Bilateral trade balances for the Netherlands and eight selected countries: Comparing gross and value added trade statistics and data sources

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1 Introduction

The recent literature on trade in value added [Koopman et al. 2010, 2014, Johnson and Noguera 2012] highlights the limitations of traditional trade statistics –i.e. in gross trade values– to deal with the increasing importance of global supply chains in international trade. First, the increased flow of intermediate inputs between countries creates a "double counting" problem when these inputs cross borders, sometimes more than once. More importantly, traditional gross trade statistics can present a misleading picture of international trade relations. They can exaggerate the relative importance of countries at the end of global supply chains with respect to countries that are positioned at the beginning and middle of these supply chains. For example, China imports a large proportion of intermediate inputs, assembles these intermediate inputs into final goods
that are later exported to the main global consumer markets in the US and the EU. Chinese exports are much larger in gross terms than in value added terms, because Chinese gross exports are accounting for the large proportion of imported intermediate inputs. Trade in value added statistics are constructed to factor out the flows of imported intermediate inputs in the trade of final goods and services. Therefore, value added trade data yield statistics that better reflect the implicit content of labour, capital and other country-specific value added components in international trade flows.

It is important to note that overall trade balances are equal when using gross or value added terms: the flow of intermediate inputs cancel out in the aggregate. However, bilateral trade balances estimated in gross and value added terms may diverge—and sometimes have large differences— that reflect the particular position of a country in global supply chains. For instance, the first papers in the literature found that the United States trade deficit with China is approximately one-third lower in value added than in gross terms (Koopman et al., 2010).

In this paper we focus on the Dutch experience, where trade surplus have been relatively high and increasing in recent years. This background document is part of a larger project at CPB studying the current account surplus of the Netherlands. In this paper we focus on the trade component of the current account and we compare the Dutch trade data in gross and value-added terms that are estimated from the GTAP and the WIOD databases. In particular, we analyse if the Dutch bilateral trade balances and trade patterns change when analysing trade in value added—instead of gross—terms.

We find that the relatively large overall Dutch trade surplus is mainly explained by its large surplus with other EU27 countries and that this pattern is confirmed by both traditional gross or value added trade statistics. However, the bilateral trade surplus with the rest of the EU is substantially lower (between half and one-third) in value added than in gross terms. Accordingly, Dutch trade deficits with other global regions are also smaller in value added than in gross terms, and sometimes the sign of the balance is even reversed. This result highlights the role of the Netherlands as a (net) importer of intermediate inputs from outside the EU that are later exported within the EU. This relatively large component of imported intermediate inputs that transit through the Netherlands creates a wedge between bilateral balances in gross and value added terms. This wedge is even more significant when looking at the bilateral trade balances by sectors—instead as aggregated for the total economy.

In addition, comparing the GTAP and the WIOD data output, we find that the main differences between the trade in value added patterns estimated from both sources relate to the relative changes over time: more stable when using the WIOD database, but more compositional changes when using the GTAP database. We also find that the
differences between gross and valued added trade are even more evident at the sectoral level, where the movement of intermediate inputs flows is more visible – since at the aggregate level many of these inter-sectoral intermediate input flows cancel out.

In the final section of the paper we perform a similar –but more condensed– analysis for selected EU countries (i.e. Germany, France, United Kingdom, Spain and Italy) and other large international trading countries: United States, Japan and China. At the intra-EU level we find that there are significant and increasing trade imbalances within the EU27 for its major economies. For most of the countries analysed (the Netherlands, Germany, France, the UK and Spain), we find that the overall trade balances are a direct consequence of the intra-EU balances. The exception is Italy, for which its trade deficit is increasing due to its bilateral trade relations with China and the Rest of the World region. The use of the GTAP and WIOD databases to calculate trade in value added provides valuable information that can be compared with the traditional gross trade statistics. For some countries –notably the Netherlands, Japan and China– the differences between gross and value added bilateral trade balances can be substantial. These differences depict the importance of the aggregate flows of intermediate inputs through these countries. On the contrary, for countries that are the international trade hubs –i.e. mainly as exporters of final goods– the differences between gross and value added balances are less important, but nonetheless can be informative for particular cases. For example, the much lower trade deficit of the US with China in value added terms than in gross terms is a well known international trade issue.

Finally, we also show that there are large discrepancies between the estimated bilateral trade flows –both in gross and value added terms– between the two multi-regional IO (MRIO) databases we use: GTAP and WIOD. More precisely, these differences are the result of the adjustments done to the underlining trade data –which also determines gross trade values– that are needed to deal with the inconsistencies in country-specific trade statistics. Here we have shown that overall trade balances between the GTAP and the WIOD databases are usually large, and this is also reflected in bilateral trade divergences. In general, however, the overall patterns of bilateral trade balances and the relation between gross and value added calculations is usually consistent between both databases.

The paper is structured as follows. Section 2 introduces the estimation of trade in value added statistics, while Section 3 discusses the characteristics and differences between the WIOD and the GTAP database. The bilateral trade analysis for the Netherlands is presented in Section 4 and in Section 5 for the other eight selected countries. We summarise our results in Section 6.
2 Estimating trade in value added

Gross trade statistics are directly provided by national statistical agencies. Value added trade statistics, on the other hand, must be estimated using multi-region input-output (MRIO) tables. The core of these MRIO tables is the national input-output (IO) matrix that provides information on how the output of each industry is used as an intermediate input in other industries and for final use. More importantly, it provides information on the value added by industry - i.e. the share of primary production factors that is used to produce a unit of gross output. Value added can be further disaggregated into the specific primary factors that are used (e.g. capital, skilled and unskilled labour).

Finally, the national IO-tables are complemented with international trade statistics, which then allows to track how intermediate and final output - and the value added embedded in these output values - travels domestically and internationally.

With the information contained in an MRIO table, we can track the value added generated in a specific country and industry all the way to the country where it is finally used. This process may entail a simple chain (e.g. the value added of a worker directly providing a service to a final consumer, such as a hair cut) or it can entail a long and complicated international production chain (i.e. the value added of a worker that provides a service that is used to produce an intermediate input, that is shipped to another country to produce a more complex intermediate input, that finally ends up being used in the final output of a good that is consumed in a third country).

We refer to Appendix A for the theoretical background and calculation methods of trade in value added. There we provide an integrated framework for the analysis of gross and value added trade flows and explain that the aggregate trade balance is the same for gross trade and for value added trade. This is so because at the aggregate level ‘imports in exports’ cancel. Generally, cancellation of ‘imports in exports’ does not occur at the bilateral level. If the bilateral trade balance in terms of value added is larger than the bilateral balance in terms of gross trade the country to which this excess accrues must have less ‘imports in bilateral exports’ than its trading partner.

One may verify that the aggregate value added trade balance equals the aggregate gross trade balance. We know that at the aggregate level all intermediate imports cancel out and only net trade in value added remains. However, at the bilateral level this equality does not have to (and seldom) holds, since intermediate imports do not cancel out bilaterally.

\[\text{Footnote 1: For example, if the Netherlands imports energy from Norway for 50 to produce diary products that are exported to Germany for 100, the German trade balance with the Netherlands is -100 in gross terms and -50 in value added terms, while the German trade balance with Norway is 0 in gross terms and -50}\]
3 Data sources and adjustments

National statistical agencies perform several adjustments to trade data. In the case of the Netherlands, these adjustments include the way in which trade data is recorded, the reconciliation between the data from Netherlands Statistics (CBS) and the Dutch Central Bank (DNB), and how to treat re-exports.

In addition, these reconciled national data may not be consistent with other international sources. The main issue here is that there are large discrepancies in trade data between countries, even at relatively disaggregated sectoral levels. For instance, matching imports from a particular reported sector by the destination country are usually not equivalent to the exports reported by the origin country for the same sector. Thus, multi-region input-output (MRIO) databases need to reconcile and calibrate these discrepancies in international trade data. There are several MRIO databases that can be used to estimate trade in value added. In this paper we use the GTAP database and the WIOD database.

As a general principle the GTAP compilation approach relies more on matching trade data—which has been determined to have established reliability—with the IO data. On the other hand, the WIOD data relies more on the IO data and then matches the trade data to it (cf. Wiedmann et al., 2011). The GTAP database, in addition, is a truly "global" database in the sense that all countries—or global regions are represented by their particular IO tables (or IO structures from comparable countries/regions). These differences are also reflected in the dimensionality of the databases: GTAP has 113 countries and global regions with 57 sectors for particular years (in this paper we use the data for 2001, 2004 and 2007), while WIOD has 40 countries and 35 sectors for a time series running from 1995 to 2011.

Thus, a major difference between both databases—from the trade data perspective—is the Rest of the World (RoW) region. In GTAP, RoW is a relatively insignificant region, with a decreasing importance in each new database version. On the other hand, the RoW region in WIOD is a very significant region that includes all other countries not explicitly separated in the database. As such, this region is a crude aggregation of very

\[\text{aggregate trade balance of Germany is} \ -100 \ \text{in gross and value added terms, but the bilateral trade balances are different. In the aggregate the intermediate input flows cancel out and there is no wedge between gross and value added balances.}\]

\[\text{Other MRIO databases are constructed by the OECD-WTO (www.oecd.org/trade/valueadded) and UNCTAD-EORA (www.worldmrio.com).}\]

\[\text{For instance, the Rest of the World region in version 8 of the database (with base year 2007) includes only Antarctica, Bouvet Island, British Indian Ocean Territory, and French Southern Territories.}\]
heterogeneous economies (i.e. at different development levels, country sizes, production structures and trade characteristics). Moreover, the trade calibration procedure employed in WIOD –were IO data is given more importance than bilateral trade data– also implies that the trade data discrepancies so common in international trade data cannot be fully calibrated, and the RoW region is implicitly absorbing these differences.

On the other hand, the GTAP data has the disadvantage that it employs a proportionality assumption to allocate total imports between intermediate and final use for all countries in the same proportion– i.e. irrespective of the country of origin. This is problematic if one wants to measure trade in value added for countries with large export processing sectors, such as China and Mexico. The WIOD data, however, uses the UN BEC method to split bilateral imports between intermediate and final output and this provides a more accurate treatment of the trade data.

To illustrate the underlying differences in trade statistics between data sources, Figure 1 presents the trade balances for the Netherlands using the GTAP, WIOD databases, as well as the Netherlands Statistics (CBS) and OECD data. Here we observe that the discrepancy between different sources can be large –even between databases that only present aggregate trade data: CBS and OECD. In particular, the CBS and WIOD data are more similar (at least in their trend even though there is a relatively constant wedge between both), which reflects the underlying principle in constructing the WIOD that national statistics are not greatly adjusted to reconcile international differences –which means that these international differences are indirectly translated to the Rest of the World (ROW) region. On the other hand, OECD and GTAP do adjust the data to reconcile international discrepancies and this is reflected in large differences in some years with the other sources –in particular, for the GTAP database.

An important issue for the estimation of bilateral trade balances and value added accounting, is the treatment of re-exports. This is specially important for the Netherlands, as well as Singapore and Hong Kong. These methodological adjustments can create large discrepancies in trade flows. Both the GTAP and the WIOD databases incorporate basic adjustment mechanisms to deal with re-exports (cf. WIOD, 2012). However, since version 6 (with base year 2001), the GTAP database includes specific adjustments to deal with the special re-export cases for the Netherlands, Hong Kong and Singapore (Gehlhar, 2006, 2012).

It is important to note that Statistics Netherlands (CBS) has a different definition of *re-exports* (i.e. *wederuitvoer* in Dutch) than the commonly used definition in

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4 In particular, the RoW region in WIOD is artificially constructed using the average IO and trade share values of a group of emerging countries: Brazil, Russia, India, China, Indonesia, and Mexico (BRICIM), together with a series of additional statistical calibration procedures (WIOD, 2012).
international databases such as GTAP and WIOD. For CBS re-exports are "goods transported via the Netherlands, which are temporarily owned by a resident of the Netherlands, without any significant industrial processing". This definition, however, allows for value-added processes from services to be part of final re-exports. On the other hand, the common international definition of re-exports is that re-exports do not undergo any value-added processes –i.e. foreign goods that are re-exported in the same state as previously imported. This last definition is equivalent to that of "transit trade" employed by CBS (cf. www.cbs.nl). For instance, the CBS defined re-export represent between half and two-thirds of total Dutch exports of goods (depending on the particular year) and this indirectly represents the importance of the Port of Rotterdam for Dutch trade in goods.
4 Trade in value added analysis for the Netherlands

In this section we analyse the patterns in trade and the differences between gross and value added trade for the Netherlands.

4.1 Using the GTAP data

From Figure 2 we observe that the overall Dutch trade surplus is directly related with its surplus with the rest of the EU27. Compared with the EU27 region, the changes in other regions are relatively minor.

When comparing gross with value-added trade, the above pattern is similar but there is a narrowing of the surplus/deficit with some regions. In particular, for the EU27 the surplus is significantly reduced in value-added terms, while the deficit with other regions decreases (most notably with the USA, RoW and China). This pattern between gross and value added differences is maintained over the years, even when surplus is increasing due mainly to an increase in the Dutch surplus with the rest of the EU27.
Figure 2: Netherlands, bilateral trade balances using gross and value-added data by global regions using the GTAP database, millions of euros

Notes: The regional aggregation is presented in Table 1 in Appendix B. Source: Own estimations using the GTAP database.
In Figure 3 we analyse the trade data within the EU27 and find that in 2001 the Netherlands had significant trade surpluses (both in gross and value added terms) with only three main partners: Germany, Italy and France. In this year, moreover, the difference between gross and value added surplus is significant, especially for Germany where value added is around one-fifth of the gross trade surplus. Comparing 2001 with 2004 and 2007 we observe that the Netherlands has trade surpluses with increasingly more EU27 countries, and more remarkable, the gross and value added surpluses are usually comparable. The main exception is Germany, where value added is around one-third of the gross trade surplus. For the UK and other smaller countries (Finland, Sweden, Bulgaria and Romania) the value added is larger than the gross surplus.

Thus, for Germany, the Netherlands has remained an international trade spoke providing much more intermediate inputs from third countries to Germany than Germany is sending to the Netherlands. For the rest of EU countries the value added trade surplus has increased significantly between 2001 and 2007. While in 2001 the value added to gross surplus ratio was 0.34, for 2004 it was 0.64 and for 2007 0.70.
Figure 3: Netherlands, bilateral trade balances using gross and value-added data for the EU27 and selected EU countries using the GTAP database, millions of euros

Notes: The vertical axis values are the same for all three graphs, but the values for EU15 and EU27 exceed the upper limit in 2007. Source: Own estimations using the GTAP database.
Furthermore, in Figure 4, where we present total trade flows (exports and imports) for the Netherlands in 2007. From this figure it is clear that EU is by far the most important trading partner for the Netherlands, in particular Germany, Belgium, the UK and France. The USA is the most important trade partner outside the EU. Trade flows with the Rest of the World (RoW) are relatively high, but only because RoW aggregates the rest of the countries not classified in the other regions presented in the figure. Therefore, not only are the EU trade balances important for the Netherlands, but also the overall trade flows within the EU.

Figure 4: Netherlands, bilateral gross trade flows in 2007, millions of euros

Notes: The regional aggregation is presented in Table 1 in Appendix B. OWE is the Other Western Europe region, OEE is the Other Eastern Europe region, HK is Hong Kong, SEA is the South East Asia region, RoW is the Rest of the World. Source: GTAP database.
4.2 Using the WIOD data

Even though the surplus levels are very different between the GTAP and the WIOD databases, the gross/value-added and regional pattern is very similar. As with the GTAP data, in Figure 5 we use the WIOD data and also find that the large Dutch trade surpluses are mainly driven by the surplus with the EU27 region. Moreover, the value added trade surplus is lower than the gross trade surplus for this region. The gross/value added difference can be explained by value added trade surpluses (instead of deficits) with other regions – i.e. USA and ROW; and lower value added trade deficits with the rest of the regions: China, Russia and Other Asia.

The remarkable difference between the patterns of Figure 5 (WIOD) and Figure 2 (GTAP), is that the WIOD data shows a widening in the gap between gross and value added surpluses for the EU27 (with a gross to value added ratio of 0.64 in 1995, to 0.49 in 2011), while the GTAP shows the inverse effect: a narrowing of this gap (from 0.34 in 2001 to 0.70 in 2007). This difference is probably explained by the presence of re-exports in the WIOD data, which artificially inflate the gross trade surplus. In addition, the relative importance of the bilateral trade balance with the EU27 is increasing with the WIOD data, while it is decreasing with the GTAP data. In general, using the WIOD data we find smaller changes in the gross and value added ratios, as well as smaller changes in the composition of the bilateral trade balances by regions/countries than using the GTAP data.

In Figure 6 we show the decomposition of the EU27 bilateral trade balance for selected countries. For 1995 the Dutch gross trade surplus was evenly distributed among the different EU15 countries, while in 2011 Germany had increased its relative importance. When looking at the value added surpluses, there is almost no change in the relative importance of countries. This contrasts with the GTAP value added results, where the relative importance of specific EU countries has changed over time.
Figure 5: Netherlands, bilateral trade balances using gross and value-added data by global regions using the WIOD database.

Notes: Differences between gross and value added total trade is explained by the treatment of the international transport sector in WIOD. Source: Own estimations using the WIOD database.
Figure 6: Netherlands, bilateral trade balances using gross and value-added data for the EU27 and selected EU countries using the WIOD database.

Source: Own estimations using the WIOD database.
It is well known that the overall Dutch trade surplus is driven by a surplus with the EU27 (cf. [Statistics Netherlands, 2013]). Also, that this pattern is confirmed when using trade in value added statistics, even when the overall trade in value added surplus of the Netherlands with the rest of the EU27 is less important as recorded by gross trade statistics. In this paper we show how these patterns are changing over time when using two different trade in value added databases. When using the WIOD database we find that the value-added contribution of the EU27 surplus to the total surplus has increased, while the relative importance of specific countries has remained fairly constant. The GTAP database on the other hand, shows more changes in both the EU27 overall contribution as well as the relative importance of EU countries.

As explained in Section 3 these different results using the GTAP and WIOD databases are created by the different methodologies used to reconcile divergent bilateral trade flows between countries. The WIOD database has the advantage of being constructed to be fully comparable over time, this may explain why it has more stable gross and value added trade patterns. On the other hand, the GTAP database has the advantage that it relies relatively more on available and improved trade statistics that provide a better outlook on changes in international trade patterns.

To sum up, the Netherlands is highly integrated with the EU27 and moreover, is a spoke in global supply chains. It redirects exports of intermediate inputs from the World into the EU15 mainly through the port of Rotterdam, while the inverse process – EU countries sending intermediate inputs through the Netherlands – is relatively unimportant. Despite this special position in international trade networks, the overall pattern of Dutch bilateral trade surpluses by region does not change when analysing trade in value added instead of in traditional gross trade statistics.

### 4.3 Sectoral analysis for the Netherlands in 2007

Using the GTAP data for 2007 for the Netherlands, we disaggregate the overall trade balances by sector. For analytical purposes we aggregate the 57 GTAP sectors into 13 sectors (see Table 2 in Appendix B for the specific GTAP aggregation). In particular, we do not aggregate the medium to high technological manufacturing sectors that are the most integrated into global value chains: chemical, rubber and plastic products (CRP), motor vehicles and parts (MVH), other transport equipment (OTN), other machinery and equipment (OME) and electronic equipment (ELE).

From Figure 7 we find that – even when the trade balance with the EU27 is still the main driver of the total balance – the bulk of the Dutch trade surplus in 2007 can be associated with a handful of sectors. In gross terms, there are mainly five important
sectors in surplus: energy (ENG), low-technology manufacturing (LTM), chemicals, rubber and plastic products (CRP), other machinery and equipment (OME) and transport services (TRA). While agriculture and raw materials (AGO) is the main sector with a gross trade deficit.

In the case of value added trade, we find that the large trade surplus of the Netherlands is concentrated in just three sectors: LTM, OME and CRP, which represent roughly three quarters of the total surplus. The LTM sector has many GTAP sub-sectors, but in the case of the Netherlands this relatively large surplus is mainly driven by agro-industry sectors (e.g. diary and processed food products).

In addition, when we look at sector-specific balances we find some significant divergences between gross and value added trade, even more than for the total economy case. This is special evident in the agricultural sector (AGO), energy (ENG) and chemical, rubber and plastic products (CRP). For some sectors the total balance even switches sign (from deficit to surplus or vice versa) for several sectors: AGO, MVH, ELE and OBS.

To sum up, at the sectoral level we find that the distinction between gross and value added trade is crucial for the analysis. This reflects the role of the Netherlands as an international trade network centre that redirects large amounts of intermediate inputs to third countries.

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5 The large gross surplus in transport services is generated by international transport services. In particular, for the international transportation sector in GTAP we know which regions/sectors use their output but we do not know who owns these services and thus, they cannot be assigned to a region and are treated as a separate region (not shown in the graph).
Figure 7: Netherlands, bilateral trade balances by aggregated sectors using gross and value-added data from the GTAP database, 2007

Notes: Sector codes and aggregations are specified in Table 2 in Appendix B. Source: Own estimations using the GTAP8 database.
5 Bilateral trade analyses for other countries

In this section we analyse additional countries using the GTAP and WIOD databases. First, we look at the overall trade balances over time (complemented with OECD data). Secondly, we analyse country-specific balances disaggregated into bilateral trade balances with global regions and the relation between gross and value added statistics. Here we focus on the results for 2007 using the GTAP database, while the complete results for all years and using both datasets are presented in Appendix B.

5.1 Germany

We start with Germany, who has experienced an increase in its overall trade surplus since 2000, that reverted the previous trade deficits from the 1990s (see Figure 8). We also observe that the WIOD trade balances are significantly larger than the OECD and GTAP values. This fact is a recurring issue with the WIOD data and as explained above, it is related to the mechanism used by WIOD to deal with international divergences in trade statistics.

Figure 8: Germany, trade balance as percentage of GDP using different data sources

In Figure 9 we show the German bilateral balances for 2007 using the GTAP database. The main feature of the German trade data is that the gross and value added surpluses for the EU27 are very similar. In contrast to the Netherlands, Germany also has relatively large trade surpluses with the United States (and other NAFTA countries) and the RoW region. The weight of the EU27 surplus, however, is relatively high at around two-thirds of the overall trade balance.
Figure 9: Germany, bilateral trade balances in 2007 in gross and value added terms using the GTAP database

Notes: Sector codes and aggregations are specified in Table 2 in Appendix B. Here the RoW also includes the OWE, India, and East Asia regions. Source: Own estimations using the GTAP8 database.

The complete results for all available years and using both the GTAP and WIOD datasets are presented in Appendix B. In Figure 24 in Appendix B we present the bilateral balances by global regions calculated using the GTAP database. We find that Germany has a similar situation as the Netherlands: an increasing trade surplus that is mainly driven by its EU27 surplus. We still find that the gross and value added surpluses for the EU27 are very similar – but the weight of the EU27 surplus with respect to the overall trade balance is still high – around 75 to 80% in 2001 and 2004, and decreasing to around 60% in 2007 (due to an increase in the relative importance of the surpluses with the USA and RoW).

Within the EU27, Germany has trade surpluses mainly with France, the UK, Italy and Spain (see Figure 25 in Appendix B). For the last two countries the surplus has increased. The EU15 accounts for almost all the within EU27 German trade surplus. Ireland and the Netherlands are the main countries with trade surpluses with Germany. It is remarkable that –with some exceptions– the gross and value added balances are very similar. This indicates that even though German exports may be highly integrated in global supply chains this is not creating a wedge between gross and value added trade statistics. Germany can be considered as a hub that imports intermediate inputs from different regions but that also exports back intermediate imports embedded in
intermediate exports to these regions.

In Figure [40] we present the German bilateral trade balances using the WIOD data. Here we observe that the increase in the German trade surplus is not driven mainly by its surplus with the rest of the EU27, but by the increase in the surplus with the Rest of the World region. However, recall from Section [3] that the WIOD uses the RoW region as the region where un-calibrated divergences in trade statistics are dumped, and thus, the importance of the RoW for Germany may be more a data calibration problem by the WIOD database. When looking at the intra-EU27 trade balances in Figure [41] we find similar results as with the GTAP database: Germany has a trade deficit with the Netherlands that is much bigger in gross than in value added terms.

5.2 France

In contrast to Germany and the Netherlands, France has experienced a clear deterioration in its current account balance (see Figure [10]). From 1990 to 2005 it experienced a steady decline in its trade surplus that became an increasing trade deficit until 2012. For France there is close relation between the WIOD and OECD data, with the GTAP data following the same declining trend but at lower levels.

Figure 10: France, trade balance as percentage of GDP using different data sources

![Graph showing trade balance as percentage of GDP](image)

The French bilateral trade balances for 2007 is shown in Figure [11]. In this year, France had an overall trade deficit that is explained mainly by its bilateral deficit with Germany. There is also a significant wedge between gross and value added balances for the EU27 (about a one-third difference), while the balance with Spain and the EU12 (new Member States) moves from a gross deficit to a value added trade surplus. France
has significant trade surpluses with the UK and the NAFTA region (i.e. mainly with the US).

Figure 11: France, bilateral trade balances in 2007 in gross and value added terms using the GTAP database

Notes: Sector codes and aggregations are specified in Table 2 in Appendix B. Here the RoW also includes the OWE, India, and East Asia regions. Source: Own estimations using the GTAP8 database.

However, the French trade balances have changed much over time. Analysing the disaggregated bilateral balances using the GTAP data, we observe that the case of France is very different from the Netherlands and Germany. Figure 26 in Appendix B shows that France has an overall trade surplus in 2001 but then runs large and increasing trade deficits in 2004 and 2007. In 2001 France has a large surplus with the US and RoW and deficits with the EU27 and China. The deterioration in its trade balance is caused mainly by a significant increase in the trade deficits with the EU27, China and to a lesser extent with Russia (and the other Eastern Europe) and the OWE (other Western Europe) regions; while the surpluses with the US and RoW regions decrease –to the point where France has a deficit with RoW in value added terms in 2007. Comparing gross and valued added terms, we observe that the deficit with the EU27 is larger in gross terms than value added, while there is also a wedge in the trade balances for the USA and RoW.

In Figure 27 in Appendix B we see that within the EU27 two countries stand out. France has a large trade deficit with Germany and a surplus with the UK for the three years analysed. However, the significant increase in the French trade deficit with the
rest of the EU27 is explained by the increase in the deficit with Germany, and to a lesser extent to bigger deficits with the Netherlands, Italy and Ireland. Moreover, the gross deficit is approximately one-third larger than the value added deficit. This reflects that the imported intermediate inputs embedded in exports to France are larger than the imports embedded in intermediate exports from France. In other words, France is a net exporter of intermediate inputs from the EU to third regions.

When using the WIOD data –Figures 42 and 43 in Appendix B– we find very similar results than with the GTAP data: France has large trade surpluses with the RoW and USA, while the trade deterioration has been mainly driven by a widening trade deficit with other EU27 countries. Moreover, we also find that there are significant wedges between the gross and value added balances.

5.3 United Kingdom

From Figure 12 we see that the UK has had persistent overall trade deficits, even though the average values in the 1990s were smaller and less volatile than in the 2000s. Again we observe that the WIOD values are above those for the OECD, while the GTAP values show even bigger trade deficits in the 2000s.

Figure 12: United Kingdom, trade balance as percentage of GDP using different data sources

Figure 13: United Kingdom, trade balance as percentage of GDP using different data sources

Figure 13 shows the 2007 results for the United Kingdom using the GTAP data. Around half the British trade deficit is explained by the deficit with other EU countries, while it also has significant deficits with Asia (e.g. China, Japan and South East Asia) and the RoW region. However, there are not much differences between the gross and
value added bilateral balances. The main exception is the EU15 and in particular, Ireland, for which the UK has a very large wedge between its gross and value added trade surpluses (see below).

Figure 13: United Kingdom, bilateral trade balances in 2007 in gross and value added terms using the GTAP database

Notes: Sector codes and aggregations are specified in Table 2 in Appendix B. Here the RoW also includes the OWE, India, and East Asia regions. Source: Own estimations using the GTAP8 database.

In Appendix B we present the results for all available years and the disaggregated bilateral balances calculated from the GTAP and WIOD databases. Using the GTAP data we observe that the United Kingdom has a large overall trade deficit, which is also explained by its bilateral deficit with the rest of the EU27 (Figure 28). The salient feature for the UK is that it has a trade surplus with the US after 2004. Within the EU27—see Figure 29—the UK has bilateral trade deficits with all major countries (e.g. Germany, France, Italy and the Netherlands). British trade with Ireland is a special case, where the UK has a gross trade surplus but almost balanced trade in value added terms. This means that the UK is a relatively large exporter to Ireland of intermediate inputs that originate in third countries. Otherwise the balances with other regions and within the EU27 are very similar in gross and value added terms.

Using the WIOD data we find similar results as with the GTAP data: the British trade deficit is a direct consequence of its deficit with the rest of the EU27 and it has large trade surpluses with the United States. (see Figure 44 in Appendix B). However, in the case of the UK we find again that the Rest of the World region has
disproportionately high trade balances (that are not found in the GTAP data), which can signal problems with the methodology used by WIOD to deal with international trade statistic divergences. In particular, the extremely large trade deficit with RoW in 2011 may explain why there is an increase in the difference between gross and value added trade with the EU27 in that year –that was not so remarkable in previous years. From Figure 45 we observe that this increase in the value added trade deficit is driven by the EU15, which even has a small trade surplus in gross terms.

5.4 Spain

Spain experienced overall trade deficits through the whole period, with a sharp increase in the deficits from 1990 to 2008 and an improvement in its trade balance after that year (see Figure 14). In this case, the values for the three data sources are relatively similar.

Figure 14: Spain, trade balance as percentage of GDP using different data sources

In Figure 15 we present the results for Spain in 2007. We observe that the EU27 trade deficit is mainly driven by the Spanish deficit with Germany, both of which are around a quarter of the overall deficit. Spain also has important trade deficits with all the non-EU regions, in particular with the Rest of the World. Interestingly the trade balance with France and the rest of the EU15 switches from gross surplus to a value added deficit, but the wedge between both measures is not significant for most of the other regions.

From Figure 50 in Appendix B we also observe that using the GTAP data the large and increasing trade deficit –between 2001 and 2007– was mainly explained by its deficit with other EU27 countries. However for 2007 the overall trade deficit is also a
Figure 15: Spain, bilateral trade balances in 2007 in gross and value added terms using the GTAP database

![Graph showing bilateral trade balances in Spain](image)

Notes: Sector codes and aggregations are specified in Table 2 in Appendix B. Here the RoW also includes the OWE, India, and East Asia regions. Source: Own estimations using the GTAP8 database.

consequence of rising trade deficits with China, Russia, RoW, other Asian regions and the reversal of the trade balance with the US. These results are also present when using the WIOD data (see Figure 15), however, here we also find that the Spanish deficit with the EU27 all but disappears in 2011 and this explains the reduction in the overall trade deficit after 2008.

When analysing the within EU27 trade using GTAP data (Figure 31), the main observation is that Germany accounts for almost all the intra-EU27 Spanish deficit—even though deficits with Italy, Netherlands and Ireland increase for 2004 and 2007. Spain has a persistent trade surplus with Portugal and in more recent years with the UK. The WIOD data (Figure 46) shows similar results—with the exception of Italy for which there is a trade deficit in the GTAP data but a large trade surplus using the WIOD data. For 2011, moreover, we find that the significant decrease in the Spanish trade deficit with the rest of the EU27 is explained by a sharp reduction in the deficit with Germany and the reversal in the trade balances (from deficit to surplus) with France and the UK. Finally, the EU15 trade balance is positive in gross terms, but negative in value added terms.
5.5 Italy

From Figure 16, we also find that Italy has experienced—as was the case of France—a steady deterioration of its trade balance since the mid-1990s, which turned an initial surplus into a trade deficit after the year 2000 (when using the OECD data). After the 2008 crisis, the trend has reverted, and the trade deficit has decreased. However, we find again that the overall WIOD values are consistently higher than the OECD values, with the GTAP values laying in between both series.

Figure 16: Italy, trade balance as percentage of GDP using different data sources

The 2007 bilateral trade results for Italy are shown in Figure 17. The most striking feature is that Italy is an exception within the EU, and has a relatively balanced within-EU trade. However, as with the rest of peripheral EU countries, it also has a significant trade deficit with Germany. The deficits with the RoW and China are also important contributors to the overall Italian trade deficit. On the other hand, Italy has a relatively high trade surplus with the US—which drives its surplus with the NAFTA region shown in the figure. In addition, there are not many differences between the balances in gross and value added terms.

When looking in Appendix B at the disaggregated bilateral balances from the GTAP data for all available years, we confirm that the case of Italy is rather different than the rest of the EU countries analysed so far. In particular, from Figure 32, we observe that the overall trade balance for Italy is not directly related to its balance with the rest of the EU27. Italy moved from an overall trade surplus in 2001 to a deficit in 2004 and 2007 due mainly to a deterioration in its balance with the Rest of the World region, and
increasing deficits with China and Russia. Another distinct characteristic of Italy is that it has a large and consistent trade surplus with the United States. Moreover, even when its bilateral balance with other EU27 countries has also deteriorated, this deficit is not the main driver of its overall deficit. Looking at the WIOD data for Italy in Figure 47 we find that after 2004 the Italian trade deficit with other EU27 countries has been the driver of the overall trade balance deterioration, and more significantly, in 2011 the largest deficit is with Russia, even when the value added deficit is very similar to that with the EU27, in gross terms it is very large when compared with 2007.

In Figure 33 we observe that Italy has a large and increasing deficit with Germany when we use the GTAP data, and also significant deficits with the Netherlands and Ireland. However, Italy has experienced sustained trade surpluses with the UK and the EU12 group, while increasing its surplus with France, Greece and Spain. Using the WIOD data (Figure 48) we also observe a large trade deficit with Germany and the Netherlands, but here Spain has a large trade deficit (becoming even the biggest deficit in 2011), which contrasts with the trade surplus from the GTAP data.

In general, the gross balances are of a higher magnitude (positive or negative) than in value added terms, which reflects that Italy is acting –to certain extent– as a spoke in international trade networks and redirects intermediate inputs between regions.
5.6 United States

The United States has experienced persistent trade deficits in the period analysed, with a sharp deterioration from the late 1990s to the mid-2000s and a slow recovery in recent years (cf. Figure 18). Comparing the three data sources we observe that for the case of the US there are not many significant differences.

Figure 18: United States, trade balance as percentage of GDP using different data sources

Figure 19 shows the GTAP data results for the United States in 2007, which has a trade deficit with all the regions analysed. The most significant deficit is with China, and more importantly, the deficits with China are smaller in value added terms than in gross terms, which was one of the first findings of the trade in value added literature (cf. Koopman et al., 2010; Johnson and Noguera, 2012). Nonetheless, this wedge is much less pronounced than for other bilateral balances presented here so far, in particular, for the case of the Netherlands.

In Figure 34 in Appendix B we use the GTAP database to disaggregate the overall trade balances in gross and value added terms for the remaining years. We observe that in 2001 the US has trade deficits with all global regions, in particular with China, Other NAFTA (i.e. Mexico and Canada), Japan and the EU27. From 2001 to 2007 most of these deficits increase by similar amounts. At the EU27 level (Figure 35), the US deficit can be explained by its EU15 deficit –in particular with Germany, Italy and Ireland– and the value added EU15 deficit is bigger than the gross deficit.
5.7 Japan

In Figure 20 we observe that Japan has experienced overall trade surpluses of around 2% of GDP between 1995 and 2010. In this case, until the mid-2000s the three data sources have similar values, but they later divergence.

In Figure 21 we present the bilateral trade balances for Japan in 2007. We observe that the overall Japanese trade surplus is driven by the surpluses with the NAFTA region (mainly the US) and the EU. Within the EU, the trade surplus is fairly distributed within the countries shown. Japan has a relatively large trade deficit with the RoW region that is explained by its imports of raw materials. Note that the valued added trade surpluses with NAFTA and the EU are higher than in gross terms, while the gross trade surplus with China is much higher than in value added terms. This highlights the role of China as a redirector of intermediate inputs from Japan that are processed and later exported to the main global consumption markets –i.e. the US and the EU (cf. Lejour et al. [2014]).

The bilateral trade balances calculated using the GTAP database for all three available years (see Figure 36) present significant differences between the gross and value added terms. In particular, Japan has a large gross trade surplus with the East
Notes: Sector codes and aggregations are specified in Table 2 in Appendix B. Here the RoW also includes the OWE, India, and East Asia regions. Source: Own estimations using the GTAP8 database.

Asia region, but the value added surplus is around four-times smaller. The wedge between gross and value added balances is also significant for the United States, RoW and the EU27 regions. As mentioned above, Japan illustrates the case of a highly global integrated economy that serves as a spoke in international supply chains: it imports a
large proportion of intermediate inputs from RoW (i.e. oil and other natural resources), exports intermediate inputs to other East Asian countries (e.g. Korea, Taiwan) who redirect these intermediate inputs to the main global demand regions (US and EU). Thus, Japan has larger value added than gross surpluses with the US and the EU27. Within the EU27 –Figure 37– Japan has surpluses with all the selected countries, in particular with the EU15 sub-region –i.e. Germany, Belgium and more recently with Spain.

5.8 China

China also has had persistent overall trade surpluses with a significant surge in the mid-2000s. In Figure 22 we also observe that for China the GTAP values are significantly different from the OECD and WIOD balances.

Figure 22: China, trade balance as percentage of GDP using different data sources

Figure 23 shows the bilateral trade balances for China in 2007. As with Japan, China has relatively large trade surpluses with the EU and the US, and significant deficits with the rest of the World and with other Asian countries. This result further illustrate the importance of the East Asian global supply network for international trade. China is a net importer of intermediate inputs from Japan, Korea, South East Asia and the rest of the World, and then re-direct these intermediate inputs to the EU and the US to become a net exporter of intermediate inputs to these regions. In the case of China and Japan, the importance of analysing trade in value added –in contrast to only gross trade– becomes obvious.

From Figure 38 in Appendix 32 the GTAP data calculations show that the Chinese
Figure 23: China, bilateral trade balances in 2007 in gross and value added terms using the GTAP database

Notes: Sector codes and aggregations are specified in Table 2 in Appendix B. Here the RoW also includes the OWE, India, and East Asia regions. Source: Own estimations using the GTAP8 database.

trade surplus between 2001 and 2007 can also be explained directly by its very large surpluses with the US and the EU27. As explained above, since the value added surpluses are smaller than the gross trade surpluses, this indicates that China is redirecting intermediate inputs from other regions (i.e. Japan and East Asia) to both these final demand markets. Moreover, combining the information for Japan and China we can trace intermediate inputs (at the very aggregate level) moving from Japan to East Asia to China and then to the US and the EU27. Finally, from Figure 39 we observe that within EU-27 trade balances are concentrated on the large EU15 countries: France, Germany, Italy and Spain.

6 Summary

The use of the GTAP and WIOD databases to calculate trade in value added provides valuable information that can be compared with the traditional gross trade statistics. For some countries –notably the Netherlands, Japan and China– the differences between gross and value added bilateral trade balances can be substantial. These differences depict the importance of the aggregate flows of intermediate inputs through these countries. On the contrary, for countries that are the international trade hubs –i.e.
mainly as exporters of final goods– the differences between gross and value added balances are less important, but nonetheless can be informative for particular cases. For example, the much lower trade deficit of the US with China in value added terms than in gross terms is a well known international trade issue.

As part of the CPB project on the Dutch current account, the trade in value added analysis presented here provides relevant information concerning the Dutch bilateral trade balances. We find that its bilateral trade surplus with the rest of the EU is substantially lower (between half and one-third) in value added than in gross terms. Accordingly, its trade deficits with other global regions is also smaller in value added than in gross terms. This highlights the role of the Netherlands as a net importer of intermediate inputs from outside the EU that are later exported within the EU27. Additionally, the divergence between gross and valued added trade is even more visible at the sectoral level, where the movement of intermediate inputs flows can be better understood. This also implies that at the aggregate level –where sectoral flows are aggregated– many of the inter-sectoral intermediate input flows cancel out and the difference between gross and value added trade is smaller.

For most of the EU countries we analyse –the Netherlands, Germany, France, the UK, and Spain– the internal EU trade balances dominates the overall balances. In other words, the overall trade balance can be explained by the surplus or deficit of that particular country with the rest of the EU. This is also the case for Greece and Portugal. The only exception is Italy, where the trade balances with the USA, RoW and to a lesser extent Russia and China, are larger than the Italian trade balance with other EU countries. Furthermore, the Euro area block has had a roughly balanced external current account over the years, but internally there are very significant trade imbalances. In particular, the core countries (i.e. Germany and the Netherlands) have trade surpluses, while the peripheral countries (i.e. Spain, Portugal, Greece) plus the UK and France (only in more recent years) have trade deficits. This remains the case even when the value added trade balances are less sharp than the gross trade balances.

Trade in value added statistics can also be useful to analyse changes in international trade networks over time. In particular, the WIOD database has a continuous series from 1995 to 2011. However, we find that the WIOD data has less variation over time than the OECD trade data, and accordingly, the pattern of bilateral balances does not change much over time. Even though in 2011 we do observe some changes in the trade patterns. The GTAP database, on the other hand, has more variation on the patterns of bilateral balances, but it is limited to a sample of few years and thus, it is less suitable to analyse changes over time.

Footnote: Results not presented here but available upon request.
One important issue related to trade in value added calculations is the large discrepancies between the existing multi-regional IO (MRIO) databases. More precisely, these differences are the result of the adjustments done to the underlying trade data—which also determines gross trade values—that are needed to deal with the inconsistencies in country-specific trade statistics. Here we have shown that overall trade balances between the GTAP and the WIOD databases are usually large, and this is also reflected in bilateral trade divergences. In general, however, the overall patterns of bilateral trade balances and the relation between gross and value added calculations is usually consistent between both databases.

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A Appendix A: Trade in value added arithmetic

We explain the theoretical background of trade in value added, provide an integrated framework for the analysis of gross and value added trade flows and conclude that bilateral gross trade balances differ from bilateral trade in value added balances because of bilateral differences in ‘imports in exports’.

A typical MRIO table has the following structure:

\[
\begin{bmatrix}
S & F & x \\
W & x' \\
\end{bmatrix} = 
\begin{bmatrix}
Z_{11} & Z_{12} & \cdots & Z_{1m} & f_{1} & f_{12} & \cdots & f_{1m} & x_1 \\
Z_{21} & Z_{22} & \cdots & Z_{2m} & f_{2} & f_{22} & \cdots & f_{2m} & x_2 \\
\vdots & \vdots & \ddots & \vdots & \vdots & \vdots & \ddots & \vdots & \vdots \\
Z_{m1} & Z_{m2} & \cdots & Z_{mm} & f_{m1} & f_{m2} & \cdots & f_{mm} & x_m \\
w_{11}' & w_{12}' & \cdots & w_{1m}' & \vdots & \vdots & \ddots & \vdots & \vdots \\
w_{k1}' & w_{k2}' & \cdots & w_{km}' & x_1' & x_2' & \cdots & x_m' \\
\end{bmatrix}
\]  

(1)

Assuming that the number of countries or regions is \(m\), the number of industries is \(n\) and the number of primary input categories is \(k\), \(Z\) is an \(mn \times mn\) matrix of intermediate input deliveries, \(F\) is an \(mn \times m\) matrix of final output deliveries, \(x\) is a vector of length \(mn\) with total gross output (i.e. the sum of intermediate and final output deliveries), \(W\) is a \(k \times mn\) matrix with primary inputs and \(x'\) is the row vector of length \(mn\) with gross inputs (i.e. the sum total of intermediate inputs and primary inputs). It is convenient to decompose these huge arrays on a country basis and to split the primary input matrix by type of primary input. Then \(z_{rs}(i, j)\), which is an entry in \(Z_{rs}\), denotes the intermediate input delivery from industry \(i\) in country \(r\) to industry \(j\) in country \(s\). Similarly, \(f_{rs}(i)\) indicates final output produced by industry \(i\) in country \(r\) that is finally used in country \(s\), \(x_r(i)\) gives total output from industry \(i\) in country \(r\), \(w_{ks}(j)\) denotes the value of primary input \(k\) that is used by industry \(j\) in country \(s\), and \(x_s(j)\) shows the sum total of all inputs used by industry \(j\) in country \(s\).

The table is characterised by two adding up conditions. First, for gross output we have:

\[ x_r(i) = \sum_s \sum_j z_{rs}(i, j) + \sum_s f_{rs}(i) \]  

(2)

and for gross input:

\[ x_s(j) = \sum_r \sum_i z_{rs}(i, j) + \sum_k w_{ks}(j) \]  

(3)
These conditions can be rewritten using the concepts of input coefficients $A$ and $V$, which are obtained by dividing the entries of $Z$ and $W$ respectively, by the column totals $x'$. Using $t$ as a unit or summation vector of appropriate length, one can rewrite both conditions as:

$$ x = Z_1 + F_t = Ax + F_t \quad \text{or} \quad (I - A)x = F_t \quad \text{or} \quad x = (I - A)^{-1}F_t = BF_t \quad (4) $$

and as:

$$ t'A + t'V = t' \quad \text{or} \quad t'(I - A) = t'V \quad \text{or} \quad t'V(I - A)^{-1} = t'VB = t' \quad (5) $$

In these equations $B$ denotes the so-called global Leontief inverse. Equation (4) shows that its typical element $b_{rs}(i,j)$ indicates the gross output that is needed from industry $i$ in country $r$ to produce one unit of final $j$-output in country $s$. From Equation (5) we derive that $t'VB = t'F$ or that the value of final outputs equals a 'global bundle' of primary input values. This property of global input-output analysis began to be used empirically in the pioneering studies of trade in value added by Daudin et al. (2011), Johnson and Noguera (2012), and Koopman et al. (2014).

Local Leontief inverses (the inverses that one would obtain from national input-output tables) play also a role in the calculation of trade in value added. Before turning to these inverses it is useful to introduce some extra notation: the parts of $Z$ and $F$ that are not traded but remain at home are denoted by $Z₀$ and $F₀$ respectively:

$$ Z = \begin{bmatrix} Z_{11} & 0 & \ldots & 0 \\ 0 & Z_{22} & \ldots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \ldots & Z_{mm} \end{bmatrix} \quad \text{and} \quad F = \begin{bmatrix} f_{11} & 0 & \ldots & 0 \\ 0 & f_{22} & \ldots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \ldots & f_{mm} \end{bmatrix} $$

The parts that are traded can then be denoted as $Z = Z - Z₀$ and $F = F - F₀$. The adding-up conditions can also be cast in terms of local inverses as:

$$ x = \bar{Z}_1 + (\bar{Z} + \bar{F})t = A\bar{x} + (\bar{Z} + \bar{F})t \quad \text{or} \quad (I - A)\bar{x} = (\bar{Z} + \bar{F})t \quad (6) $$

or

$$ x = (I - A)^{-1}(\bar{Z} + \bar{F})t = L(\bar{Z} + \bar{F} + \bar{F})t $$

and:

$$ t'A + t'(\bar{A} + V) = t' \quad \text{or} \quad t'(I - A) = t'(\bar{A} + V) $$

or

$$ t'(\bar{A} + V)(I - A)^{-1} = t'(\bar{A} + V)L = t' \quad (7) $$
In these equations the local Leontief inverse $L$ is a block-diagonal matrix where the blocks contain the local inverses. Equation 6 shows that its typical element $l_{rr}(i,j)$ indicates the gross output that is needed from industry $i$ in country $r$ to produce in country $r$ one unit of intermediate $j$-exports or one unit of final $j$-output. Indicating gross exports as $e = (Z + F)v$ it follows from Equation 7 and the block-diagonal shape of $L$ that $e' \left( \sum_q A_{qr} + V_r \right) L_{rr} e_r = e' e_r$ or that national exports can be decomposed in 'imports in exports' and 'primary inputs in exports'. This property of local input-output analysis was prominently used in the seminal paper on vertical specialisation by Hummels et al. (2001).

Before turning to the 'imports in exports' issue it should be mentioned that the international trade flows of $Z$ are valued at FOB export prices. The global input-output tables that we derived from the GTAP datasets and the tables from WIOD differ in the ways in which international trade margins (the difference between the CIF import price and the FOB export price) are taken care of. In the GTAP tables an international trading services market is appended as an $m + 1^{th}$ region to the intermediate delivery matrix $Z$. The international trading services market does not have its own primary inputs but takes these indirectly from the national industries that supply international trading services to this market. National industries and final users import these services from the international trading services market. The primary inputs present in the GTAP global input-output tables add-up to value added. In the WIOD tables international trading services are not part of $Z$ and the international trade margins are –somewhat inappropriately– allocated to the primary input matrix. Hence, in the WIOD tables not all primary inputs add-up to value added: international trade margins remain as a separate input. This extra primary input is ignored in our analysis.

From now on only a single primary input coefficient vector is assumed to be present: $v'_r$, which is value added per unit of gross output. In the sequel this value added input coefficient vector is also represented as a diagonal matrix: $\hat{v}_r$. From Equation 7 it was concluded that exports can be decomposed in 'imports in exports' and 'value added exports'. In what follows we use additional country indexes: $t, u, p$ and $q$, and exports at the country level can be written as:

\[
e_r = \sum_s A_{rs} \sum_t B_{st} \sum_u f_{tu} + \sum_u f_{ru} \tag{8}
\]

Applying the 'imports in exports' and 'value added exports' decomposition on this
export vector yields the following decomposition for aggregate exports:\footnote{In Equation \ref{eq:varepsilon}, after the third equality sign, we use the identity: $L_{rr} \sum_q \mathcal{A}_{qr} B_{st} = B_{rt} - \delta_{rt} L_{tt}$ in which $\delta_{rt}$ is a toggle variable that takes the value 1 when $r = t$ and the value 0 otherwise. This identity follows from $L A B = B - L$, which is true because of the following: $(I - L A)^{-1} L = [(I - A)(I - L A)]^{-1} = (I - A - \bar{A})^{-1} = B$. Premultiplication with $(I - L A)$ yields: $L = (I - L A)B$ or $L A B = B - L$.}

$$\begin{align*}
    v^r e_r &= v^r \left( \sum_q \mathcal{A}_{qr} + \hat{v}_r \right) L_{rr} e_r \\
    &= v^r \left( \sum_q \mathcal{A}_{qr} + \hat{v}_r \right) L_{rr} \sum_s \mathcal{A}_{rs} \sum_t B_{st} \sum_u f_{tu} \\
    &\quad + v^r \left( \sum_q \mathcal{A}_{qr} + \hat{v}_r \right) L_{rr} \sum_u L_{ru} \\
    &= v^r \sum_q A_{qr} \sum_t (B_{rt} - \delta_{rt} L_{rr}) \sum_u f_{tu} + v^r \sum_q A_{qr} L_{rr} \sum_u L_{ru} \\
    &\quad + v^r \sum_t (B_{rt} - \delta_{rt} L_{tt}) \sum_u f_{tu} + v^r L_{rr} \sum_u L_{ru} \\
    \text{Imports in intermediate exports} &\quad \text{Imports in final output exports} \\
    &+ \text{Domestic value added in intermediate exports} \quad \text{Domestic value added in final output exports}
\end{align*}$$

\footnote{In Equation \ref{eq:varepsilon}, after the third equality sign, we use the identity: $L_{rr} \sum_q \mathcal{A}_{qr} B_{st} = B_{rt} - \delta_{rt} L_{tt}$ in which $\delta_{rt}$ is a toggle variable that takes the value 1 when $r = t$ and the value 0 otherwise. This identity follows from $L A B = B - L$, which is true because of the following: $(I - L A)^{-1} L = [(I - A)(I - L A)]^{-1} = (I - A - \bar{A})^{-1} = B$. Premultiplication with $(I - L A)$ yields: $L = (I - L A)B$ or $L A B = B - L$.}

\footnote{In Equation \ref{eq:varepsilon}, after the third equality sign, we use the identity: $L_{rr} \sum_q \mathcal{A}_{qr} B_{st} = B_{rt} - \delta_{rt} L_{tt}$ in which $\delta_{rt}$ is a toggle variable that takes the value 1 when $r = t$ and the value 0 otherwise. This identity follows from $L A B = B - L$, which is true because of the following: $(I - L A)^{-1} L = [(I - A)(I - L A)]^{-1} = (I - A - \bar{A})^{-1} = B$. Premultiplication with $(I - L A)$ yields: $L = (I - L A)B$ or $L A B = B - L$.}

Bilateral exports from $r$ to $s$ are:

$$\begin{align*}
    e_{rs} &= \mathcal{A}_{rs} \sum_t B_{st} \sum_u f_{tu} + L_{rs} = \mathcal{A}_{rs} \sum_t (B_{st} - \delta_{st} L_{tt}) \sum_u f_{tu} + \mathcal{A}_{rs} L_{ss} \sum_u f_{su} + L_{rs} \\
    &= \mathcal{A}_{rs} L_{ss} \sum_t \sum_q A_{sq} B_{qt} \sum_u f_{tu} + \mathcal{A}_{rs} L_{ss} \sum_u f_{su} \\
    &\quad + L_{rs} \\
    \text{Exports from } r \text{ in exports of } s &\quad \text{Exports from } r \text{ for final output production in } s \\
    &+ \text{Final output exports from } r \text{ to } s
\end{align*}$$

\footnote{In Equation \ref{eq:varepsilon}, after the third equality sign, we use the identity: $L_{rr} \sum_q \mathcal{A}_{qr} B_{st} = B_{rt} - \delta_{rt} L_{tt}$ in which $\delta_{rt}$ is a toggle variable that takes the value 1 when $r = t$ and the value 0 otherwise. This identity follows from $L A B = B - L$, which is true because of the following: $(I - L A)^{-1} L = [(I - A)(I - L A)]^{-1} = (I - A - \bar{A})^{-1} = B$. Premultiplication with $(I - L A)$ yields: $L = (I - L A)B$ or $L A B = B - L$.}
Using Equation 10 the aggregate imports $m_r$ of country $r$ can be derived as follows:

$$m'_r = \sum q v'_r v_q r$$

$$= \sum q v'_r \sum t (B_{rt} - \delta_{rt} L_{tt}) \sum u f_{tu} + \sum q v'_r \sum t (A_{qr} L_{rr}) \sum u f_{ru} + \sum q v'_r \sum J_{qr}$$

$$= \sum q v'_r \sum t (B_{rt} - \delta_{rt} L_{tt}) \sum u f_{tu} + \sum q v'_r \sum t (A_{qr} L_{rr}) \sum J_{ru} + \sum p \sum q v'_p B_{pq} A_{qr} L_{rr} f_{rq} + \sum p \sum q v'_p B_{pq} J_{qr}$$

$$= \sum q v'_r \sum t (B_{rt} - \delta_{rt} L_{tt}) \sum u f_{tu} + \sum q v'_r \sum t (A_{qr} L_{rr}) \sum J_{ru} + \sum p \sum q v'_p B_{pq} J_{qr}$$

Value added imports for final output produced and used in $r$ Value added in final output imports of $r$

(11)

The aggregate trade balance in terms of gross trade is the same as the balance in terms of value added trade because ‘imports in exports’ cancel out. The aggregate balance in terms of value added trade is:

$$i' e_r - m'_r = v'_r L_{rr} \sum t (B_{rt} - \delta_{rt} L_{tt}) \sum u f_{tu} + v'_r L_{rr} \sum s J_{rs}$$

Domestic value added in intermediate exports Domestic value added in final output exports

$$- \sum p v'_p (B_{pr} - \delta_{pr} L_{rr}) f_{rr}$$

Value added imports for final output produced and used at home

$$- \sum p \sum q v'_p B_{pq} J_{qr}$$

Value added in final output imports

---

8 In Equation 11 after the third equality sign, use was made of the identity from Equation 5 to establish $\sum q v'_r A_{qr} L_{rr} f_{rr} = \sum p \sum q v'_p B_{pq} A_{qr} L_{rr} f_{rr}$ and $\sum q v'_r L_{rr} f_{rr} = \sum p \sum q v'_p B_{pq} J_{qr}$. In view of the dimension of $B_{pq}$ (gross output from $p$ needed per unit of final output in $q$) one may wonder whether it is allowed to post-multiply $B_{pq}$ with the intermediate inputs $A_{qr} L_{rr} f_{rr}$. This is allowed, however, because $v'_r A_{qr} L_{rr} f_{rr}$ is part of the value of final output produced in $r$. In fact, the only missing component is $v'_r L_{rr} f_{rr}$; taken together these inputs exactly match the value of $v'_r L_{rr}$ because of Equation 7.

9 In Equation 11, after the fourth equality sign, the identity $\sum q B_{pq} A_{qr} L_{rr} = (B_{pq} - \delta_{pq} L_{rr})$ was used. This identity follows from $B \overline{A} L = B - L$, which is true because of the following: $L(I - \overline{A})^{-1} = (I - \overline{A}L)(I - \overline{A})^{-1} = (I - A - \overline{A})^{-1} = B$; post-multiplication with $(I - \overline{A})$ yields $L = B(I - \overline{A})$ or $B \overline{A} L = B - L$. 

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However, the bilateral balances in gross and value added terms are different. The obvious reason is differences in ‘imports in exports’. For the sake of completeness we decompose Equation 10 in a gross and value added part:

\[
\Delta^\prime e_{rs} = \sum_q l' A_{qr} L_{rr} \bar{A}_{rs} \sum_t (B_{st} - \delta_{st} L_{tt}) \sum_u f_{tu} + \sum_q l' A_{qr} L_{rr} \bar{A}_{rs} L_{ss} \sum_u f_{su}
\]

Imports of \( r \) in exports of \( s \)

\[
+ \sum_q l' A_{qr} L_{rr} \bar{A}_{rs} \sum_u f_{su} + \sum_t l' A_{qr} L_{rr} f_{rs}
\]

Imports of \( r \) in final output exports to \( s \)

\[
+ \sum_t l' A_{qr} L_{rr} f_{rs} \sum_u f_{su} + \sum_t l' A_{qr} L_{rr} f_{rs} \sum_u f_{su}
\]

Value added in final output exports to \( s \)

Direct value added exports for final output production in \( s \)

To conclude, it is clear that if the bilateral trade balance \((\Delta^\prime e_{rs} - \Delta^\prime e_{sr})\) is larger in value added terms than in gross terms the exports of \( s \) to \( r \) must contain more imports than the exports of \( r \) to \( s \). Conversely, if the bilateral trade balance is smaller in value added terms then the exports of \( r \) to \( s \) must be more import-intensive than the exports of \( s \) to \( r \).
### Appendix B: Additional tables and figures

#### Table 1: Regional aggregation for GTAP data

<table>
<thead>
<tr>
<th>Code</th>
<th>Region description</th>
<th>GTAP countries/regions</th>
</tr>
</thead>
<tbody>
<tr>
<td>EU27</td>
<td>All European Union countries</td>
<td>Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Portugal, Spain, Sweden, UK</td>
</tr>
<tr>
<td>EU15</td>
<td>EU members before 2004</td>
<td>Bulgaria, Czech Republic, Cyprus, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia, Slovenia, Romania</td>
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<tr>
<td>EU12</td>
<td>EU new members</td>
<td>Switzerland, Norway, Iceland, Liechtenstein, Croatia, Serbia, Montenegro, Albania, Macedonia, Turkey</td>
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<td>Russia, Belarus, Ukraine, Georgia, Azerbaijan, Armenia, Moldavia, Rest of Eastern Europe, Rest of Europe</td>
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<td>OEE</td>
<td>Other Eastern Europe</td>
<td>China (including Hong Kong)</td>
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<td>India</td>
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<tr>
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<td>Korea, Taiwan, and Other East Asia</td>
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<td>South East Asia</td>
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<td>Japan</td>
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<tr>
<td>USA</td>
<td>USA</td>
<td>Canada and Mexico</td>
</tr>
<tr>
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<td>Other NAFTA</td>
<td>Australia, New Zealand, Rest of South Asia, Rest of USSR, Iran, Rest of Middle East, Africa, South America and the Caribbean</td>
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<td>Rest of Europe</td>
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<td>27 SGR</td>
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<td>28 OFD</td>
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<td>31 WAP</td>
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<td>32 LEA</td>
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<td>Medium-low technology manufacturing</td>
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<td>39 FMP</td>
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<td>41 MVH</td>
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<td>44 DWE</td>
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<td>Other business services</td>
<td>57 OBS</td>
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Table 3: Regional aggregation for WIOD data

<table>
<thead>
<tr>
<th>Region description</th>
<th>WIOD countries/regions</th>
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<tbody>
<tr>
<td>EU27</td>
<td>All European Union countries</td>
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<tr>
<td>EU15</td>
<td>Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Portugal, Spain, Sweden, UK</td>
</tr>
<tr>
<td>EU12</td>
<td>Bulgaria, Czech Republic, Cyprus, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia, Slovenia, Romania</td>
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<td>Russia</td>
<td>Russia</td>
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<tr>
<td>China</td>
<td>China</td>
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<tr>
<td>East Asia</td>
<td>Japan, Korea and Taiwan</td>
</tr>
<tr>
<td>Other Asia</td>
<td>India and Indonesia</td>
</tr>
<tr>
<td>USA</td>
<td>USA</td>
</tr>
<tr>
<td>Other NAFTA</td>
<td>Canada and Mexico</td>
</tr>
<tr>
<td>Aus_Bra_Tur</td>
<td>Australia, Brazil and Turkey</td>
</tr>
<tr>
<td>RoW</td>
<td>Rest of the World</td>
</tr>
</tbody>
</table>

Notes: *RoW* region is not associated with any particular country nor regions, but instead is an *extra* region that absorbs the remaining differences in international trade flows.
Figure 24: Germany, bilateral trade balances using gross and value-added data by global regions using the GTAP database, millions of euros

Notes: The regional aggregation is presented in Table \[\text{1}\] in Appendix \[\text{B}\]. Source: Own estimations using the GTAP database.
Figure 25: Germany, bilateral trade balances using gross and value-added data for the EU27 and selected EU countries using the GTAP database, millions of euros

Source: Own estimations using the GTAP database.
Figure 26: France, bilateral trade balances using gross and value-added data by global regions using the GTAP database, millions of euros

Notes: The regional aggregation is presented in Table [1] in Appendix [1]. Source: Own estimations using the GTAP database.
Figure 27: France, bilateral trade balances using gross and value-added data for the EU27 and selected EU countries using the GTAP database, millions of euros

Source: Own estimations using the GTAP database.
Figure 28: United Kingdom, bilateral trade balances using gross and value-added data by global regions using the GTAP database, millions of euros

Notes: The regional aggregation is presented in Table 1 in Appendix 1. Source: Own estimations using the GTAP database.
Figure 29: United Kingdom, bilateral trade balances using gross and value-added data for the EU27 and selected EU countries using the GTAP database, millions of euros

Source: Own estimations using the GTAP database.
Figure 30: Spain, bilateral trade balances using gross and value-added data by global regions using the GTAP database, millions of euros

Notes: The regional aggregation is presented in Table in Appendix. Source: Own estimations using the GTAP database.

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Figure 31: Spain, bilateral trade balances using gross and value-added data for the EU27 and selected EU countries using the GTAP database, millions of euros

Source: Own estimations using the GTAP database.
Figure 32: Italy, bilateral trade balances using gross and value-added data by global regions using the GTAP database, millions of euros

Notes: The regional aggregation is presented in Table in Appendix. Source: Own estimations using the GTAP database.
Figure 33: Italy, bilateral trade balances using gross and value-added data for the EU27 and selected EU countries using the GTAP database, millions of euros

Source: Own estimations using the GTAP database.
Figure 34: United States, bilateral trade balances using gross and value-added data by global regions using the GTAP database, millions of euros

Notes: The regional aggregation is presented in Table 1 in Appendix A. Source: Own estimations using the GTAP database.
Figure 35: United States, bilateral trade balances using gross and value-added data for the EU27 and selected EU countries using the GTAP database, millions of euros

Source: Own estimations using the GTAP database.
Figure 36: Japan, bilateral trade balances using gross and value-added data by global regions using the GTAP database, millions of euros

Notes: The regional aggregation is presented in Table 1 in Appendix 1. Source: Own estimations using the GTAP database.
Figure 37: Japan, bilateral trade balances using gross and value-added data for the EU27 and selected EU countries using the GTAP database, millions of euros

Source: Own estimations using the GTAP database.
Figure 38: China, bilateral trade balances using gross and value-added data by global regions using the GTAP database, millions of euros

Notes: The regional aggregation is presented in Table 1 in Appendix B. Source: Own estimations using the GTAP database.
Figure 39: China, bilateral trade balances using gross and value-added data for the EU27 and selected EU countries using the GTAP database, millions of euros

Source: Own estimations using the GTAP database.
Figure 40: Germany, bilateral trade balances using gross and value-added data by global regions using the WIOD database, millions of US$

Notes: Differences between gross and value added total trade is explained by the treatment of the international transport sector in WIOD. Source: Own estimations using the WIOD database.
Figure 41: Germany, bilateral trade balances using gross and value-added data for the EU27 and selected EU countries using the WIOD database, millions of US$

Source: Own estimations using the WIOD database.
Figure 42: France, bilateral trade balances using gross and value-added data by global regions using the WIOD database, millions of US$

Notes: Differences between gross and value added total trade is explained by the treatment of the international transport sector in WIOD. Source: Own estimations using the WIOD database.
Figure 43: France, bilateral trade balances using gross and value-added data for the EU27 and selected EU countries using the WIOD database, millions of US$.

Source: Own estimations using the WIOD database.
Figure 44: United Kingdom, bilateral trade balances using gross and value-added data by global regions using the WIOD database, millions of US$

Notes: Differences between gross and value added total trade is explained by the treatment of the international transport sector in WIOD. Source: Own estimations using the WIOD database.
Figure 45: United Kingdom, bilateral trade balances using gross and value-added data for the EU27 and selected EU countries using the WIOD database, millions of US$. 

Source: Own estimations using the WIOD database.
Figure 46: Spain, bilateral trade balances using gross and value-added data by global regions using the WIOD database, millions of US$

Notes: Differences between gross and value added total trade is explained by the treatment of the international transport sector in WIOD. Source: Own estimations using the WIOD database.
Figure 47: Spain, bilateral trade balances using gross and value-added data for the EU27 and selected EU countries using the WIOD database, millions of US$

Source: Own estimations using the WIOD database.
Figure 48: Italy, bilateral trade balances using gross and value-added data by global regions using the WIOD database, millions of US$

Notes: Differences between gross and value-added total trade is explained by the treatment of the international transport sector in WIOD. Source: Own estimations using the WIOD database.
Figure 49: Italy, bilateral trade balances using gross and value-added data for the EU27 and selected EU countries using the WIOD database, millions of US$

Source: Own estimations using the WIOD database.
Figure 50: United States, bilateral trade balances using gross and value-added data by global regions using the WIOD database, millions of US$

Notes: Differences between gross and value added total trade is explained by the treatment of the international transport sector in WIOD. Source: Own estimations using the WIOD database.
Figure 51: United States, bilateral trade balances using gross and value-added data for the EU27 and selected EU countries using the WIOD database, millions of US$

Source: Own estimations using the WIOD database.
Figure 52: Japan, bilateral trade balances using gross and value-added data by global regions using the WIOD database, millions of US$

Notes: Differences between gross and value added total trade is explained by the treatment of the international transport sector in WIOD. Source: Own estimations using the WIOD database.
Figure 53: Japan, bilateral trade balances using gross and value-added data for the EU27 and selected EU countries using the WIOD database, millions of US$

Source: Own estimations using the WIOD database.
Figure 54: China, bilateral trade balances using gross and value-added data by global regions using the WIOD database, millions of US$

Notes: Differences between gross and value added total trade is explained by the treatment of the international transport sector in WIOD. Source: Own estimations using the WIOD database.
Figure 55: China, bilateral trade balances using gross and value-added data for the EU27 and selected EU countries using the WIOD database, millions of US$

Source: Own estimations using the WIOD database.