output table). Naturally, input-output tables developed by statistical offices aggregate firms into groups (sectors) of firms that produce similar products, and, as such, input-output tables will not be able to reveal the total domestic value-added generated by the production of an iPhone in any country. However they will be able to provide such estimates for the whole economy and indeed by the sectors.

The iPhone example also highlights that beyond trade flows, more information on other income flows, particularly those related to the use of intellectual property, are required to answer the question of who ultimately benefits from trade. In other words ownership also matters: Foxconn, the company that assembles iPhones in China is a Chinese Taipei owned firm. However, part of the value-added generated and recorded in Mainland China will be repatriated to Chinese Taipei. There are various ways in which input-output based models could be refined to capture these flows and the OECD intends to explore these as part of its medium term work programme.

*Source*: Xing and Detert (2010), iSuppli, Chipworks.

5. There is a need therefore for better metrics to measure the contribution of trade to nations' value-added, income and employment. Against this backdrop, this note has two key objectives. The first is to clarify the concept of trade in a value-added context, such that gross trade flows can be decomposed into domestic value-added components and imported components. The second is to present on-going initiatives in the measurement of trade in value-added and to discuss some of the methodological challenges ahead and to provide some insights on what could be done beyond the measurement of trade in value-added.

## 1. A framework for the measurement of trade in value-added terms

6. Several papers, workshops and international conferences have now addressed the issue of the measurement of trade flows in the context of the fragmentation of world production.[4] Each of these contributions makes the case that the issue is relevant and important, and at the same time, an issue that requires the development of new trade statistics that complement those already produced. The very nature of the issue necessarily requires a coordinated international approach to build a framework and methodology, based on underlying official statistics that have widespread recognition and approval. The 'complementarity' of these new statistics helps to address three key problems with current trade statistics:

i. The first concerns the implicit multiple counting of intermediate goods and services, thus potentially overstating the importance of trade, particularly in some goods and services. When world trade is calculated as an aggregation of all bilateral trade flows measured in gross terms, the value of the same labour, capital or intermediate input is implicitly counted as many times as it crosses a border for further processing: reflecting its *embodiment* in the good as it goes through the processing chain;

ii. The second issue is perhaps the most important. The fact that exports increasingly embody intermediate inputs sourced from abroad makes it difficult to identify the real contribution a given export may make to an economy's material well-being, be that in terms of income or employment. Moreover, conventional trade statistics are not necessarily able to reveal those sectors of the economy where value-added originates. In developed economies a large share of the total value-added generated by manufactured exports originates in the service sector. Disentangling the domestic value chain into its sectoral components can therefore shed new light on the sources of international competitiveness and the direct and indirect employment impacts of trade;

iii. One final issue, that the OECD intends to tackle as part of its medium term work programme, concerns the need to go 'beyond value-added'. Value-added[5] in a National Accounts sense reflects the compensation of resident labour, capital, non-financial assets and natural resources used in production. However, measuring flows of value-added reflects only part of the 'global trade' story. The fragmentation of production processes often involves fragmentation within a multinational enterprise. In that sense part of value-added, or at least part of what is referred to as operating surplus in the National Accounts, may be repatriated to the parent company. This may be a straight forward transfer from the affiliate to the parent (recorded as profit repatriation) or it may reflect payments for the use of those intellectual property products that are not recognised as produced assets in the National Accounts. Either way the point is that even estimates of value-

4. An OECD-World Bank workshop on "new metrics for global value chains" was organised on 21 September 2010. WTO hosted a Global Forum on Trade Statistics on 2-4 February 2011, in collaboration with Eurostat, UNSD and UNCTAD.

5 It also includes 'other taxes and subsidies on production', *i.e.*, those taxes and subsidies that are unrelated to the quantity, price of volume of goods and services produced.

added in trade may not provide the full picture of the importance of trade to an economy. Increasingly what also matters is where the value-added ends up. In this context it is important to recognise that the delineation of intellectual property products into those that are referred to as 'produced' (e.g. software) and those that are referred to as 'non-produced' (e.g. trademarks) makes a significant difference.

7. Even if measuring trade in value added does not provide the full story about the operation of global production networks, it does provide more meaningful measures of the importance of trade to economic growth. [6] The underlying concept is not particularly contentious, and there is widespread agreement that it reflects for a given export, the percentage or amount of domestic value-added that is generated by the export, throughout the production chain. In other words any given export can be decomposed into value-added contributions from different domestic industries and different foreign industries.

8. Several approaches can be used to shed some light on the value-added content of trade flows but many of these only provide part of the story. The iPod example given above for example, only tells the story for one single product but it also only tells the story about where intermediate inputs where directly sourced in the first preceding link in the production chain. It does not, for example, reflect where the intermediate inputs used in making the iPod's intermediate inputs were sourced,

9. A particular challenge is to disentangle domestic and foreign value-added in the context of highly fragmented production networks where "circular" trade takes place: inputs are shipped abroad and then come back as more processed products. Circular trade is particularly important in North America (especially between Mexico and the USA), but is also significant in Europe and in Eastern Asia. Conventional statistics do not provide a measure of domestic and foreign value-added in bilateral trade flows. Therefore, researchers often 'harmonize' Input-Output (I-O) tables from different countries and link them with bilateral trade data in order to estimate the share of domestic value-added both in exported and imported goods and services. In addition, when working on bilateral balances in value-added terms, one needs to fully track down foreign value-added to the original source country. Indeed, part of the value of the imports from the last known exporting country may originate from third countries (and even, as mentioned, include re-imports from the domestic economy). As shown below, this requires a full set of inter-country I-O tables, where all bilateral exchanges of intermediate goods and services are accounted for: in other words an **international input-output table.**

10. A last remark is that despite their shortcomings for understanding international trade linked to global production networks, traditional trade statistics tracking the physical movement of goods (gross accounting) remain fully relevant from an analytical point of view. The concept of "value-added" is useful to understand where economic activity and jobs are generated, not only internationally along the supply chains, but also domestically, as each exporting sector relies on intermediate inputs in goods and services purchased from other domestic suppliers. In other words, measuring trade in value added is very important to understand the supply side of international trade and identify the respective sources of competitiveness. But on the demand side, gross trade flows tell us how much consumers, firms and administrations have spent on imported goods and services. Although even here some care is needed as the goods and services recorded in conventional trade statistics don't always change ownership, particularly if the products are

6 . In particular, WTO director-general Pascal Lamy has, on many occasions, expressed this view. See for example his column in the *Financial Times*, 24 January 2011.

processed within affiliates of multinational enterprises or they are, as is increasingly the case, sent abroad for further processing without any cash transaction occurring for the underlying goods to be processed.[7]

11. While the literature on trade in value-added is quite technical, it has attracted a lot of attention from policymakers.[8] What initially seemed a concern for trade statisticians is now understood as a key issue for the policy debate. For example, Pascal Lamy notes that "the statistical bias created by attributing commercial value to the last country of origin perverts the true economic dimension of the bilateral trade imbalances. This affects the political debate, and leads to misguided perceptions".[9] Recently, the French Senate devoted a special seminar to the related statistical and policy issues. [10]

### *1.1 Policy drivers*

12. What can we expect from developing these new statistics on international trade? There are at least six areas where measuring trade in value-added brings a new perspective and is likely to impact policy choices:

- ***Global imbalances***: Accounting for trade in intermediate parts and components, and taking into account 'trade in tasks', does not change the overall trade balance of a country with the rest of the world - it redistributes the surpluses and deficits across partner countries (see Box 2). When bilateral trade balances are measured in gross terms, the deficit with final goods producers (or the surplus of exporters of final products) is exaggerated because it incorporates the value of foreign inputs.[11] The true imbalance is therefore also with the countries who have supplied inputs to the final producer. As pressure for rebalancing increases in the context of persistent deficits, there is a risk of protectionist responses that target countries at the end of global value chains on the basis of an inaccurate perception of the origin of trade imbalances.

- ***Market access and trade disputes:*** Measuring trade in value added sheds new light on today's trade reality, where competition is not between nations, but between firms. Competitiveness in a world of global value chains means access to competitive inputs and technology. Optimum tariff structure in such a situation is flat (little or no escalation) and reliable (contractual arrangements within supply chains, especially between affiliated establishments, tend to be long term). Outsourcing and offshoring of elaborate parts and components can only take place in situations where the regulatory frameworks are non-discriminatory, and intellectual property is respected. WTO's World Trade Report 2011 on preferential trade agreements reveals that more and more PTAs are going beyond preferential tariffs, with numerous non-tariff areas of a regulatory nature being included in the agreements. According to the report, global production networks may be

7 . The recent revision to the System of National Accounts (the 2008 SNA) fully reflects the ownership principle and, so, the value of imports and exports in the 2008 SNA does not include the value of intra-firm trade or goods sent abroad for processing, when no exchange of ownership takes place.

8 . See Annex I for a brief overview of the literature.

9 . *Financial Times*, 24 January 2011.

10 WTO and Commission des Finances du Sénat, (2011) "Globalization of industrial production chains and measurement of trade in value added", Conference proceedings.

11. See Maurer and Degain (2010). Koopmans *et al.* (2010) find that the domestic value added of Chinese exports is on average 60%.

prompting the emergence of these "deep" PTAs as good governance on a range of regulatory areas is far more important to these networks than further reductions in already low tariffs. [12]

- Moreover, in the context of the fragmentation of production and global value chains, mercantilist-styled 'beggar thy neighbour' strategies can turn out to be 'beggar thyself' miscalculations. As mentioned earlier, domestic value-added is not only found in exports but also in imports: some goods and services are intermediates shipped abroad whose value comes back to the domestic economy embodied in imports. As a consequence, tariffs, non-tariff barriers and trade measures –such as anti-dumping rights– are likely to impact domestic producers in addition to foreign producers. For example, a study of the Swedish National Board of Trade on the European shoe industry highlights that shoes "manufactured in Asia" incorporate between 50% and 80% of European Union value-added. In 2006, anti-dumping rights were introduced by the European Commission on shoes imported from China and Vietnam. An analysis in value-added terms would have revealed that EU value-added was in fact subject to the anti-dumping rights.[13]

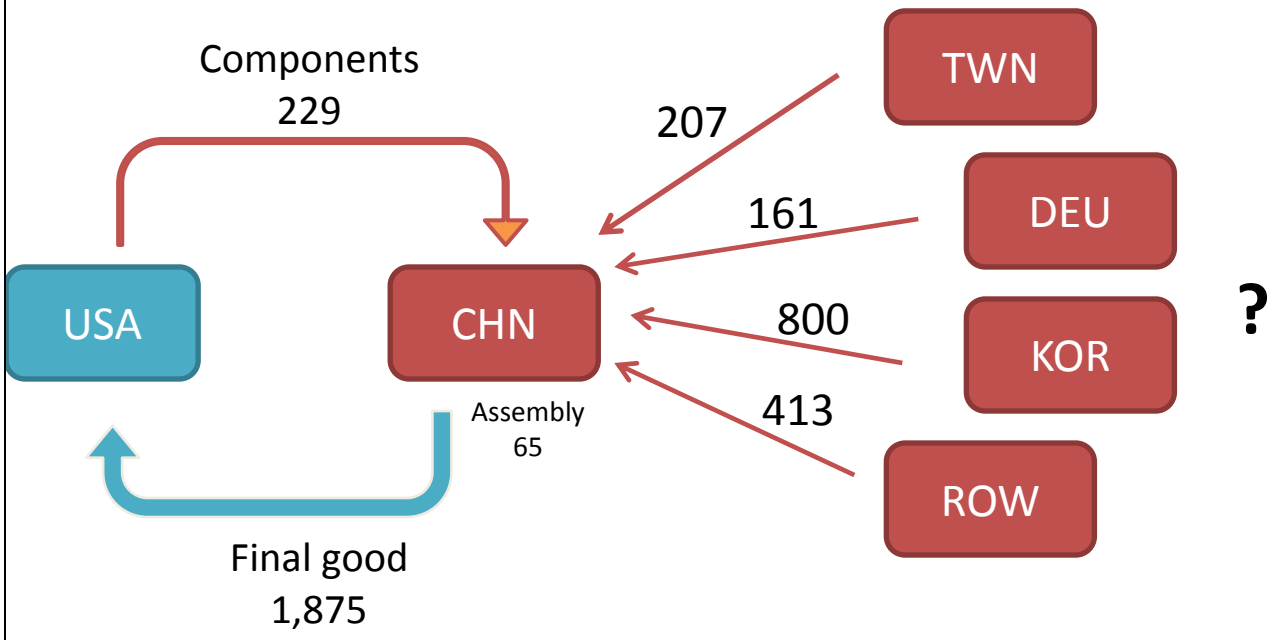
12 WTO (2011) "World Trade Report 2011: The WTO and preferential trade agreements: From co-existence to coherence".

13. "Adding value to the European Economy. How anti-dumping can damage the supply of globalised European companies. Five case studies from the shoe industry", Kommerskollegium, National Board of Trade, Stockholm, 2007.

**Box 2. The balance of trade in gross and value-added terms (the iPhone example continued)**

"*It is easy to observe, that all calculations concerning the balance of trade are founded on very uncertain facts and suppositions*." (David Hume, *Of the Balance of Trade*, 1742)

To understand how the measurement of trade in value-added affects bilateral trade balances, we can use the setting of the iPhone example described in Box 1. Assuming that 10 million iPhones are exported from China to the US, the iPhone trade represents a trade deficit of USD 1,646 million for the US economy (this is simply calculated as the difference between US exports of intermediate inputs to China –USD 229 million– and US imports of assembled iPhones –USD 1,875 million–, see the Figure below). In gross terms, there is only a deficit between China and the US.




In (relatively crude) value-added terms, however, China adds only a small share of domestic value-added to the iPhone corresponding to the value of the assembly work. As highlighted in the list of costs presented in Box 1, most of the components of the iPhone are sourced from economies outside China. Let's assume that Chinese assembly costs are USD 6.50 per iPhone (and are part of the miscellaneous costs in Box 1). In (relatively crude) value-added terms, the Table below shows that the US trade deficit is not only with China but also with Chinese Taipei, Germany, Korea and the rest of the world. The overall trade deficit (vis-à-vis the world) stays unchanged at USD 1,646 million.

| US trade balance in iPhones with: | CHN | TWN | DEU | KOR | ROW | World |
|---|---|---|---|---|---|---|
| **Gross** | -1,646 | 0 | 0 | 0 | 0 | -1,646 |
| **Value added** | -65 | -207 | -161 | -800 | -413 | -1,646 |

The references to ' relatively crude' above reflect the fact that no account is made in the example for the suppliers of the suppliers. It is likely that manufactured components from Chinese Taipei, Germany and Korea themselves incorporate inputs from other countries – possibly including the USA. The above calculation would have to be adjusted to fully take into account the value-added by each country in the supply chain. This is why we need to add on the above figure upstream input suppliers and why the calculation can only be done if we have all the information about all the producers involved.

- ***The impact of macro-economic shocks***: The 2008-2009 financial crises was characterised by a synchronised trade collapse in all economies. Authors have discussed the role of global supply

chains in the transmission of what was initially a shock on demand in markets affected by a credit shortage. In particular, the literature has emphasized the "bullwhip effect" of global value chains.[14] When there is a sudden drop in demand, firms delay orders and run down inventories with the consequence that the fall in demand is amplified along the supply chain and can translate into a standstill for companies located upstream. A better understanding of value-added trade flows would provide tools for policymakers to anticipate the impact of macro-economic shocks and adopt the right policy responses. Any analysis of the impact of trade on short-term demand is likely to be biased when looking only at gross trade flows. This was again more recently demonstrated in the aftermath of the natural disaster that hit Japan in March 2011. [15]

- ***Trade and employment:*** Several studies on the impact of trade liberalisation on labour markets try to estimate the 'job content' of trade. Such analysis is only relevant if one looks at the value-added of trade. What the value-added figures can tell us is where exactly jobs are created. Decomposing the value of imports into the contribution of each economy (including the domestic one) can give an idea of who benefits from trade. The EU shoe industry example given above can be interpreted in terms of jobs. Traditional thinking in gross terms would regard imports of shoes manufactured in China and Viet Nam by EU shoe retailers as EU jobs lost and transferred to these countries. But in value-added terms, one would have to account for the EU value-added and while workers may have indeed lost their job in the EU at the assembly stage, value-added based measures would have highlighted the important contribution made by those working in the research, development, design and marketing activities that exist because of trade (and the fact that this fragmented production process keeps costs low and EU companies competitive). When comparative advantages apply to "tasks" rather than to "final products", the skill composition of labour imbedded in the domestic content of exports reflects the relative development level of participating countries. Industrialised countries tend to specialise in high skill tasks, which are better paid and capture a larger share of the total value added. A WTO and IDE-JETRO study on global value chains in East Asia shows that China specializes in low-skill types of jobs. Japan, on the contrary, has been focusing in export activities intensive in medium and high skill labour, while importing goods produced by low-skilled workers. The study also shows that the Republic of Korea was adopting a middle-of-the ground position (in 2006), but was also moving closer to the pattern found in Japan. [16]

- ***Trade and the environment:*** Another area where the measurement of trade flows in value-added terms would support policymaking is in the assessment of the environmental impact of trade. For example, concerns over greenhouse gas emissions and their potential role in climate change have triggered research on how trade openness affects CO2 emissions. The unbundling of production and consumption and the international fragmentation of production require a value-added view of trade to understand where imported goods are produced (and hence where CO2 is produced as a consequence of trade). Various OECD studies note that the relocation of industrial activities can have a significant impact on differences in consumption-based and production based measures of CO2 emissions (Ahmad *et al*., 2003, Nakano *et al.*, 2009).

- ***Trade, growth and competitiveness:*** Likewise, indicators of competitiveness such as 'revealed comparative advantage' are affected by the measurement of trade in gross terms. Going back to

14. See Escaith *et al.* (2010) and Lee *et al.* (1997).

15 See an application of international IO on "Japan's earthquake and tsunami: International trade and global supply chain impacts", VoxEU, April 2011 at http://www.voxeu.org/index.php?q=node/6430

16 See WTO and IDE-JETRO (2011).

the iPhone example, traditional trade statistics suggest that China has a comparative advantage in producing iPhones but with value-added measures its comparative advantage is in assembly work. Having in mind development strategies and the concerns of policymakers to identify export sectors and promote industrial policies, the analysis of the export competitiveness of industries cannot ignore the fragmentation of production and the role of trade in intermediates.

13. The above examples make a compelling case for the production of trade statistics in value-added terms. There is no doubt that such analysis is highly relevant from a policy perspective. The challenge and indeed difficulty relates to the international dimension of the statistics; in other words those related to the construction of a global, or international, input-output table. While national statistical institutes have an important role to play here, as providers of underlying national data, there is clearly a role and need for an international organisation to coordinate and harmonise national statistics in order to create a multi-regional research tool. As described below, the OECD and WTO are looking to motivate such an initiative in co-operation with other international organisations, national statistics offices and research projects.

### *1.2 Conceptual framework*

14. In a perfect world with perfect information it would be possible to decompose every single product in a value-added chain that was able to identify where the value-added originated by tracing the value-added throughout the production chain.

15. Conceptually (ignoring taxes and subsidies for simplicity) it is possible to decompose any particular product with value $V^p$ into the value-added generated in country *i* such that the total value of

$$V^p = \sum_i VA_i^p \qquad \text{(I)}$$

16. This is relatively clear and simple. However complications can arise when aggregating up for a whole industry group or for a whole economy, as shown in the example below.

17. Consider an economy *i* that produces only two products *a* and *b* for export, with product *a* exported to country *j* for further processing before being re-imported into country *i* for use in the production of *b*. Let's assume that 100 units of *a*, with value 200, are produced and exported and then used in the production of 100 units of product *c*, with value 300, that are in turn used in the production of 100 units of *b* that are exported with value 400. Let's further assume, for simplicity, that each unit of *a* is produced entirely in country *i;* in other words no intermediate inputs are directly or indirectly sourced from abroad. Let's also assume that apart from the intermediate imports referred to above all the value-added in *b* is also generated in country *i* only.

18. Following (I) above, it is at least, in theory, possible to show that the 100 units of *a* generated 200 units of domestic value-added (in country *i*) and the 100 units of *b* generated 300 units of domestic value-added (in country *i* – 200 from the production of *a* and100 from the final step in the production of *b*). We know that total gross exports in the economy were equal to 600 (200 of *a* + 400 of *b*), which to some extent overstates the contribution of overall trade to the economy, but simply summing the value-added contribution at the product level (the value-added generated by *a* - 200 - and the total value added generated in producing *b* - 300) will also overestimate the significance of trade in this context, as the overall value-added generated in the economy through the sale of both *a* and *b* is only 300; reflecting the fact that of the 300 units of value-added generated through the production of b, 200 units reflect the embodiment of product *a*, whose value-added is separately shown under the production of *a*.

19. In this context it's important to note that the level of detail through which information is presented makes a difference; a point we develop below.

20. In practice of course we will never have the level of detail needed to conduct a value-added decomposition for all individual products in the way theorised above, so it will be necessary to use aggregated data. A pragmatic approach to doing this is by exploiting Input-Output tables, which are readily available in many (notably OECD) economies.

21. Input-output tables are designed to measure the interrelationships between the producers of goods and services (including imports) within an economy and the users of these same goods and services (including exports). In this context they can be used to estimate the contribution that imports make in the production of any good (or service) for export. For example, if a motor car manufacturer imports certain components (e.g. the chassis) the direct import contribution will be the ratio of the value of the chassis to the total value of the car. And if the car manufacturer purchases other components from domestic manufacturers, who in turn use imports in their production process, those imports are included in the car's value. These indirect imports should be included in any statistic that attempts to measure the contribution of imports to the production of motor cars for export. The total direct and indirect imports are known as 'import content of exports', or 'embodied imports'.

22. In an input-output framework the relationship between producers and consumers can be simply described as follows:

$$g = A*g + y \qquad \text{where:}$$

*g*: is an n*1 vector of the output of n industries within an economy.

*A*: is an n*n matrix describing the interrelationships between industries (known as the technical coefficients matrix); where $a_{ij}$ is the ratio of inputs from domestic industry *i* used in the output of industry *j*.

*y*: is an n*1 vector of final demand for domestically produced goods and services, including exports.

23. Assuming that all goods produced by any particular industry are homogenous, total imports embodied directly and indirectly within exports and the additional domestic activity induced by this additional production can be calculated thus:

$$\text{Import content of exports} = m*(1-A)^{-1}*e, \text{ where:}$$

*m*: is a 1*n vector with components $m_j$ (the ratio of imports to output in industry *j*)

*e*: is a n*1 vector of exports by industry.

24. In the same way, one can estimate the total indirect and direct contribution of exports to value-added by replacing the import vector *m* above with an equivalent vector that shows the ratio of value-added to output (v). So, the contribution of exports to total economy value-added is equal to:

$$v*(I-A)^{-1}*e \qquad \text{(II)}$$

25. At the whole economy level this works fine, both for imports, if we accept the fact that they are measured gross, and importantly for value-added. Returning to the example above the approach would accurately record the 300 contribution total exports made to value-added. In addition, policy makers are

equally interested in understanding the contribution that specific sectors make to the domestic content of exports, both directly and indirectly. In advanced industrialised economies, a large share of global GDP (and employment) accrues to services, while international trade remains largely dominated by goods. Yet, identifying backwards linkages from those export oriented sectors producing tradable goods (agriculture, manufacture) allows to map where the domestic value added was created. The break-up of domestic content by direct and indirect sectoral value added reveals that a large chunk of the value originates indirectly from service sectors. This break-down is particularly important when identifying the sources of national competitiveness, which may rest in up-stream sectors which are not considered as exporters by traditional statistics, or measuring the employment impact of export production.

26. An additional level of complexity arises because imports may often themselves embody some domestic value-added (re-imports), which can be significant for economies that are intricately part of a global value chain. In order to trace this value, an international input-output table is needed; a table that in effect reallocates imports and exports to intermediate consumption or final domestic demand (such as household and government final consumption and capital formation).

27. Let α be an international technical coefficients matrix with dimensions *(n*c) * (n*c)*, where *c* is the number of countries and *n* is, as before, the number of industries. Further let the table be structured so that rows 1 to *n* reflect the industries of country 1, and rows *n*+1 to 2*n* the industries of country 2 and so on, and $v^k_i$ is the direct value-added produced by industry *i* in country *k*, as a share of its total output. It can be shown that the total direct and indirect domestic value-added produced by industry j in country *k* is equal to:

$$\sum_i v_i^k * L_{(kn+i)(kn+j)} \qquad \text{(III)}$$

where: $L_{ij}$ is the *ij*th element of the global Leontief inverse $(I-\alpha)^{-1}$.

28. Similarly,

$$\sum_i v_i^k * L_{(hn+i)(hn+j)} \qquad \text{(IV)}$$

reflects the total value-added generated in country *k* for unit output of industry *j* in country *h*, and

$$v^k_i * L_{(hn+i)(hn+j)} \qquad \text{(V)}$$

reflects value-added generated by industry *i* in country *k* for unit of output of industry *j* in *h*, providing a mechanism that shows the contributions made across different sectors of the economy.

29. Therefore, for any given export by an industry, it should be possible to decompose the entire value into:

(i) the domestic value-added generated in its production, both directly from the main producing industry, and indirectly via transactions between domestic industries and via transactions between domestic and foreign industries; and

(ii) the imported value-added generated in producing the imports used in production (excluding any part of the import value that reflects domestic value-added)

30. As such an international input-output table will allow users and policy makers to decompose the entire value of any good, exported by industry I, in the following way:

| | | | |
|---|---|---|---|
| Direct domestic value-added from industry I. | Indirect domestic value-added generated via purely domestic transactions, broken down by all domestic industries. | Indirect imported value-added (broken down by producing country and industry). | Indirect domestic value-added embodied in imports (broken down by all domestic industries) |

31. The ability to generate output such as this is, in itself, beneficial to policy makers interested in the real contribution that industries make to economic growth, and indeed employment (as the flows above can be reformulated to show employment contributions), since they can be used to assess the domestic content of both imports and exports. The approach provides a mechanism to shed light on current trade balances in a number of new ways, that presents flows in value-added both on a bilateral country basis and also at the sectoral level. Two important metrics fall out of this. The first, key indicator, is bilateral balances based on where the value-added is consumed as final domestic demand, illustrating the scale of the global production chain across sectors and countries, so, for example, the value-added generated by country A in producing exports to country B for further processing before being exported for final domestic consumption in country C would be recorded as imports of value-added by country C from country A, even though the no direct transaction occurred between A and C. The second metric is to look at bilateral balances in the context of direct bilateral trade flows, i.e. to record the flows of value-added embodied in gross exports and imports. Although very similar to the key indicator in practice, this is an important complement that aims to record flows from the reporting country's importer and exporter perspective. So whilst the key indicator would record value-added flows from A to C, on the basis of where the value-added is finally consumed, the complement would record flows of value-added from A to B, on the basis of the trade flows.

## 2. Measuring the value-added content of trade in practice

32. As emphasised in the previous section, measuring the value-added content of trade requires an international input-output table. Constructing such a table is a data-intensive process and presents numerous challenges. This section describes the work undertaken at the OECD to harmonise single-country input-output tables which form the basis of the construction of an international input-output database that can be used to estimate trade in value-added terms. Appendix 2 presents all on-going initiatives to build such tables. The section also discusses techniques to estimate bilateral trade flows of intermediate goods and services and describes refinements that are designed to produce more robust estimates of the value-added content of trade.

### *2.1 The construction of an international input-output table*

33. The following steps describe how an international input-output table is being built in the OECD. The key challenge here is to identify and create links between exports in one country and the purchasing industries (as intermediate consumption) or final demand consumers in the importing country. In this respect it's important to note that the data issues faced by the OECD in this regard are similar to those confronted by other initiatives, such as IDE-JETRO (Asian Input-Output Tables) or the World Input Output Database project, with whom (as well as the US-ITC) the OECD and WTO have been coordinating actively in order to share experiences and derive a set of best practices..

34. The data sources at OECD are harmonised input-output tables and bilateral trade coefficients in goods and services, derived from official sources.[17] The model specification and estimation procedures can be summarized as follows:

a) Preparation of I-O tables for reference years using the latest published data sources e.g. Supply and Use tables (SUTs), National Accounts and trade statistics;

b) Preparation of bilateral merchandise data by end-use categories for reference years. The published trade statistics are adjusted for *analytical* purposes (such as confidential flows, re-exports, waste and scrap products and valuables). Trade coefficients of utility services are estimated based on cross border energy transfers. Other trade coefficients of service sectors are based on OECD Trade in Services and UN Service Trade statistics. However, many missing flows are currently estimated using econometric model estimates;

c) Conversion of c.i.f. price based import figures to f.o.b. price based imports to reduce the inconsistency issues of mirror trade (because of asymmetry in reporting exports and imports in national trade statistics, imports of country A from B usually differ significantly from the exports reported from B to A). In an international I-O system, trade flows should be perfectly symmetric (the bilateral trade flows should be consistent at the highest relevant level of disaggregation) and consistent with the supply-utilization tables trade data;

d) Creation of import matrices ;

e) Total adjustment (missing sectors, trade with rest of the world, etc) and minimization of discrepancy columns using biproportional methods;

*Harmonised input-output tables for reference years*

35. The OECD has been updating and maintaining harmonised I-O tables, splitting intermediate flows into tables of domestic origin and imports, since the mid-1990s - usually following the rhythm of national releases of benchmark I-O tables. The process of compiling the OECD's I-O database greatly depends on cooperation with national statistical institutes. Ideally, national authorities provide the latest Supply-Use tables and benchmark symmetric input-output tables (SIOTs) at the most detailed level of economic activity possible; with a basic price valuation; and, preferably, separating domestically produced and imported intermediate goods and services.

36. The first edition of the OECD I-O Database dates back to 1995 and covered 10 OECD countries with I-O tables spanning the period from the early 1970s to the early 1990s. The first updated edition of this database, released in 2002, increased the country coverage to 18 OECD countries, China and Brazil, and introduced harmonised tables for the mid-1990s. The tables are now available for 46 countries[18] (33 OECD and 13 non-OECD countries) with tables for the mid-2000s (mainly 2005) now available for most of them (Table 1).

17 . Some research oriented initiatives have been using the GTAP data base for international input-output data. This is not however based on official sources of statistics,

18 . For more details, see also www.oecd.org/sti/inputoutput.

**Table 1. Country coverage of OECD Input-Output Database (as of March 2012)**

| OECD | mid-90s | early-00s | mid-00s | Non-OECD | mid-90s | early-00s | mid-00s |
|---|---|---|---|---|---|---|---|
| Australia | 1994/95 | 1998/99 | 2004/05 | Argentina | 1997 | - | - |
| Austria | 1995 | 2000 | 2005 | Brazil | 1995 | 2000 | 2005 |
| Belgium | 1995 | 2000 | 2005 | China | 1995 | 2000 | 2005 |
| Canada | 1995 | 2000 | 2005 | Chinese Taipei | 1996 | 2001 | 2006 |
| Chile | 1996 | - | 2003 | Cyprus | 1995 | 2000 | 2005 |
| Czech Republic | 1995 | 2000 | 2005 | India | 1993/94 | 1998/99 | 2006/07 |
| Denmark | 1995 | 2000 | 2005 | Indonesia | 1995 | 2000 | 2005 |
| Estonia | 1997 | 2000 | 2005 | Latvia | - | - | 2004 |
| Finland | 1995 | 2000 | 2005 | Lithuania | - | - | 2005 |
| France | 1995 | 2000 | 2005 | Malaysia | - | 2000 | - |
| Germany | 1995 | 2000 | 2005 | Malta | - | 2000 | 2004 |
| Greece | 1995 | 2000 | 2005 | Romania | - | 2000 | 2005 |
| Hungary | 1998 | 2000 | 2005 | Russian Federation | 1995 | 2000 | - |
| Iceland | - | - | - | Singapore* | 1995 | 2000 | 2005 |
| Ireland | 1998 | 2000 | 2005 | South Africa | 1993 | 2000 | 2005 |
| Israel | 1995 | - | 2004 | Thailand | - | - | 2005 |
| Italy | 1995 | 2000 | 2005 | Viet Nam | - | 2000 | - |
| Japan | 1995 | 2000 | 2005 | EU27 | - | - | 2005 |
| Korea | - | 2000 | 2005 | | | | |
| Luxembourg | 1995 | 2000 | 2005 | | | | |
| Mexico | - | - | 2003 | | | | |
| Netherlands | 1995 | 2000 | 2005 | | | | |
| New Zealand | 1995/96 | 2002/03 | - | | | | |
| Norway | 1995 | 2000 | 2005 | | | | |
| Poland | 1995 | 2000 | 2005 | | | | |
| Portugal | 1995 | 2000 | 2005 | | | | |
| Slovak Republic | 1995 | 2000 | 2005 | | | | |
| Slovenia | 1996 | 2000 | 2005 | | | | |
| Spain | 1995 | 2000 | 2005 | | | | |
| Sweden | 1995 | 2000 | 2005 | | | | |
| Switzerland | - | 2001 | 2006 | | | | |
| Turkey | 1996 | 1998 | 2002 | | | | |
| United Kingdom | 1995 | 2000 | 2005 | *: not published - internal use only | | | |
| United States | 1995 | 2000 | 2005 | Available year, -: not available | | | |

37. The I-O tables show transactions between domestic industries but as a complement to these tables are supplementary tables which break down total imports by user (industry and category of final demand). Some countries provide these import tables in conjunction with their I-O tables but in some cases they are derived by the OECD Secretariat.

**Table 2. OECD Input-Output industry classification**

| ISIC Rev.3 code | | Description |
|---|---|---|
| 1+2+5 | 1 | Agriculture, hunting, forestry and fishing |
| 10+11+12 | 2 | Mining and quarrying (energy) |
| 13+14 | 3 | Mining and quarrying (non-energy) |
| 15+16 | 4 | Food products, beverages and tobacco |
| 17+18+19 | 5 | Textiles, textile products, leather and footwear |
| 20 | 6 | Wood and products of wood and cork |
| 21+22 | 7 | Pulp, paper, paper products, printing and publishing |
| 23 | 8 | Coke, refined petroleum products and nuclear fuel |
| 24ex2423 | 9 | Chemicals exluding pharmaceuticals |
| 2423 | 10 | Pharmaceuticals |
| 25 | 11 | Rubber and plastics products |
| 26 | 12 | Other non-metallic mineral products |
| 271+2731 | 13 | Iron & steel |
| 272+2732 | 14 | Non-ferrous metals |
| 28 | 15 | Fabricated metal products, except machinery and equipment |
| 29 | 16 | Machinery and equipment, nec |
| 30 | 17 | Office, accounting and computing machinery |
| 31 | 18 | Electrical machinery and apparatus, nec |
| 32 | 19 | Radio, television and communication equipment |
| 33 | 20 | Medical, precision and optical instruments |
| 34 | 21 | Motor vehicles, trailers and semi-trailers |
| 351 | 22 | Building & repairing of ships and boats |
| 353 | 23 | Aircraft and spacecraft |
| 352+359 | 24 | Railroad equipment and transport equipment n.e.c. |
| 36+37 | 25 | Manufacturing nec; recycling (include Furniture) |
| 401 | 26 | Production, collection and distribution of electricity |
| 402 | 27 | Manufacture of gas; distribution of gaseous fuels through mains |
| 403 | 28 | Steam and hot water supply |
| 41 | 29 | Collection, purification and distribution of water |
| 45 | 30 | Construction |
| 50+51+52 | 31 | Wholesale and retail trade; repairs |
| 55 | 32 | Hotels and restaurants |
| 60 | 33 | Land transport; transport via pipelines |
| 61 | 34 | Water transport |
| 62 | 35 | Air transport |
| 63 | 36 | Supporting & auxiliary transport activities; activities of travel agencies |
| 64 | 37 | Post and telecommunications |
| 65+66+67 | 38 | Finance and insurance |
| 70 | 39 | Real estate activities |
| 71 | 40 | Renting of machinery and equipment |
| 72 | 41 | Computer and related activities |
| 73 | 42 | Research and development |
| 74 | 43 | Other Business Activities |
| 75 | 44 | Public administration and defence; compulsory social security |
| 80 | 45 | Education |
| 85 | 46 | Health and social work |
| 90-93 | 47 | Other community, social and personal services |
| 95+99 | 48 | Private households and extra-territorial organisations |

38. The main assumption used in creating these import matrices is the 'proportionality' assumption, which assumes that the share of imports in any product consumed directly as intermediate consumption or final demand (except exports) is the same for all users. Indeed this is also an assumption that is widely used by national statistics offices in constructing tables. This hypothesis is acceptable for industrialised countries, where there is little product differentiation between what is produced for export and what is produced for the domestic market. [19] It is more stretching however for developing countries, as the import content of exports is usually higher (and much higher for processing) than the import content of products destined for domestic consumption. Improving the way that imports are allocated to users will form a central part of the future work of the OECD and WTO, as well as the international statistical system, as stated in the Global Forum on Trade Statistics, in Geneva in February 2011.[20] This will require a better understanding of how countries estimate their import-flow matrices and lead to attempts to encourage better methods of allocation at the national level where feasible.

19 The results of parallel projects at EUROSTAT on micro-data bases linking trade statistics and business registers will help characterizing better the profile of export-oriented firms.

20 . Global Forum "Measuring Global Trade — Do we have the right numbers?" 2-4 February 2011, jointly organised by the United Nations Statistics Division (UNSD), the Statistical Office of the European Communities (Eurostat) with the World Trade Organization (WTO) and the United Nations Conference on Trade and Development (UNCTAD).

39. Measuring trade in value added relates to industries' activity rather than to products, as in conventional trade statistics. The OECD's input-output tables are based on an industry by industry basis reflecting the fact that the underlying source data measures the activities and production of industries, which means that the relationships between value-added and industrial output are unaffected by statistical manipulations that will be required to build product by product based input-output tables.. The industry classification used in the current version of OECD's I-O database is based on ISIC Rev.3 (Table 2), meaning that it is compatible with other industry-based analytical datasets, and in particular with the OECD bilateral trade in goods by industry dataset (derived from merchandise trade statistics via standard Harmonised System to ISIC conversion keys). The system, by necessity (*i.e.* to maximise cross country comparability), is relatively aggregated. Differentiating between types of companies within a given sector is essential however to improve the quality of trade in value-added results (particularly in the context of exporting and non-exporting companies), and, so, part of future work will be to explore ways, using micro-data that could improve the quality of results (see Ahmad and Araujo, 2011) and below.

*Measuring bilateral trade in intermediate inputs*

40. Central to the construction of an international input-output database is the estimation of trade flows between countries. Indeed, these trade flows in intermediate goods and services are the glue which tie together the individual input-output matrices derived from national accounts. As mentioned, national sources on disaggregated bilateral trade flows show a high level of asymmetry, and are not always compatible with national account data. The OECD is currently developing a *Bilateral Trade Database by Industry and End-Use Category* (BTDIxE), 1988-2009, derived from OECD's International Trade by Commodities Statistics (ITCS) database and the United Nations Statistics Division (UNSD) UN COMTRADE database, where values and quantities of imports and exports are compiled according to product classifications and by partner country (Figure 1 for China and Figure 2 for United States). Further information on this initiative can be found in Annex III. The database will provide the basis for a finer allocation of imports by exporting country to users (intermediate consumption, household final demand, and investment) and greatly improve the quality of inter-industry trade flows in the global input-output matrix and therefore the trade in value-added results.

*Improving the quality of the assumptions used to allocate imports to users*

41. As mentioned, the homogeneity assumption is usually made to disaggregate the use of imported intermediate goods; firm level data however reveals a large heterogeneity in the import penetration rates of firms, between those actively engaged in trade and those producing only for the domestic market. The TEC (Trade by Enterprise Characteristics) exercise[21] is a joint project of the OECD and Eurostat which disaggregates trade values (imports and exports) according to the characteristics of trading firms. This is achieved by linking customs data and business statistics at the level of the firm and covers virtually the entire population of a country's business and (internationally) trading population. Customs data provide volume and value and HS codes of the products traded at the 6 digit level together with the identification of the business entities involved in the international transaction. This information is then matched with company level information available in countries' business registers; which contain information on firm size and turnover, activity (industry) and ownership. Linking these two sources of firm-level information

21 More information on the TEC exercise can be found in the OECD Statistics Brief n. 16 (2011) and the Eurostat website: http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/International_trade_by_enterprise_characteristics. The resulting database, which displays aggregate trade values due to confidential rules, is accessible through the OECD website: http://stats.oecd.org/Index.aspx >> Globalisation >> Trade by Enterprise Characteristics.

allows estimates of firm-level value-added to be derived and provides characteristics of the firms engaged in value-added creation through exports and/or imports.

42. As such, the TEC database provides a unique opportunity to further refine the quality of the import data used in the I-O tables and also to create sub-categories of industry groups that discriminate between export intensive, import intensive, import/export intensive firms and other firms, allowing for a more detailed understanding of international production networks.

43. One of the challenges in using the TEC database in this way relates to fact that many exporting and importing companies are classified to the wholesale sector, even if the wholesaler just reflects the distribution or purchasing arm of a manufacturer. Linking these wholesalers to the manufacturing part of the company therefore will form an important part of the work.

*Constructing improved estimates of bilateral trade in services*

44. This is perhaps one of the most challenging statistical issues faced in the construction of an international input-output table, as statistics covering bilateral trade in services are generally only available for most countries (in a comparable way) at the total services level. Some countries are able to provide breakdowns of trade in services using the Extended Balance of Payments (2002) breakdown (which has recently been revised, EBOPS 2008) but not typically on a bilateral basis.

45. The OECD plans to investigate the scope for using raw data as the basis of the construction of a Bilateral Trade in Services database by creating links between the detailed EBOPS data and the total services bilateral trade data. Some work in this area using gravity modelling has already been conducted and the aim is to explore how this work could be refined and indeed automated for future assimilation into a global input-output table. The TEC database offers considerable potential scope here as well. In the interim the provisional results from the earlier work and standard methods, such as RAS[22], for allocating international trade in services between industries will be used in constructing global input-output tables.

## 3. Concluding remarks: challenges ahead

46. As described above, the OECD and WTO have been closely cooperating with other stakeholders involved or interested in the issue of producing estimates of trade in value-added, and is. However, many statistical and methodological issues remain to be resolved. In particular, much more can be done to improve the quality of these estimates: particularly concerning the quality of detailed bilateral trade in intermediates (for both goods and services). More generally, "best practices" need to be established when trade and national accounts divergences cannot be resolved simply, and diverging sources need to be arbitraged. These best practices and their documentation should build on the existing experience accumulated in various national and international initiatives and projects.

47. Given the importance of the subject, the OECD and WTO will be looking to engage more closely with their networks of official statistics institutes and other international organisations in the coming years in order to attempt to mainstream the production of trade in value-added statistics, such that their quality can be considered in the same light as other official statistics. Most initiatives have taken place as time-limited or one-off special projects, with the exception of those conducted by IDE-JETRO and OECD. It is now essential to take stock of the experience accumulated, and mainstream the subject into the regular work of the international statistical system. Such mainstreaming would, in turn, provide an official mandate for funding the related activities and provide a source of official statistics that are recognised as

22 . See for example, Parikh (1979).

such by the international statistical community. OECD has already developed the institutional and technical capacity to shoulder the technical responsibilities of such an undertaking, capitalising on its network of official statistics institutions. Both, OECD and WTO have strong networks in the area of trade policy and can therefore provide the proper institutional environment to maintain and expand the existing network of experts and projects working on this subject, and channel the results and their policy implications to the most appropriate international fora. "Different means of calculating trade is relevant well beyond…the politics of bilateral trade balances. […], trade shifts from a one-to-one balance into a network of value-added chains, where interdependence dominates and everyone can win."[23]

48. Clearly the key technical challenges in the immediate future concern the quality of trade statistics and the assumptions made to allocate imports to users (industries/consumers). In addition, there are a number of issues that arise from the recent revision to the System of National Accounts (2008 SNA) and Balance of Payments Manual (BPM6) which provide the underlying basis for international trade transactions and indeed those recorded in input-output tables. Chief amongst these concerns changes made to the recording of 'goods sent abroad for processing' and 'merchanting'. But other important changes have been made too, such as the recognition that 'research and development' expenditures should be recorded as investment, which directly changes value-added. Indeed the recognition of R&D as investment shines a spot-light on other intellectual property products and on the importance of flows of income as opposed to only value-added. Again the institutional networks of the OECD and its partner international organisations in the international statistics community are well placed to provide an umbrella for these issues to be further developed.

49. Finally, a crucial practical challenge is communicating pertinent output concerning trade in value added in ways that are easily understood and interpreted by policy makers in general —and trade negotiators in particular— as well as non I-O practitioners in general (including economic researchers and journalists). Meaningful trade in value added statistics and indicators should be presented in simple, unambiguous, terms whether via summary tables or via graphical output – the latter, possibly exploiting recent advances in software for producing 'dynamic' graphs for online visualisation. Significant efforts to develop robust indicators of international trade in value added should be accompanied by **effective communication** to target audiences.

23 . Pascal Lamy, Financial Times, 24 January 2011.

## ANNEX I - A BRIEF OVERVIEW OF THE LITERATURE ON TRADE IN VALUE-ADDED

Even if global manufacturing through international supply chains has become a major characteristic of the international economy in the past 20 years, reflections about the global nature of production date from much earlier times. A first intent to formalize it is attributed to Leontief in the 1960s (Leontief and Strout, 1963).

Current reflections on the value-added content of international trade stem from two streams of economic literature. The first one deals with the importance of trade in intermediate goods and services. This is not a new topic as Sanyal and Jones already noted in a seminal paper published in 1982 that the bulk of international trade was in intermediate products and that trade in intermediates did not consist mainly of raw material or primary inputs but of products that had already received some value-added (the authors called them 'middle products'). Today, trade in intermediates accounts for about 56% of world trade in the case of goods and 70% in the case of services (Miroudot *et al.*, 2009). The growth of trade in intermediates has been highlighted in various recent surveys, in particular in Asia (see for example, Hayakawa, 2007). Looking at trade in intermediate goods and services is the first step in the measurement of trade in value-added.

Following the definition introduced by Hummels *et al*. (2001), the second stream of literature focuses on "vertical trade". This later expression refers to the vertical specialization of trade which is the consequence of the international fragmentation of production. There is vertical trade when three conditions are met: (1) a good (or service) is produced in two or more sequential stages; (2) two or more countries provide value-added during the production process; and (3) at least one country uses imported inputs in the process and some of the output is exported. When taking into account both direct and indirect imported inputs, as suggested by Hummels *et al.* (2001), the vertical specialisation share (VS share) of world trade is about 25%.

The literature on vertical trade aims at measuring sequential trade in vertical production chains by looking at the import content of exports. Trade in value-added is a broader concept but shares with this literature a common concern: how can we distinguish the foreign and domestic value-added in gross exports. Coefficients from imports and domestic matrices in input-output tables are used to operate this distinction. One issue that has been identified is the use of the same coefficients for the production sold on the domestic market and for exports, in particular in countries with a high level of "processing trade" such as China (see Koopman *et al.*, 2008).

The first papers to explicitly refer to a measurement of the value-added of trade (with some empirical measurement) requiring explicitly an international input-output framework are Daudin *et al*. (2006, 2009), Johnson and Noguera (2010) and Koopman *et al.* (2011). The implications for official statistics and national accounts can be found in Escaith (2008). The three studies rely on the GTAP database to calculate trade flows in value-added. Daudin *et al.* (2009) identify "who produces what and for whom" by reallocating the value-added contained in final goods to each country participating in their production. In addition to the VS share of Hummels *et al.* (2001), the authors calculate the share of exports used as inputs to further exports and the domestic content of imports (that is domestic value added that comes back to the country through intermediates originally exported and re-imported within more processed products). Johnson and Noguera (2010) present similar calculations but based on a different decomposition of value-added exports. They focus on bilateral trade flows and calculate the ratio of value added to gross exports, a

measure of the intensity of production sharing. As an illustration, they show that the US-China bilateral imbalance in 2004 is 30-40% smaller when measured in value-added terms. As opposed to Hummels *et al.* (2001), their framework allows two-way trade in intermediates (each country can both import and export intermediates while in the VS framework the last country exports final goods only).

Koopman *et al*. (2011) provide a full decomposition of value-added exports in a single conceptual framework that encompasses all the previous measures. Exports are first decomposed into domestic value-added, returned domestic value added (domestic value added that comes back incorporated in foreign inputs produced with domestic inputs) and foreign value-added. Domestic value-added is then split between exports absorbed by direct importers and indirect exports sent to third countries. By taking into account the returned domestic VA and the indirect exports to third countries, two sources of indirect value-added exports are taken into account and the decomposition is complete (thus matching standard trade data in gross terms when all the decomposed values are aggregated).

Between the pioneering work of Hummels *et al.* (2001) and these latest studies, the conceptual framework has been enhanced and we now have a full understanding of what constitutes trade in value-added terms. The exercise consists in distinguishing domestic and foreign value-added. But, as previously pointed out, the difficulty is that "domestic value-added" can be found indirectly in imports of foreign inputs (as 'returned domestic VA') and when exported to another country can be also indirectly found in exports from third-countries. The field is therefore not only extremely relevant, but also fully mature for its full inclusion in official statistics (Escaith, 2008). When fully accounting for this, one can have a clear distinction between the foreign and domestic value-added. The next step in the analysis is to provide a full decomposition of the foreign value-added according to the country of origin of the VA. There are also issues with such decomposition but the techniques are basically the ones reviewed in the above literature.

## ANNEX II - ON-GOING PROJECTS AND INITIATIVES ON THE CONSTRUCTION OF INTERNATIONAL INPUT-OUTPUT TABLES

In the last two years, the papers that have put the emphasis on trade in value-added have stimulated the research on input-output analysis and international trade. There are several projects that aim at producing international input-output tables that can be used to calculate the domestic and foreign content of bilateral trade flows. Table 3 below gives an overview of existing initiatives regarding the construction of such tables. It should be noted that inter-country I-O tables only represent the first step in the production of trade statistics in value-added terms. Some of these projects do not have as a primary objective the estimation of such statistics and international input-output tables are useful for many other analytical purposes.

One of the oldest attempts to develop a systematic international input-output data base derived from official sources deals with Asian countries and the US. This project has been implemented by the Institute of Developing Economies, affiliated with Japanese External Trade Organization. IDE-JETRO has a set of US-Asian tables covering 10 countries, 76 sectors and 4 years.[24] They have additional bilateral tables, including China-Japan. While the country coverage is limited to the US and Asia, one advantage of these tables is that firm surveys are used to allocate imports of intermediates across partner countries. In other projects, this allocation relies only on statistical imputation methods. IDE-JETRO has been cooperating with WTO to explore more in details the trade-related implications of global and regional production networks, and compare the relative merits of the different measurement methodologies suggested by the literature (see above, paragraphs 9 and following).

The first studies on the value-added of trade have relied on the GTAP database and more specifically its set of international input-output tables. GTAP database is a non-official data set, hosted by Purdue University. It has a world-wide coverage which includes more than 90 individual countries, remaining economies being bundled together in regions. Being research-oriented and especially designed for the community of Computable General Equilibrium Model users, GTAP data are internally consistent. Nevertheless, data benchmarking and arbitraging for consistency may lead to discrepancies with original national accounts. This may limit its use for international organizations which need to source their estimate to national sources as closely as possible. The GTAP database version 7 covers the year 2004 and includes 113 regions (94 countries and 19 composite regions) and 57 industries.[25] Single country I-O tables are contributed to GTAP by individual researchers and then harmonised and reconciled with other macro-economic data. The advantage of this process is that the database has a wide coverage and is very detailed but the drawback is that tables from different years and heterogeneous sources are put together.

As the aim of the GTAP project is to build a Computable General Equilibrium (CGE) model of trade, the emphasis is on completeness and how to design a full representation of world trade relations. The primary concern is not to measure the value-added content of trade in a way consistent with official statistics. Yet, many initiatives related to trade in value added, more closely related to economic research than statistical developments, have based their work on the GTAP data bases. It is in particular the case of

24. Asian International Input-Output Table 2000, Statistical Data Series No. 89 Explanatory notes.

25. See Walmsley and Lakatos (2008) for a description of I-O tables in GTAP.

many papers referred to in this note, such as Daudin *et al*. (2006, 2009), Johnson and Noguera (2010) and Koopman *et al*. (2011).

While data are already available for selected years in the case of GTAP and Asian I-O tables, there are four other major initiatives where the construction of the tables is still an on-going process. First, the World Input-Output Database (WIOD) project[26] is being undertaken by a consortium of 11 institutions funded by the European Union (under the 7th Framework Program or FP7). WIOD is developing inter-country tables for the 27 EU economies and 13 additional countries. The main source is national Supply-Use tables rather than I-O tables with the advantage that time-series will be estimated for the period 1995-2009. WIOD tables, expected in mid-2012, will be based on official National Accounts statistics and will use an end-use classification to allocate trade flows across partner countries.

The OECD, which is part of the WIOD consortium, has also developed a model of inter-country tables based on its I-O database (see Section 2 of this note). Finally, the AISHA and EXOPIOL projects (the later also funded by the European Commission) are mentioned in the Table below but developed more specifically to analyse environmental issues.

**Table 3. On-going projects on the construction of international input-output tables**

| Project | Institution | Sources | Number of countries | Number of industries | Available years |
|---|---|---|---|---|---|
| AISHA | University of Sydney | Based on national I-O tables optimized and reconciled through a mathematical model | 160 countries | 25-500 (national number of sectors is kept) | 2000-2008 (time series) |
| Asian International Input-Output Tables | IDE-JETRO | National accounts and firm surveys | 10 economies | 76 sectors | 1975,1985, 1990, 1995, 2000 and 2005 |
| A new environmental accounting framework using externality data and I-O tools for policy analysis (EXIOPOL) | 18 universities and research centers from Europe, China and India | National I-O tables and supply-use tables | 43 countries | 129 industries and products | 2000 |
| Global Trade Analysis Project (GTAP ver 8) | Purdue University, consortium of 27 institutions | Contributions from members of the GTAP network (includes various sources and is not limited to official statistics) | 129 regions | 57 sectors (GTAP commodities) | 2004 / 2007 |
| OECD Inter-country Input-Output database | OECD | National I-O and supply-use tables and National Accounts | 55 countries + RoW | 37 sectors | 1995,2000, 2005 and 2009 |
| World Input-Output Database | University of Groningen, consortium of 11 institutions | National accounts (supply-use tables) | 40 countries | 35 industries and 59 products | 1995-2009 (time series) |

At this stage of the research on trade in value-added, this is useful to be able to compare several sources and data estimated according to different methodologies. The plurality of projects should not be seen as a duplication of work as the initiatives described in Table 3 are all of a different nature and complementary.

As previously emphasised, international I-O tables address many issues beyond trade and have multiple uses. This is, however, important in the future to find some convergence on the way data are collected and estimated, and define best practices for both the data collection and the measurement methods. The identification of "best practices", a common procedure in official statistics, would greatly reduce the cost of replicating and extending present initiatives.[27] Some of the above mentioned projects

26. See www.wiod.org.

27. Some regions like Africa and Western Asia are still absent from a systematic coverage based on official data, while they would probably benefit most from a better understanding between vertical trade, trade in tasks and development.

are limited in time and one concern should be to institutionalize the construction of trade statistics in value-added terms. This is why the present note encourages further co-operation between international organizations, with national statistics offices and other research institutions to complement the work that has already been done and converge to a set of commonly accepted computation methods and imputation techniques which could form, for the time being, the "best practices" for estimating trade in value added.

## ANNEX III - BILATERAL TRADE DATABASE BY INDUSTRY AND END-USE CATEGORY

The OECD is currently developing a *Bilateral Trade Database by Industry and End-Use Category* (BTDIxE), 1988-2009, derived from OECD's International Trade by Commodities Statistics (ITCS) database and the United Nations Statistics Division (UNSD) UN COMTRADE database, where values and quantities of imports and exports are compiled according to product classifications and by partner country (Figure 1 for China and Figure 2 for United States).

The OECD International Trade by Commodities Statistics (ITCS) database is updated on the basis of annual data submissions received from OECD Member Countries and, in some cases, from EUROSTAT. Due to the convergence of OECD ITCS and UNSD COMTRADE[28] updating processes, data sharing and other related co-operation between the two organisations, tables can also be computed for non-OECD members as declaring countries, notably the countries which belong to the OECD *Enhanced Engagement Programme*, namely Brazil, China, India, Indonesia and South Africa.

In ITCS and COMTRADE, data are classified by declaring country (*i.e.* the country supplying the information), by partner country (*i.e.* origin of imports and destination of exports), and by product (*i.e*. according to Harmonized System (HS)). In both data sources, trade flows are stored according to the product classification used by the declaring country at the time of data collection. In general, source data are held according to Standard International Trade Classification (SITC) Rev. 2 for the time period 1978-1987, the Harmonized System (1988) for 1988-1995, HS Rev. 1 (1996) for 1996-2001, HS Rev. 2 (2002) for 2002-2006 and HS Rev.3 (2007) from 2007 onwards.

To generate estimates of trade in goods by industry and by end-use category, 6-digit product codes from each version of HS from ITCS and COMTRADE are assigned to a unique ISIC Rev.3 industry and a unique end-use category- and hence SNA basic classes of goods, (see Table 4 below). Thus, 8 sets of conversion keys have been estimated using classification correspondence tables, developed internally by the OECD Directorate for Science Technology and Industry, and available classification correspondence tables published by UNSD.

[28] http://unstats.un.org/unsd/comtrade/

**Figure 1. Export share by industry and end-use category (China, 1995, 2010)**

**1995 (USD 237 billion)** **2010 (USD 1918 billion)**

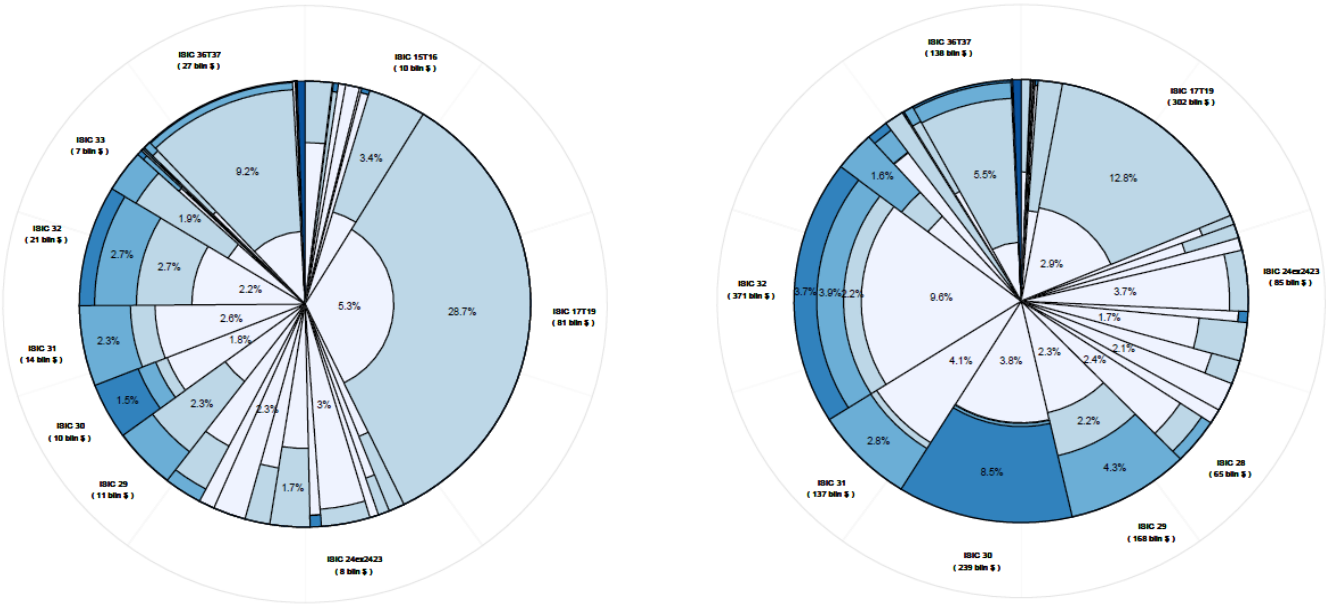



**Figure 2. Export share by industry and end-use category (United States, 1995, 2010)**

**1995 (USD 633 billion)** **2010 (USD 1244 billion)**

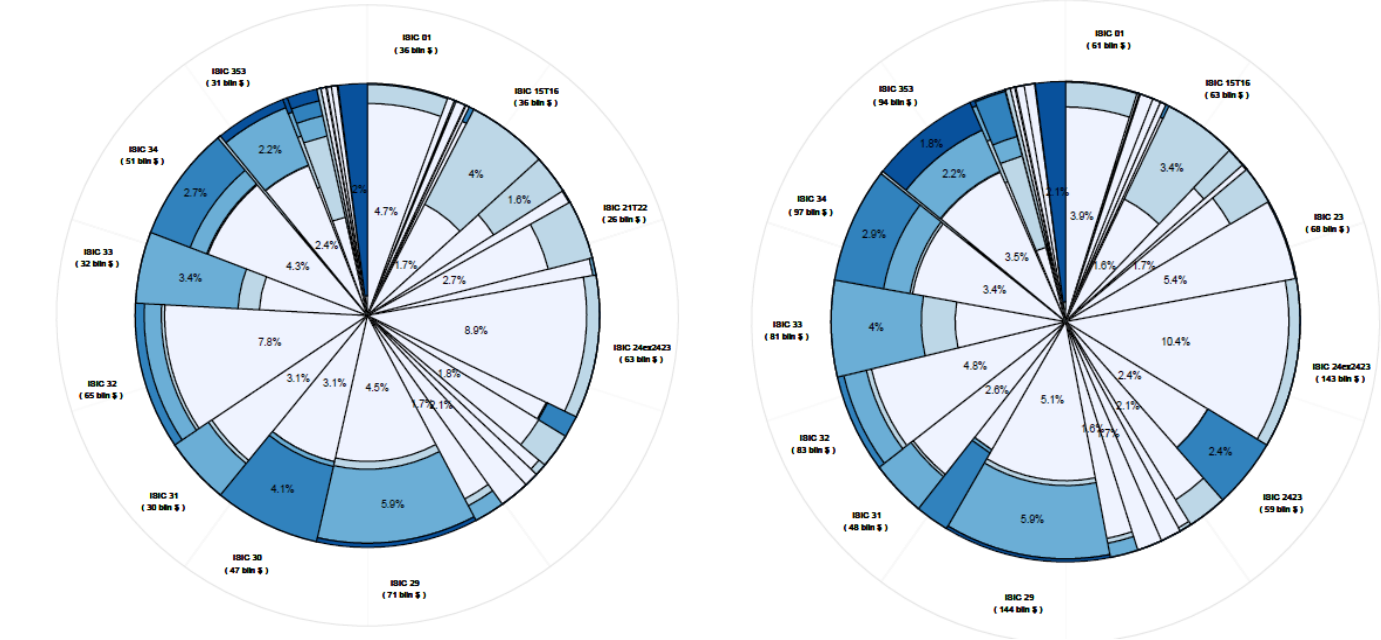


**Table 4. Current BEC and SNA classes of goods**

| | | End-use | | | |
|---|---|---|---|---|---|
| | | Intermediate | Final demand goods: Household consumption | Final demand goods: Industrial capital goods | Other |
| Products characteristics | Primary products | Food and beverages (111)<br>Industrial supplies (21)<br>Fuels and lubricants (31) | | | |
| | | | Food and beverages (112) | | |
| | Processed unfinished | | Food and beverages (122) | | |
| | | | Fuels and lubricants e.g. gasoline (32) | | |
| | | Food and beverages (121)<br>Industrial supplies (22)<br>Parts and components of transport equipments (53)<br>Parts and components of capital goods (42) | | | |
| | Processed finished | Packed medicaments (part of 63) | | | |
| | | | Non-industrial transport equipments (522)<br>Non durable consumer goods (63)<br>Semi-durable consumer goods (62)<br>Durable consumer goods for households (61) | | |
| | | | Durable personal consumer goods e.g. personal computers (part of 61),<br>Mobile phones (part of 41)<br>Passenger motor cars (51)<br>Fixed line phones (part of 62) | | |
| | | | | Capital goods (41)<br>Industrial transport equipments (521) | |
| | Other | | | | Goods n.e.c (7) |

*Sources:* http://unstats.un.org/unsd/cr/registry/regcst.asp?Cl=10&Lg=1
*Note:* Numbers are BEC code

A provisional BTDIxE database is completed in the third quarter of 2011. There are several thorny issues to be considered including:

- **Confidential trade:** There is currently a different treatment in ITCS and UNSD COMTRADE. Standard conversion keys from HS do not account for confidential trade, although if defined at 2-digit HS *chapter* level (*e.g.* the difference between reported 2-digit data and sum of 6-digit components) some can be allocated to ISIC and BEC codes.
- **Re-exports:** Adjustments are required for **re-exports** which are significant for major continental trading hubs. Sufficient data are available in order to adjust for reported trade between China and the rest of the world via *Hong Kong*, but not currently for other major hubs such as Belgium, Netherlands and Singapore, and this will need to be investigated.
- **Identifying used/second-hand capital goods**: HS codes, and thus reported trade in ITCS and COMTRADE cannot differentiate between new and old capital goods (such as second-hand aircraft and ships). Estimating international trade in these flows in a value-added context requires an elaboration of the input-output framework that allows these flows to be recorded in a way that aligns with total global value-added produced in a given period.
- **Final consumption goods as intermediates**: Goods identified as consumer goods in the BEC/SNA classes may be used as intermediates in service activities *e.g.* pharmaceuticals (medical services) and various foodstuffs (catering services), and it will be important to fine-tune the estimation here using feedback loops with input-output data.
- **Unidentified scrap and waste:** Certain types of waste and scrap do not have separate 6-digit HS codes – *e.g.* PCs and other electrical equipment exported (often to developing countries) for recycling.

The development of this database is however only the first step. Integrating the results of this database into a global input-output table will form the major and relevant part of this work for the project. The database will provide the basis for a finer allocation of imports by exporting country to users (intermediate consumption, household final demand, and investment) and greatly improve the quality of inter-industry trade flows in the global input-output matrix and therefore the trade in value-added results

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