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ITALIAN REGIONS IN GLOBAL VALUE CHAINS: AN INPUT-OUTPUT APPROACH

by Chiara Bentivogli*, Tommaso Ferraresi#, Paola Monti*,
Renato Paniccià# and Stefano Rosignoli#

Abstract

This work uses input-output techniques to analyse the value added content of the inter-regional and international trade of Italian regions, which are characterized by marked differences in their level of development and production structure. Regions differ from one another in their degree of dependence on international and other regions' demand: in those of the Centre and North, the contribution of foreign demand to regional production of value added is greater than in Southern Italy, where the role of national demand is much more important. Most regions show a significant participation in global value chains for given amounts of exports to other countries and regions, which, however, are smaller overall in relation to total production in the South. The latter is also somewhat peripheral in the geography of international trade and depends to a greater extent on national suppliers; moreover, the supply ties between the different regions of the South are weak compared with the ties with some regions of the Centre and North.

JEL Classification: E16, F1, F14, F15, F17, R10.
Keywords: global value chains, input-output tables, trade in value added, regional trade.

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1. Introduction[1]

As global value chains (GVC) grow in importance as a production mode, gross exports become less significant both as an indicator of a country's competitiveness and as a measure of the stimulus of foreign demand to national value added. Indeed, the value of exports recorded by trade statistics might contain a non-negligible amount of foreign valued added, owing to the increase in the international fragmentation of production. This line of reasoning applies to transactions between countries, as well as regions of a given country, that may be connected to international trade both directly and indirectly through trade with other regions.

The trade literature has dealt traditionally with foreign trade and for a long time has neglected within-country trade flows. This happened not only because of a lack of information or need to monitor inner trade balances, but also because differences in comparative advantages were considered less important in interregional trade than in international trade owing to common or more similar institutional features among regions (legislation, language, culture, easier enforcement of contracts), higher factor mobility, and lower frictions in interregional trade (absence of tariffs, shorter distances). Even if many regions within the same country share these features, they might differ remarkably in many respects, such as infrastructure, productive structure, functioning of institutions and so on, and therefore enjoy different comparative advantages and competitiveness levels that are significant factors in determining firms' participation in GVC. Acemoglu and Dell (2010), for example, show that for the Americas within-country differences in the efficiency of production are greater than between-country differences. They relate these differences mostly to institutions and to the implied policy outcomes which in fact differ considerably between areas of the same country and impact on technology adoption and human capital.

Analysing the value added content in gross external and interregional exports implies assuming that relations between firms located in two regions of the same country can be modelled in a similar way to those between firms located in two different countries. This assumption is both justified from a theoretical point of view (see Iammarino, McCann, 2013 for a discussion) and in line with GVC analysis, which includes in value chains all relations between firms wherever they are located.

Italy is an interesting subject for a sub-regional analysis of value added exports because it is a textbook case of regional gaps (Banca d'Italia, 2009 and 2010). Italy's regions differ considerably in terms of trade openness, growth path, economic performance and economic specialization. Besides, Italian industrial districts are an example of agglomeration and of short-length GVC: firms are very concentrated geographically, have strong linkages with other firms in the district and weak links with firms located in other Italian regions or abroad, even if they ship a large share of their production abroad.

[1] The views expressed in the article are those of the authors and do not necessarily correspond to those of the Bank of Italy and of IRPET. We would like to thank Jan Oosterhaven, Josef Richter and the participants at the Input-Output Workshop (Osnabrück, March 2017) and at the IRPET internal seminar (Florence, May 2017), Anna Maria Falzoni and the participants at the Italian Trade Study Group (Bergamo, June 2017) and at the 21st FMM Conference: the Crisis of Globalisation (Berlin, November 2017), and Alessandro Borin, Alberto Felettigh and Michele Mancini (Bank of Italy) for their useful suggestions and comments.

This paper analyses GVC in greater depth by extending to interregional trade the decompositions of gross trade flows conceived for world input-output tables by Koopman *et al.* (2014) and refined by Meng *et al.* (2013), Wang *et al.* (2013) and Borin and Mancini (2015, 2017a, 2017b).[2] The empirical analysis proposed in this paper is - to our knowledge - one of the few efforts to estimate the degree of integration of Italian regions in global value chains based on an international-interregional IO approach[3]. The analysis uses a new dataset built on 2012 data for the Italian regions and a number of their main trade partners that contains detailed information on the network of bilateral exchanges in goods and services. The dataset construction involved linking together the supply and use tables (SUTs) of the Italian regions, the European Union, the USA, Canada, and Japan by means of trade data. For Italy, regional SUTs and interregional trade data are from IRPET's MRIO model which exploits information on the multi-plant structure of firms. In order to distinguish between international and interregional trade we define regions' exports (imports) to another region as *gross outflows (inflows)*, and regions' exports (imports) to another country as *gross exports (imports)*.

The main results of the analysis of the decomposition of gross international and interregional flows are the following:

- the activation of regional value added for each euro of gross exports and outflows (EO) is 65.6% on average, with some heterogeneity but no real clustering of regions; this result is slightly lower than previous decompositions for Italy (e.g. Cappariello and Felettigh, 2015);
- the main interesting divide between Northern (and Central) regions with respect to Southern ones is not so much the ability to 'extract' value added from each euro of outflows and exports, as the level of dependence of the generation of domestic value added on international or interregional demand, with Northern and Central regions having a larger share of the former;
- participation in GVC is significant in most regions: on average, 53.6% of the value added in Italian regions' gross exports and outflows is created through international or interregional value chains, with some variability across regions;
- regions differ in terms of the relative importance of the share of foreign value added stemming from international sources, with the Mezzogiorno being rather peripheral in terms of international sourcing and more heavily reliant upon national partners. Lombardy and the European Union are the main sources of, respectively, national and international foreign value added in trade flows for all regions. The FVA breakdown by partner also shows that trade links between Southern regions are weak in comparison to those with some Central and Northern regions.

The paper is organized as follows. The next section (Section 2) briefly describes the dataset while Section 3 presents the decomposition methodology. Section 4 consists of an introductory analysis of gross interregional and international trade flows followed by a fully consistent decomposition of regions' interregional and international trade, starting from bilateral flows.

[2] For a technical description of the methodology used in this paper see the Appendix.

[3] Another is by Cherubini and Los (2016), based on data from WIOD and IRPET, who study the links between Italian macro-regions' employment dynamics and patterns and their integration in global value chains from 1995 to 2006.

2. The dataset

The importance of GVC in world trade has led to the development of an empirical literature that has put forward indicators based on value added in trade. One evolution of the toolboxes to study GVC is the production of multicountry input-output (IO) tables (Amador and Cabral, 2016).[4] This strand of literature uses IO tables merged with international trade statistics to trace the production stages through countries or regions. The contributions of Hummels *et al.* (2001), Johnson and Noguera (2012), Dietzenbacher *et al.* (2013a), Timmer *et al.* (2013), and Koopman *et al.*(2014, KWW), among many others, produced methodologies that have been refined in several dimensions (i.e. Meng *et al.*, 2013, MWK; Wang *et al.*, 2013; Borin and Mancini, 2015, 2017a, 2017b) and applied to world IO tables. The empirical results of these studies confirm that the difference between gross exports and value added exports has increased, but is very heterogeneous across countries and industries (Johnson, 2014). The IO literature on GVC has developed rather independently from GVC trade theory, although efforts are under way to link them (Antras and Chor, 2013 and 2018).

The availability of world IO tables at the regional level is poor. Dietzenbacher *et al.* (2013b) combine a world IO table with a multiregional IO table for Brazil showing that the participation of Brazil in GVC is limited, with a strong heterogeneity among Brazilian states. Meng *et al.* (2013) apply the KWW approach to IO data on Chinese regions integrated into an international IO model.[5] They find, for example, that the Central region does not directly export much abroad (in terms of gross exports) but provides intermediate products to the exporting coastal regions. Therefore China's coastal regions link together global and domestic value chains. MWK results are confirmed by Pei *et al.* (2017). Previous analyses of Italian regions include Cherubini and Los (2016): based on data from WIOD and IRPET, they study the links between Italian macro-regions' employment dynamics and patterns and their integration in global value chains from 1995 to 2006; they find that employment in GVC has grown in all sub-national areas but its levels are much lower in the South than elsewhere.

This paper uses an interregional-intercountry, commodity by commodity IO table (henceforth IRIC-IOT), resulting from the introduction of a multicountry dimension in the 2012 Italian multiregional supply and use table (MRSUT) in IRPET's MRIO model with 37 sectors and 54 products.[6]

One important step in the construction of IRPET's MRIO model is the estimation of interregional gross trade, given that regional accounts statistics include only net interregional imports. The initial gross interregional trade, both in intermediate and final products, is based on econometric estimates of a model that uses as explanatory variables distance, relative per capita GDP, indicators of multi-plant firms, product tradability, and the results of a Bank of Italy survey (Survey of Industrial and Service Firms, 2009) that identified the location of activity units and the destination of firms' output. These estimates were then simultaneously

[4] Among the most used world IO tables there are WIOD, GTAP, and TiVA datasets. See Bentivogli *et al.* (2014) for a short description of the datasets, and Dietzenbacher *et al.* (2013a) and Timmer *et al.* (2015) for details on WIOD.

[5] In this regard, see also Pei *et al*. (2017).

[6] See Cherubini et al.(2011), Cherubini and Paniccià (2013), and Casini Benvenuti and Paniccià (2003).

balanced, along with the regional SUTs, according to regional/national constraints and indices of reliability (Paniccià and Rosignoli, 2018).

Another important feature of IRPET's MRIO model is the reallocation of a significant share of international imports of goods and services among regions according to the location of effectively demanding activity units at the regional level. Official regional statistics on imports of goods (Coeweb data by Istat) are affected, amongst other drawbacks (see Section 4.1), by a significant bias because imports are recorded where they first cross the border and therefore tend to concentrate in regions with national harbours or airports and where headquarters of multi-plant enterprises or traders are located, like Lazio and Lombardy (Casini Benvenuti and Paniccià, 2003).

An original contribution of this paper is the introduction of the multicountry dimension in IRPET's MRSUT. First, the product and sector structure of available official SUTs for the EU (net of Italy), the United States, Canada and Japan (Italy's major trade partners and their main partners) was harmonized with that of the Italian multiregional SUT.[7] Second, international trade matrices for 54 products (goods and services) were built from the available international statistics on international trade in goods and services between each country mentioned above and the rest of the world as residual partner.[8] As a last step, foreign countries' SUTs were linked to one another and to the multiregional Italian SUT through an international trade matrix (for goods and services) using an estimation procedure similar to the one that was used to build IRPET's MRSUT. The result was a multiregional-multicountry SUT (MRMC-SUT).

The MRMC-SUT was then transformed into an interregional-intercountry commodity by commodity (under the industry-technology assumption) input-output table (IRIC-IOT)[9] similar to WIOD's tables.[10] The accounting structure of the table can be summarized by the following identity, for each j-*th* product and r-*th* region/country, which equalizes output at basic prices formation and uses:

[7] Data from national statistical offices; Eurostat for the EU.

[8] OECD Trade by commodities, Eurostat Comext, OECD Trade in services by partner country.

[9] The industry-technology assumption implies that all products of an industry have the same input structure. In the IRIC-IOT table tourism consumption is added as domestic households' consumption and is not isolated as a single economic aggregate. For this reason it is not possible to compute the share of tourism consumption and its impact on global value chains.

[10] We decided to build an interregional-intercountry matrix instead of using the WIOD for international IO matrices mostly because at the time of the estimate of the intercountry SUTs the WIOD tables were not consistent with the new SNA2008 as the regional SUT. A new WIOD fully consistent with the SNA2008 was released only in November 2016. Given the data availability, we preferred a bottom-up approach that gradually integrates partner countries' SUTs and trade flows into the multiregional model for Italy. The advantages of this choice are that it follows to a greater extent the most recent international standards for national accounts and it allows for better control of data origin and transformation. One disadvantage of this choice is that the analysis might be weakened by the fact that GVC effects on Italian regions' trade are examined only with respect to a few of its major trading partners, while a major link in GVC like China is missing. The inclusion of China in our model, together with other countries, by using the new release of WIOD will be the purpose of a future work.

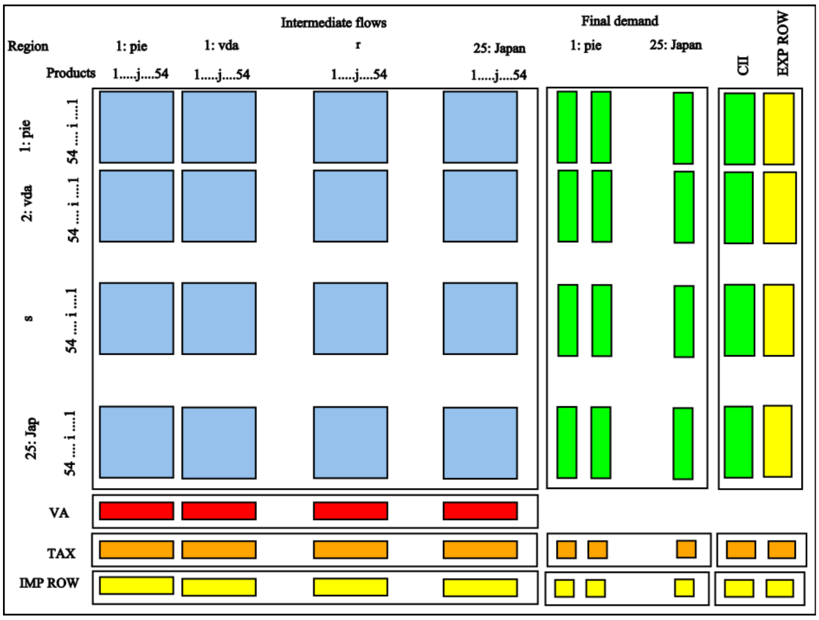
$$\sum_{s=1}^{nr+nc}\sum_{i=1}^{n} x_{ij}^{sr} + y_j^r + tax_j^r + mrx_j^r \equiv \sum_{s=1}^{nr+nc}\sum_{i=1}^{n} x_{ji}^{rs} + \sum_{s=1}^{nr+nc}\sum_{k=1}^{nf} f_{jk}^{rs} + InvC_j^r + ew_j^r$$

where:

nr = number of NUTS 2 regions (21)
nc = number of countries (4)
n = number of products (54)
nf = number of regional final demand components (5)
x = intermediate products
y = value added at basic prices
f = final regional domestic demand
tax = net indirect taxes on intermediate products purchased for producing the j-*th* product in the r-*th* region
mrx = total intermediate input from Rest of the world (Row) purchased for producing the j-*th* product in the r-*th* region
InvC = inventory changes
ew = export to Row

The structure of the matrix is illustrated in Figure 1. The intermediate input matrix component of the IRIC-IOT is a square matrix that for each of the 21 Italian regions[11] and the 4 'endogenous' foreign countries (the EU, the US, Canada and Japan), arrays 25 input matrixes of order 54 (54 types of goods and services), one for each of the 25 regions or countries of destination. Each cell represents the amount of goods and services needed to produce a given product, according to the average technology of the industries that make that product in a given region or country of destination.

Figure 1– IRIC-IOT interregional-intercountry input-output structure



[11] Including the non-allocated 'region'.

For each source region and country, the rectangular matrix of domestic final demand (in green) lines up 25 matrixes of order 54X1 (total final demand), followed by the vectors of change in inventories (CII in green) and of exports to the rest of the world (EXP ROW, in yellow).[12]

The vector of imports from the rest of the world (IMP ROW) represents the amount of goods and services that originate from countries that are not specified in the model and that are needed to produce a given product, according to the average technology of the industries making that product in a given region or country of destination. VA and TAX are respectively the vector of value added at basic prices and that of indirect net taxes.

3. The decomposition of regional trade flows

A landmark methodology for decomposing value added in trade flows is Koopman *et al.* (2014; KWW). Further refinements to the KWW framework have been proposed by Wang *et al.* (2013; WWZ), Nagengast and Stehrer (2014 and 2016; NS), and Borin and Mancini (2015, 2017a, 2017b; BM) to correctly compute KWW breakdowns at the sector, bilateral and bilateral sector level. Taking into account the refinements proposed by these contributions, the KWW decomposition can be illustrated, in the vein of Cappariello and Felettigh (2015), as in Figure 2.

The first component of gross exports is *domestic value added exports* (DVA) that are finally absorbed abroad. DVA can be further broken down into: direct final exports (1.1), exports of intermediates that are absorbed as local final goods after additional processing in the importing country (1.2), and exports of intermediates reaching the final destination as final goods (1.3). The second component of the KWW decomposition is *re-imported value added*, that is, exported intermediates that are finally re-imported either as final (1.4) or as intermediate (1.5) goods. Items 1.1 to 1.5 can be thought of as GDP in exports (GDPX), that is the country's GDP embodied in a region's exports. The third component of gross exports is *foreign value added*, which is found in intermediates absorbed by the direct importer (2.2) and in final goods exports (2.1). Taking into account the point made by Borin and Mancini (2017b), it also includes the value that the direct importing country has added to intermediates that are re-exported to a third country (and absorbed there, if a sink-based approach is adopted – see below) (2.3). The *double counted terms* account for goods crossing the borders multiple times and consist of domestic (3.1) and foreign (3.2) value added, which are counted twice in world trade statistics.

In an interregional-intercountry framework the KWW decomposition of gross trade flows has to be adapted to take into account the fact that regions' trade flows can be directed both to other countries (gross exports) and to other regions (gross outflows). In a context in which countries and regions are linked through an extensive network of direct and indirect bonds, there is need for a criterion to distinguish clearly exports from outflows, in order to correctly identify the different sources of value added.

[12] While Figure 1 shows 5 components of final domestic demand, the analysis aggregates them into a single item for each country.

To do so we distinguish regions and countries, both as direct importers in *bilateral flows* and as areas of final absorption of goods and services. As BM show, the use of bilateral flows makes it possible to identify correctly all the value added components and to distinguish between the value added absorbed by direct importers and that absorbed by third countries.

Figure 2 - KWW decomposition of gross exports

<table>
<tr><th colspan="2">GDP in exports (GDPX) (1)</th><td>+</td><th>Foreign value added (FVA) (2)</th><td>+</td><th>Double counting (3)</th><td>=</td><td rowspan="6">Gross exports</td></tr>
<tr><td rowspan="3">Domestic value added exports (DVA)</td><td>- in direct final exports (1.1)</td><td></td><td>- in exports of final goods (2.1)</td><td></td><td>- in intermediate exports orig. produced at home (3.1)</td><td></td></tr>
<tr><td>- in intermediate exp. reaching final dest. as intermediate goods (1.2)</td><td></td><td>- in export of intermediates abs. by the dir. importer (2.2)</td><td></td><td>- in intermediate exports orig. produced abroad (3.2)</td><td></td></tr>
<tr><td>- in intermediate exp. finally absorbed as final goods (1.3)</td><td></td><td>- of the direct importing country in export of intermediates re-exported by the direct importer to a third country and absorbed there (2.3)</td><td></td><td></td><td></td></tr>
<tr><td rowspan="2">Re-imported domestic value added (RDVA)</td><td>- in intermediate exp. re-imported as final imports (1.4)</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>- in intermediates exp. re-imported as interm. and finally abs. domestically (1.5)</td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

We follow Meng *et al.* (2013; MWK) - who introduce interregional trade into the general KWW methodology – in defining exports and outflows according to the location of final demand; the latter criterion has the advantage of making it possible to study how a foreign demand shock would transmit to regional value added. Stated more clearly, in the decomposition exercise, we classify as *outflows* those flows that are *finally absorbed by other regions* independently of the different geographical patterns connecting the exporting region to final demand, and as *exports* those flows that are *finally absorbed abroad*. In order to allocate the value added content in a geographically coherent way (at the regional and country level) we follow the value added using a sink-based approach, which pins down the value added of exports the last time the flow leaves an Italian region or a foreign country.[13] This means for example that if a good exported by Lombardy to Germany (gross export) is then exported by Germany to Veneto for final absorption, in our decomposition framework it is classified as an outflow from Lombardy to Veneto. Similarly, a good directed from Lombardy to Emilia-Romagna (gross outflow) to be further transformed and then shipped to France for final absorption there, would be classified as an export from Lombardy to France.

By counting each transaction only once, the last time it crosses the border, the KWW decomposition provides a breakdown that is consistent at the global level (i.e., each piece is counted once, the last time it crosses the border). Borin and Mancini (2017b) note that at the national level some transactions that are classified as double counting could be interpreted as foreign value added and propose an alternative accounting of FVA and double counting which, although counting more than once each foreign value added component at the global level, allows the genuine value added components and double counted terms at the country level to be better appreciated. Since we are interested in following the different sources of valued added at the regional level, we adopt the alternative split of FVA proposed by BM (2017b). We refer to the KWW decomposition in which FVA is computed according to BM (2017b, Section 2.3) as a *modified KWW* decomposition.

As an example of the difference between the standard decomposition of foreign value added and the one adopted here, consider the case in which French value added is embodied in Italy's bilateral exports to Germany that are then re-shipped to the US and absorbed there. According to the standard KWW decomposition applied to bilateral flows and following the sink-based approach, French value added in Italian exports should enter the double counted term, and be accounted as foreign value added in German exports to the US. According to the alternative FVA split proposed by BM (2017b), it enters FVA both in Italian and German exports. While counted more than once at the global level, such an accounting framework allows the structure of national exports in terms of value added components to be better appreciated.

Following this alternative decomposition, FVA presented in Figure 2 can be computed mimicking the structure of GDPX and drawing from the double counted term (3.2). In other words, FVA would record the foreign value added observed in direct final exports, in exports of intermediates that are absorbed as local final goods after additional processing in the importing country, in exports of intermediates reaching the final destination as final goods, and in exported intermediates that are finally re-imported either as final or as intermediate goods. The foreign value added is counted once only at the regional level, whereas it may appear more than once at the global level.

This decomposition framework à la MWK and BM allows bilateral gross exports and outflows to be finely split into a number of items according to the location of final demand and to the type of GVC segment (national vs. international) from which the value added originates[14]. For the scope of our analysis we focus on the decomposition at the regional level of two of the main KWW items, namely DVA and FVA.

[13] An alternative approach is the source-based one which tracks the first destination of value added from the country of origin (see NS, 2014 and 2016, and BM, 2015).

[14] See Appendix for a more detailed presentation.

Taking into account the reclassification of exports and outflows according to the location of final demand, DVA can be written as:

$DVA = DVAO_b + DVAX_b$

where

$DVAO_b = DVAO_{bo} + DVAO_{bx}$
$DVAX_b = DVAX_{bo} + DVAX_{bx}$

O, X = location of final demand (O = other regions' demand, X = international demand)
$_{bo}$ = contained in bilateral *gross outflows*
$_{bx}$ = contained in bilateral *gross exports*

The share of regional DVA activated by other regions' demand is given by $DVAO_b/DVA$, and the DVA share activated by international demand is $DVAX_b/DVA$.

An analogous decomposition can be done for foreign value added incorporated in gross exports and outflows (for which we follow the alternative approach proposed by BM), which can come from goods and services imported by other Italian regions (national VA, NVA_b) or by other countries (international VA, IVA_b), through goods imported respectively from other Italian regions or foreign countries.

$FVA = NVA_b + IVA_b$

where

$NVA_b = NVAO_b + NVAX_b$
$NVAO_b = NVAO_{bo} + NVAO_{bx}$
$NVAX_b = NVAX_{bo} + NVAX_{bx}$

NVA_b is the sum of the value added by other Italian regions to gross flows that have as final destination both other regions ($NVAO_b$) and other countries ($NVAX_b$). $NVAO_b$ is partly included in gross exports and partly in gross outflows ($NVAO_{bx}$ and $NVAO_{bo}$, respectively). An analogous decomposition can be done for IVA_b.

Finally, we name FVAX the sum of national and international value added in international and interregional exports that are finally absorbed abroad (NVAX+IVAX), and FVAO the sum of national and international value added in interregional and international exports activated by final demand located in other regions (NVAO+IVAO).

All bilateral KWW items of DVA can be computed separately for gross exports and gross outflows and can be aggregated back to reproduce the KWW main components. The DVA contained in bilateral *gross exports* and *outflows* can be recovered as

$DVA = DVA_{bx} + DVA_{bo}$
$DVA_{bx} = DVAO_{bx} + DVAX_{bx}$
$DVA_{bo} = DVAO_{bo} + DVAX_{bo}$

A major issue that we have to tackle when we use the IRIC-IOT table to compute Italian regions' DVA in outflows and exports is dealing with the 'Rest of the world' (Row), which is all the countries for which we do not have detailed data. In this work we treat Row as exogenous and 'direct' bilateral flows to and from Row as leakages. We then consider only flows which 'cross' first our endogenous areas. Of course, whenever Row appears as the next partner of goods and services flows, the latter cannot be further tracked. We assess the relevance of the Row for each region by showing the share of ‘unexplained’ regional gross exports and outflows.

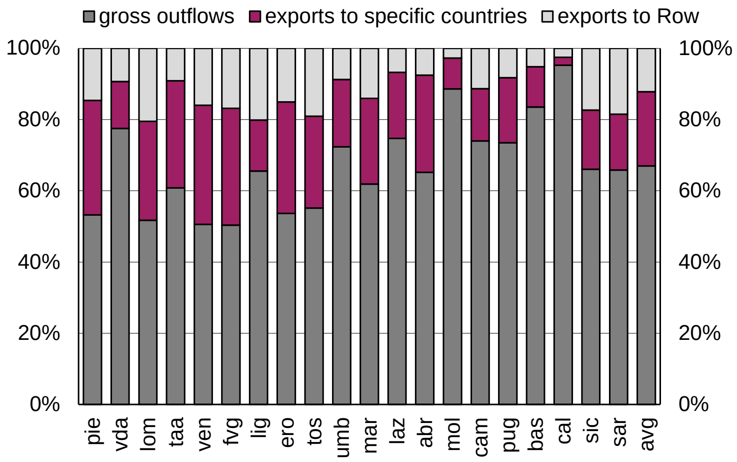
4. The sources of value added in regional trade flows

4.1 Gross trade flows

The IRIC-IOT data have two advantages over the official statistics: *i)* they include interregional gross trade, usually not included in official sources; ii) they are corrected for the bias in official statistics that tends to allocate imports to regions that host headquarters of multi-plant firms and/or main national harbours and airports. This explains why Lombardy, for example, which is an important hub for international goods and services, shows a trade deficit in official statistics and a surplus in IRIC-IOT data.

Figure 3 shows regions’ exports and outflows in goods and services as a share of total outward external flows. Exports to the Row (all countries except the EU, the US, Canada and Japan) represent a relatively small fraction of total external flows, with the exception of Lombardy, Liguria, Tuscany and the Islands.

Figure 3 – Share of gross exports and gross outflows, by Italian region (1)
(2012; % of total gross exports and outflows)

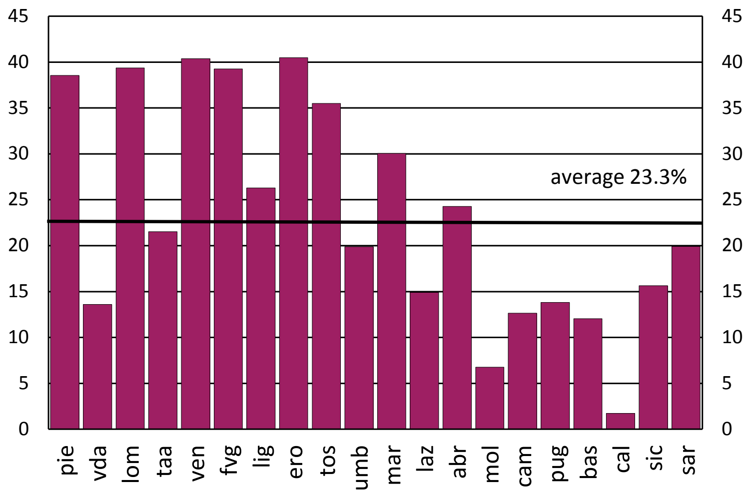


Source: Our calculations based on IRIC-IOT. (1) Specific countries include the EU (net of Italy), the United States, Canada and Japan. See Appendix 3 for a corresponding table of the regions’ codes.

This suggests that the data are sufficiently reliable as a source of information for the KWW decomposition. In all the regions outflows greatly exceed exports, as predicted by gravity models and by institutional theories emphasizing the importance of common institutions and rules for trade integration.

In Figure 4 exports are re-sized in terms of regional value added in order to better compare one region to the other. The share of exports of goods and services over regional value added ranges from 40% for Emilia-Romagna and Veneto to 2% for Calabria. It is above the average (23%) in eight Centre-Northern regions and lower than that in all regions of the Mezzogiorno except Abruzzo. Among the small regions with foreign borders, Valle d’Aosta, Trentino-Alto Adige and Liguria have a below-average degree of openness.

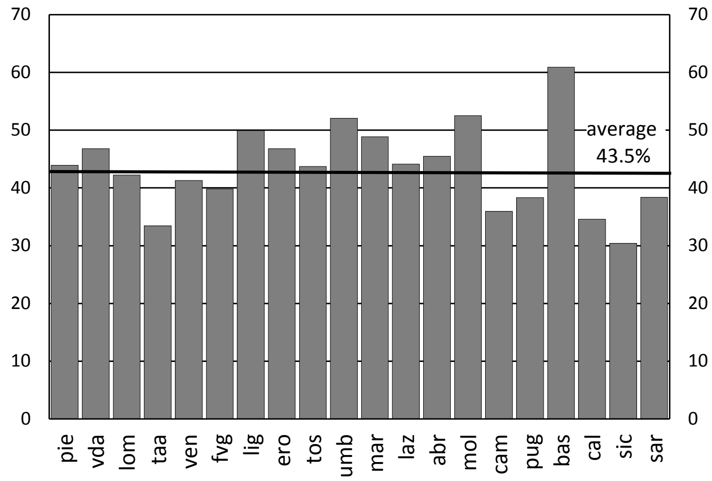
Figure 4 – Gross exports of Italian regions
(2012; % of regional value added)



Source: Our calculations based on IRIC-IOT.

The picture is very different when we look at the degree of 'internal' openness, that is, at the share of interregional exports to value added (Figure 5). The average is 44%, 20 percentage points higher than for exports on value added. The regions of the Mezzogiorno still are on the lower side, with the exception of Basilicata, Molise, and Abruzzo.[15]

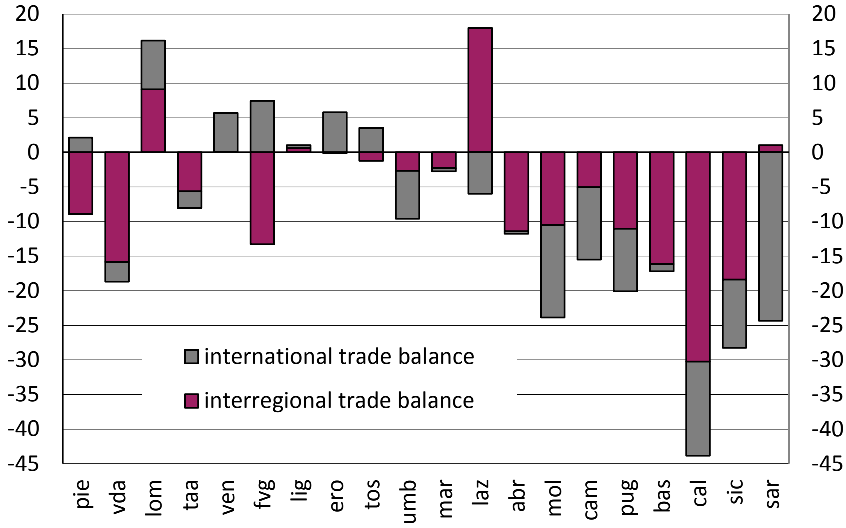
Figure 5 – Gross outflows of Italian regions
(2012; % of regional value added)



Source: Our calculations based on IRIC-IOT.

[15] Trade in services includes collective public administration consumption (defence, security, justice, law, etc.). The supply of these services is concentrated in some areas such as the capital region (Lazio) and other regions where particular collective services are required, for instance, defence in the border regions or security in areas affected by organized crime. The use of many of these services is instead spread among regions in proportion to their population. As a consequence, big producers like Lazio turn out to be large exporters of collective services to other regions. Separating outflows in goods from those in services, regions that show a well above average degree of internal openness in services are Lazio, Valle d'Aosta and Liguria; in particular, for Lazio and Valle d'Aosta more than 80% of their internal degree of openness is due to trade in services.

Figure 6 - Interregional and international trade balance of Italian regions (2012; % of regional value added)

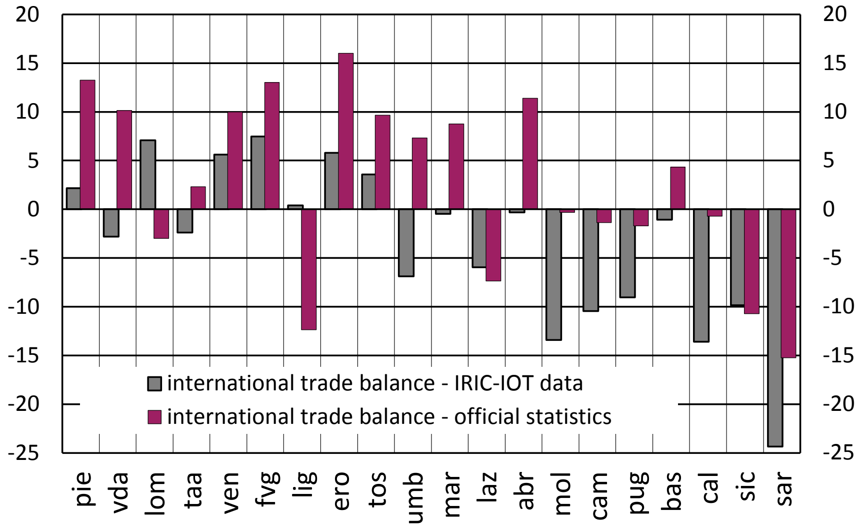


Source: Our calculations based on IRIC-IOT.

Taking into account imports from abroad and from other regions and looking at regional international and interregional trade balances, Lombardy turns out to have the largest trade surplus of the Italian regions (€50 billion, 16.2% of value added), followed by Lazio (€20 billion, 12% of value added; Figure 6). With the exception of Piedmont, Friuli-Venezia Giulia, Tuscany, Lazio, and Sardinia, the regions' international and interregional trade balances show the same sign. This suggests that the factors underlying the propensity to trade are similar both for international and for interregional trade. All Southern regions except Sardinia show a trade deficit in both types of trade. As regards the interregional trade balance, the sum of which is obviously zero, the surpluses of Lazio and Lombardy compensate the generalized deficits of all the other regions (Liguria and Sardinia show a very small surplus).

International trade balances from IRIC-IOT differ from trade balances obtained from official statistics for several reasons (Figure 7). First, as already said (Section 2), official regional statistics allocate imports to regions where they first cross the border, while IRIC-IOT allocates them according to estimates of the actual location of demand. Differences are also due to the price evaluation of trade flows (at basic prices in IRIC-IOT) and to the treatment of intra-company/enterprise intermediate trade flows (set to zero in IRIC-IOT; see Appendix for further details). Lombardy, which is an important hub for international goods and services, shows a surplus in IRIC-IOT data and a trade deficit in official statistics. Veneto, Friuli-Venezia Giulia, Emilia-Romagna and Tuscany, which have similarities in terms of productive structure (strong presence of small-to-medium firms agglomerated in industrial districts with the headquarters of firms located in the same region), keep a positive (but lower) international trade balance. At the same time the surplus of Marche becomes a small deficit in IRIC-IOT. This is probably due to a flow of pharmaceutical exports that should be set to zero according to national accounts rules of intra-company trade flows. All the regions of Southern Italy show a deficit after import reallocation, because many productive units located in the Mezzogiorno have their headquarters in other areas of the country, where imports are recorded by official trade statistics.

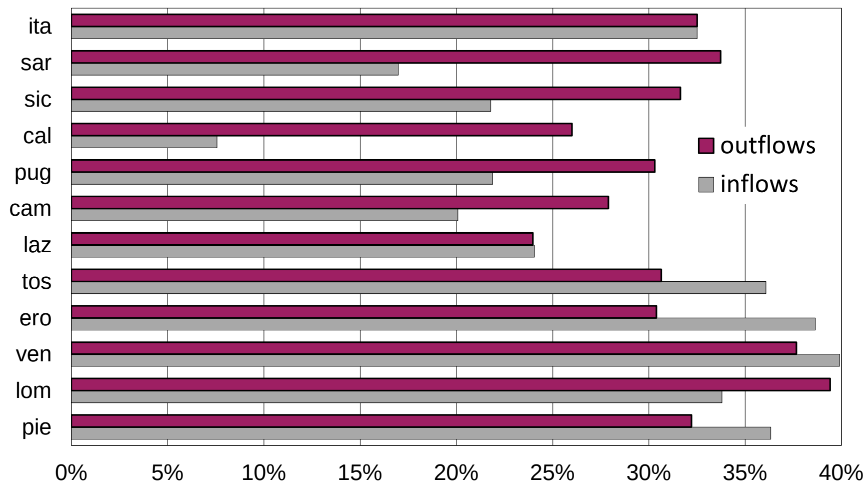
Figure 7 - International trade balance of Italian regions (2012; % of regional value added)



Source: Our calculations based on IRIC-IOT and official statistics of Istat and Bank of Italy.

From the IRIO model it is possible to calculate for each region the share of its interregional trade in intermediates that is activated by total Italian exports. For example, in 2012 Italy's exports activated about 37% of total outflows in intermediates of Lombardy and on average 31% of Italy's interregional trade in intermediates (Figure 8). [16]

Figure 8 - Impact of Italy's exports on interregional intermediate trade, for Italy as a whole and its main regions (2012; % of intermediates outflows)



Source: Our calculations based on IRIC-IOT.

[16] In the IRIC-IOT model, intermediate exports of the EU, the US, Canada and Japan are endogenous; this implies that, in order to estimate the impact of overall foreign exports on Italian intermediate interregional trade with equations A8 and A9 (Appendix 1) we need to exogenize all foreign export flows. In terms of modelling, this means to go back to the MRIO model with only the Italian regions, and treat the other foreign areas of the IRIC-IOT model as an exogenous rest of the world.

The impact of Italy's exports on interregional trade in intermediates is different among the regions. It is substantial in Lombardy, Veneto, Emilia-Romagna, and Tuscany, with differences in whether it is exports or imports that are most affected: in Lombardy the impact is higher for exports; in the other regions it is higher for imports, with Veneto and Emilia-Romagna recording the largest value of the impact on intermediate interregional inflows (39%). In the South the size of the impact is greater for exports than for imports. The relatively high incidence of the impact on outflows of Sicily, Sardinia and Apulia is mostly due to outflows of oil-derived products and basic intermediate products.

This analysis confirms that interregional and international trade are related and that the ultimate origin and destination of a significant share of interregional flows is foreign. The next chapter will estimate the components of this interdependency.

4.2 Value added trade flows

The analysis of international and interregional gross trade flows for the Italian regions is complemented here with a presentation of the results of the decomposition of gross exports and outflows (EO) into their domestic and foreign value added and double counted components. The decomposition is also used to compute a number of indicators that help to characterize the participation of Italian regions in domestic or international segments of the value chains.

Table 1 reports the results of the modified KWW decomposition of regions' EO treated as total regional outward trade flows, that is, as if exports and outflows were the same phenomenon.[17] The last column of the table displays the share of total EO that can be decomposed in the KWW framework; in the absence of an IO matrix for the Row, flows between the endogenous areas (regions and specified countries) and the Row cannot be traced until their final destination and are therefore treated as leakages. For most regions the decomposition explains at least 70% of exports and outflows; the share is very low for Sicily (57%) and Sardinia (48%), for which the results of the decomposition should be taken with caution.

A first piece of information that can be retrieved is the ability of regional EO to activate regional value added, measured by the sum of the first two columns in Table 1, which correspond to the gross domestic product contained in exports (GDPX; Cappariello and Felettigh, 2015). GDPX, indicates that, for example, in Emilia-Romagna each euro of gross EO activates 62.8 cents of the region's value added. The GDPX value for the average of Italian regions is 65.6% and ranges from a minimum of 56.3% for Basilicata to a maximum of 78% for Lazio (Figure 9). While there is some degree of regional heterogeneity, there is no clear clustering of regions.

These results seem consistent with those of Cappariello and Felettigh (2015) and Borin and Mancini (2017a) who find a GDPX of 72.7% and 73.5% for Italy in 2011, both slightly higher than our average, but with a different national database and with reference to gross exports only. A more restrictive measure of activation of the value added is domestic value added (DVA), which does not include re-imported domestic value added, but only the value added ultimately absorbed abroad (in another country or region), that is, value added that is

[17] To save space we aggregate the items of foreign VA in a single entry.

activated by external demand. As re-imported domestic value added is a small share of gross EO, the difference with GDPX is very small.

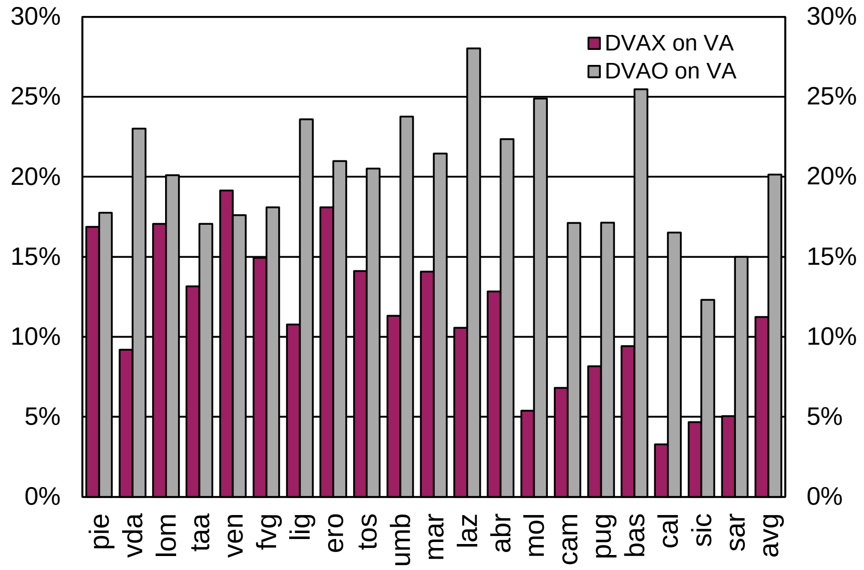
Table 1 – Modified KWW decomposition of regions' gross exports and outflows (EO) and percentage share of total EO - 2012 (1)

Italian region	Domestic content (GDP in exports, GDPX)		Foreign VA	Double counting	Share of total EO
	Domestic value added EO	Re-imported domestic value added			
Piedmont	59.7	0.8	38.7	0.8	70.4
Valle d'Aosta	64.4	0.1	35.5	0.1	82.9
Lombardy	68.8	1.7	27.8	1.6	66.3
Trentino-A. A.	66.9	0.2	32.7	0.2	82.3
Veneto	64.4	0.7	34.2	0.7	70.0
Friuli-V. G.	61.3	0.1	38.4	0.1	68.2
Liguria	68.9	0.4	30.3	0.3	65.2
Emilia-Romagna	62.1	0.6	36.4	0.8	72.3
Tuscany	64.6	0.6	34.3	0.6	67.6
Umbria	63.5	0.2	36.2	0.1	76.4
Marche	63.6	0.2	35.9	0.3	70.9
Lazio	77.2	0.8	21.5	0.5	84.6
Abruzzo	62.9	0.3	36.6	0.3	80.4
Molise	61.0	0.0	38.9	0.1	83.8
Campania	69.4	0.8	29.3	0.5	70.8
Apulia	64.7	0.5	34.4	0.4	74.8
Basilicata	56.1	0.1	43.5	0.2	84.9
Calabria	66.0	0.6	33.1	0.2	82.6
Sicily	64.2	0.8	34.4	0.5	57.3
Sardinia	71.9	0.3	27.7	0.1	47.6
Region average	**65.1**	**0.5**	**34.0**	**0.4**	**73.0**

Source: Our calculations based on IRIC-IOT. (1) The share of total EO in column 5 is computed as the ratio between 'explained gross EO' and total gross EO. Explained gross EO are gross flows that can be followed to the final destination in the IRIC-IOT; flows that at some point reach a destination other than Italian regions, the EU, the US, Canada or Japan are treated as leakages.

Some differences between regions emerge from the decomposition of domestic value added into that activated by international demand (DVAX) and that activated by other regions' demand (DVAO; Figure 9). The purple histogram (DVAX/VA) is the ratio between the DVA content in EO ultimately absorbed abroad and the total value added of the region; DVAO/VA is the DVA content in EO finally absorbed by other regions, scaled to the region's total value added. In general, DVAO is a larger share of VA than DVAX; the only exception is Veneto, for which the DVAX share of VA is greater than that of DVAO and has the highest value among the regions. The gap between the DVAX and the DVAO share is usually larger for Southern regions, which rely more on other regions' demand. For Veneto, Emilia-Romagna, Lombardy, Piedmont, Friuli-Venezia Giulia, Tuscany, and Marche the DVAX share is between 14% and 19%, well above the 11.2% average.

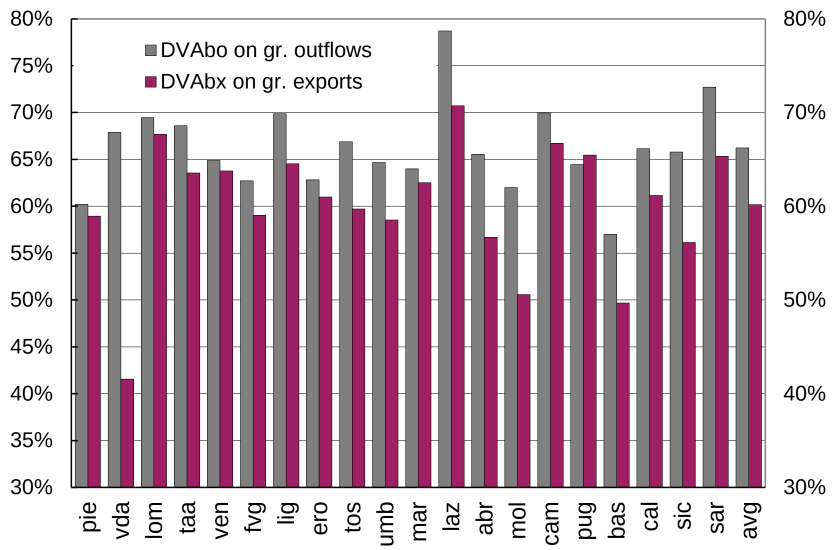
Figure 9 – Domestic value added activated by international demand (DVAX) and by other regions' demand (DVAO)
(2012; % of total regional value added)



Source: Our calculations based on IRIC-IOT.

The decomposition of domestic value added explained in Section 3 allows us to evaluate separately the domestic value added incorporated in gross exports and in gross outflows.

Figure 10 – Domestic value added in bilateral exports and outflows (1)
(2012; % of total gross explained exports and outflows)



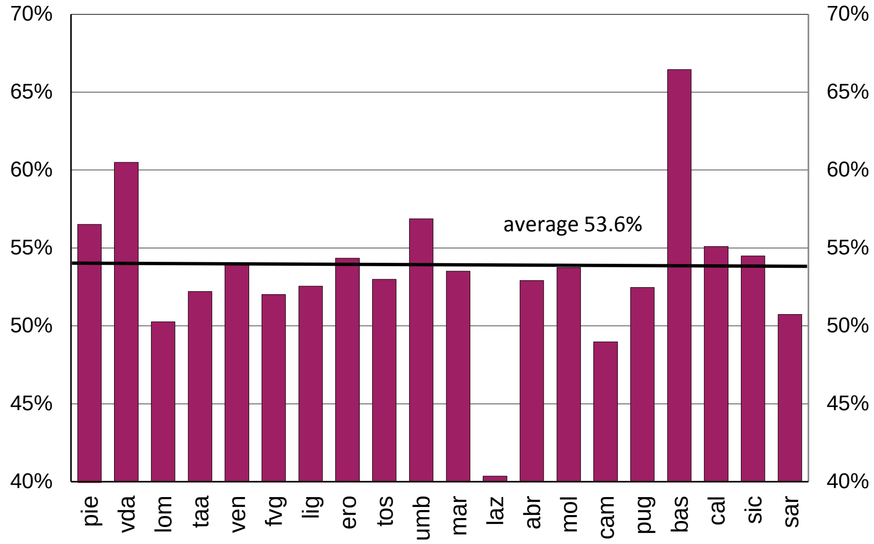
Source: Our calculations based on IRIC-IOT. (1) Total gross explained EO are gross flows that can be followed up to final destination (other Italian regions, the EU, the US, Canada, and Japan) in the IRIC-IOT table. In this Figure, domestic value added is split into domestic value added in bilateral gross outflows (DVA_{bo}) and domestic value added in bilateral gross exports (DVA_{bx}); see Section 3 for a more thorough explanation.

Figure 10 shows that, with the exception of Apulia, the share of DVA in gross outflows is higher than the share of DVA in gross exports for all regions. For DVA in gross exports the highest shares are those of Lazio and Lombardy, probably due to the importance of services exports in these regions and, for Lazio, to the fact that it is the location of the capital of Italy and therefore it ‘exports’ central government services to the other regions.

Using the metrics of domestic value added, the ranking of some regions in terms of degree of openness changes significantly. Lazio improves its position from 14th to 2nd, and Abruzzo from 11th to 6th. Piedmont falls from 2nd to 9th, Friuli-Venezia Giulia from 6th to 12th, and Tuscany from 5th to 10th. Emilia-Romagna keeps the first position in both openness indicators, while the remaining regions change their positions only marginally.

The decomposition of gross EO can be used to evaluate the extent of each region’s participation in value chains. The literature defines the GVC related components of gross exports as the value added that crosses at least two national borders (Hummels et *al*., 2001). Cappariello and Felettigh (2015) suggest using the sum of the value added owing to intermediate exports re-exported to third countries, re-imported domestic value added, foreign value added and double counting. The GVC indicator proposed by Borin and Mancini (2017a) is given by total gross EO net of the part of DVA that *i)* is exported for the very first time and *ii)* never leaves the first importing country; it is computed by using the source-based decomposition of EO. The indicator in Figure 11 follows this latter methodology.

Figure 11 – Share of gross EO that stems from regions’ participation in global value chains (2012; %)



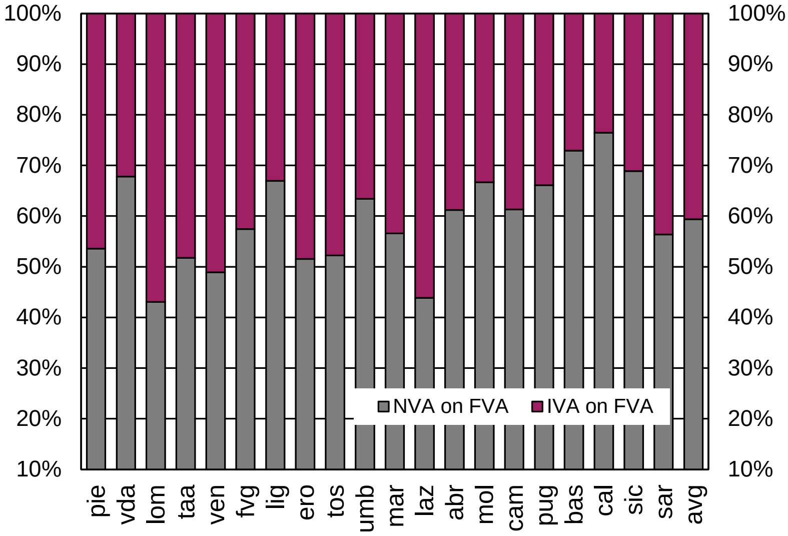
Source: Our calculations based on IRIC-IOT.

Data show a significant participation in GVC of most regions. On average 53.6% of gross EO are channelled through interregional and international value chains (Borin and Mancini, 2017a, find 43.7% in 2011 for Italy’s gross exports), with the highest share for Basilicata owing to automotive production. Lazio has the lowest percentage, owing to a high share of EO in services sent to other regions.

Among the components of the indicator, Table 1 shows an average value of 0.4% for double counting, with a maximum of 1.6% for Lombardy and a share slightly lower than 1% for Piedmont, Emilia-Romagna, and Veneto. This share is smaller than the 7.2% presented by Borin and Mancini (2017a) and the 6.8% by Cappariello and Felettigh (2015) for Italy in 2011. The difference is mainly due to the reallocation of part of double counting to foreign value added as explained in Section 2. A recalculation of double counting with our data and following the KWW methodology gives an average share of 10.4%, more similar to other estimates for Italy.

The breakdown of foreign value added by source (either other regions - NVA - or foreign countries - IVA - Figure 12) shows an average share of IVA of 41%. In Northern and Central regions this share is higher than average. In Lombardy, Veneto, and Lazio, it is also higher than that of national value added.

Figure 12 – National and international value added in EO (2012; % of foreign value added of EO)



Source: Our calculations based on IRIC-IOT.

Further details are given in Appendix 4, where the foreign value added of each region is broken down by source. Among source regions, Lombardy emerges as an important partner for all other areas (third column), with stronger links to many regions of the North-East, but also to Calabria, Sicily, and Sardinia in the South. Lazio is a major source of NVA for Central and Southern regions, but is less connected to the industrial Northern regions. As to Southern regions and the Islands, most NVA comes from the North-West and the Centre, showing that, despite the shorter distance, the regions of the Mezzogiorno do not have strong economic links. As far as the international sources of foreign value added, the European Union has the largest share of FVA for all regions, going from over 50% for Lombardy and Lazio to a minimum of 20% for Calabria.

In lieu of a conclusion

The structure of global value chains and their links with interregional value chains shape an important part of the process of national value added generation and its distribution among territories. When the IO-based measurement of GVC goes down to the regional level it is possible to better understand the role of each region in serving foreign demand and the production interdependencies among regions.

This is particularly important in a country like Italy where the persistent economic divide between North and South is mirrored in a different participation in international and interregional GVC. In this respect, our analysis shows that the main difference between the Mezzogiorno and the rest of Italy does not come from a different ability to extract value added from euros of outflows and exports, but rather from the level of dependence of domestic value added on international and interregional demand, with a lower share of the former compared with Northern and Central regions. Regions also differ in terms of the relative importance of the share of foreign value added stemming from international sources, with the Mezzogiorno being rather peripheral in the geography of international sourcing, and having weaker international linkages both forwards and backwards.

Although referring to a single year, our analysis seems to suggest that shares and patterns of interregional GVC are strictly linked to the shares and patterns of foreign GVC. This implies that a significant share of interregional and international trade is part of the same system although having a different impact on the generation of regional value added.

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Appendix

1. The multiregional and multi-country input-output model

The model related to the IRIC-IOT table is based on two main causal relations:

- a Leontevian technical relation, which determines the regional demand of intermediates and, along with the exogenous final demand, the total demand of each area;
- an allocative relation (multiregional trade pattern), which determines the macro regional output by distributing across the regions the total multiregional demand.

In a closed system it is possible to formalize the above relations in the following way:

$$d = Ax + df \tag{A1}$$

$$x = Tx \tag{A2}$$

where d is the total demand of the system (final and intermediate), x is the vector of total output and df the final demand. In equation (A1) the relation quantifies the demand for intermediate goods and services by the input cost coefficient matrix A. Equation (A2) shows the multiregional allocation pattern of demand, represented by the trade matrix coefficients T. The model assumes competitive imports. This is the typical Chenery-Moses class of models, between the pool approach (Leontief *et al.* 1977) and the 'pure' interregional model (Isard, 1960).

The basic model shown in equations (A1) and (A2) is the theoretical starting point for specifying a complete structural model in which the rest of world (Row) is added and, above all, intermediate and final trade are treated separately. In our IRIC-IOT model Row includes all countries except the EU, Japan, Canada and the US, which are the components, along with the Italian NUTS 2 regions, of the multiregional part of the model.

Hereafter the structural form of the model:

$$x + mr_x + mr_f + mw_x + mw_f + tax + tir \equiv Ax + f + er_x + er_f + ew \tag{A3}$$

$$tax = S(Ax + f) \tag{A4}$$

$$tir = N_w(mw_x + mw_f) + N_r(mr_x + mr_f) \tag{A5}$$

$$mw_x = M_x Ax \tag{A6}$$

$$mw_f = M_f f \tag{A7}$$

$$mr_x = \hat{Q}_x(I - M_x)Ax \tag{A8}$$

$$er_x = \check{Q}_x(I - M_x)Ax \tag{A9}$$

$$mr_f = \hat{Q}_f\left(I - M_f\right)f \tag{A10}$$

$$er_f = \check{Q}_f\left(I - M_f\right)f \tag{A11}$$

where:

x = output at basic prices
tax = net taxes on products
mw = foreign imports (fob): intermediate (subscript x) and final (subscript f)

mr = multiregional imports (fob): intermediate (subscript x) and final (subscript f)
tir = transport margins of international-interregional trade
f = domestic final demand
ew = exports to Row (fob)
er = multiregional exports (fob): intermediate (subscript x) and final (subscript f)
S = net product taxes coefficients
M = foreign import coefficients for intermediate (subscript x) and final (subscript f) product
Q = multiregional import-export coefficients for intermediate (subscript x) and final (subscript f) product
N_w, N_r = transport margins coefficients of foreign and multiregional trade.

A reduced form is associated with model (A3) - (A11). In particular, solving for output at basic prices we could write:

$$x = \left\{I - \left[\left[I + \check{Q}_x - (I + N_r)\hat{Q}_x\right](I - M_x) - N_w M_x - S\right] A\right\}^{-1} \left\{\left[\left[I + \check{Q}_f - (I + N_r)\hat{Q}_f\right]\left(I - M_f\right) - N_w M_f - S\right] f + ew\right\} \quad \text{(A12)}$$

Considering that:

$$T_x = \left[I + \left(\check{Q}_x - (I + N_r)\hat{Q}_x\right)\right](I - M_x)$$

and

$$T_f = \left[I + \left(\check{Q}_f - (I + N_r)\hat{Q}_f\right)\right]\left(I - M_f\right)$$

where T is the pure multiregional flows redistribution matrix, net of the RoW imports. Equation (A12) could be written as

$$x = \{I - [T_x - N_w M_x - S]A\}^{-1}\left\{\left[T_f - N_w M_f - S\right]f + ew\right\} \quad \text{(A13)}$$

Once defined matrix T we could move towards a quasi Isard type of matrix for intermediate and final goods.

If we assign

$$R_x = [T_x - N_w M_x - S]A \text{ and } R_f = \left[T_f - N_w M_f - S\right] \quad \text{(A14)}$$

we could rewrite (A12) as

$$x = \{I - R_x\}^{-1}\left\{R_f\, f + ew\right\} \quad \text{(A15)}$$

Recursively, it is possible to determine value added as

$$y = \hat{V}x \quad \text{(A16)}$$

where $\hat{V}$ = diagonal matrix of value added share per unit of output, or:

$$y = \hat{V}B\left\{R_f f + ew\right\} \quad \text{(A17)}$$

where $B = \{I - R_x\}^{-1}$

The interregional Leontevian inverse B, along with matrix $\hat{V}$, will be the key arrays for our analyses and decompositions.

2. Evaluation and regional allocation of trade flows in IRIC-IOT

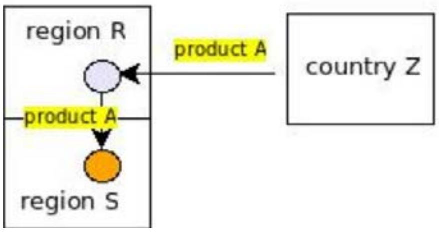
In IRIC-IOT regional trade flows differ from those recorded in official statistics mainly for the following reasons:

1) Price evaluation. Exports of goods are evaluated at basic prices in IRIC-IOT. In official regional trade statistics (Coeweb data) they are recorded at purchasing prices. This means that in IRIC-IOT a share of exports is re-allocated to international transport margins. Trade in services is recorded in ESA2010 SUTs and in IRIC-IOT at basic prices; credits and debits recorded in official statistics are at purchase prices.

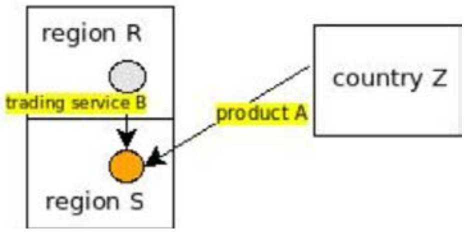
2) Coeweb data do not comply with ESA2010 recommendations on the treatment of intra-company/enterprise intermediate trade flows.

3) Change in the regional allocation of flows of goods imports. Coeweb data impute imports to the region where they first cross the border. IRIC-IOT estimates the regional allocation of imports consistent with the actual demanding region. As a result, a significant share of foreign imports is allocated to different regions in IRIC-IOT and Coeweb data. The following graph illustrates the two different methods of recording foreign import flows. Official statistics record at the regional level the import flow of good A from country Z, namely as imports of region R from country Z, although the region actually demanding that good is region S. In IRIC-IOT foreign imports of good A are assigned to region S, which in turn imports from region R transport and trading services. This methodology is closer to ESA recommendations on the treatment of trade flows (basic prices) in treating basic prices flow.

Official statistics recording



IRIC-IOT recording



3. Decomposing interregional and international trade starting from bilateral flows

Here we briefly summarize the methodology of decomposition of interregional vis-à-vis international bilateral trade flows.

Our starting point is the sink-based version of BM decomposition of bilateral trade, which we simplify in order to avoid an excessive increase in the number of items. We do not record second destination areas and identify four nodes: the shipping area in bilateral flows, the first destination, the area in which the good is processed the last time, and the area of absorption.

From paragraph 1 of the Appendix we inherit a set of matrices and vectors. Consider a framework with *G* countries and *N* products/sectors. We define E_{sr} the *Nx1* vector of bilateral (sector) exports stemming from country *s* towards country *r*. Let V_s be the *1 x N* vector of value added embedded in each unit of gross output produced in *s*, B the *GN x GN* global Leontief inverse and B_{ss} an *N x N* block matrix defining the amount of production activated in *s* to satisfy a determinate amount of its intermediate or final demand; R_{rr} is the *N x N* matrix of (domestic) input coefficients of *r* and $(I - R_{rr})^{-1}$ the national Leontief inverse; $\widehat{B}^{\phi}_{rr}$ has the identical interpretation of B_{ss}, the only difference being that *re-direction* stemming from *s* to all other countries is switched off (to avoid double counting). Finally, u_N is a unit row-vector of dimension *1 x N*.

The simplified version of BM decomposition of bilateral trade can be written as follows:

$$
\begin{aligned}
u_N E_{sr} = {} & V_s B_{ss} f_{sr} + V_s B_{ss} R_{sr}\left[\hat{B}^{\phi}_{rr} f_{rr} + \sum_{k\neq s,r}^{G} \hat{B}^{\phi}_{rk} f_{kk}\right] + V_s B_{ss} R_{sr}\left[\sum_{l\neq s,r}^{G} \hat{B}^{\phi}_{rr} f_{rl} + \sum_{k\neq s,r,l}^{G}\sum_{l\neq s}^{G} \hat{B}^{\phi}_{rk} f_{kl}\right] \\
& + V_s B_{ss} R_{sr}\left[\hat{B}^{\phi}_{rr} f_{rs} + \sum_{k\neq s,r}^{G} \hat{B}^{\phi}_{rk} f_{ks}\right] + V_s B_{ss} R_{sr} \hat{B}^{\phi}_{rs} f_{ss} + V_s B_{ss} R_{sr} \hat{B}^{\phi}_{rs} E_{s*} \\
& + \sum_{t\neq s}^{G} V_t B_{ts} f_{sr} + \sum_{t\neq s}^{G} V_t B_{ts} R_{sr} (I - R_{rr})^{-1} f_{rr} \\
& + V_r B_{rs} R_{sr} (1 - R_{rr})^{-1}\left[\sum_{j\neq r}^{G} f_{rj} + \sum_{j\neq r}^{G} R_{rj}\left(I - R_{jj}\right)^{-1} f_{jj}\right] \\
& + \sum_{t\neq s,r}^{G} V_t B_{ts} R_{sr} (I - R_{rr})^{-1} E_{r*} + V_r B_{rs} R_{sr} (I - R_{rr})^{-1} \sum_{j\neq r}^{G} R_{rj}\left(I - R_{jj}\right)^{-1} E_{j*}
\end{aligned}
\tag{1}
$$

The first component is the value added in bilateral exports of final goods and services absorbed in *r*; the second and the third items are the bilateral exports of intermediates that are either processed and absorbed by the direct importer or re-exported as intermediates by the direct importer and absorbed as intermediates in country *k*; the fourth and the fifth components are related to bilateral exports of intermediates that are finally absorbed as final goods in all countries but *s*, either exported by *r*, or by all other countries, *s* excluded; components from six to eight refer to exports that are finally absorbed by *s* either as final or as intermediates; the ninth and twelfth items are double counted terms; finally, the tenth and eleventh components are components, respectively, of foreign value added in exports of final goods and services and of intermediates. The 11 items of equation (1) are printed in different colours in order to highlight the three main components of the decomposition, namely: in purple, domestic value added exports (DVA); in grey, domestic value added in goods that finally return home (RDVA); in red, foreign value added exports (FVA), which include the value added by the exports of direct importer *r* to *s*, which are redirected to country *j* and absorbed there (BM, 2017a).

In constructing DVA, re-exports to third countries are tracked to identify the amount of DVA absorbed at home and abroad. FVA is instead allocated either to the FVA items or to the double-counted term, depending on whether the direct partner is the one finally absorbing the good or not. In the first case the FVA formula is ($\sum_{t\neq s}^{G} V_t B_{ts} R_{sr}(I - R_{rr})^{-1} f_{rr}$), and in the second case it is ($\sum_{t\neq s}^{G} V_t B_{ts} R_{sr}(I - R_{rr})^{-1} E_{r*}$).

BM (2017b, Section 2.3) propose an alternative way of computing FVA and the foreign double counting component (FDC) that aims to make the KWW decomposition more meaningful at the country level, at the loss of global consistency. According to this alternative decomposition, FVA can be calculated similarly to DVA+RDVA: for each bilateral flow between countries *s* and *r*, FVA is allocated to country *s*, independently from the number of borders it has crossed in between; this violates the consistency constraint at the global level. Compared with the FDC component of the traditional KKW decomposition, FDC is reduced by the amount of value added that is allocated to FVA. The FVA items can be recovered by substituting V_sB_{ss} with $\sum_{t\neq s}^{G} V_t B_{ts}$ in the first eight components in equation (1).

In an interregional-intercountry framework, a number of new concepts and definitions have to be introduced. First, direct bilateral flows can connect regions with regions (E_{sr}), regions with countries (E_{sR}) and countries with countries (E_{SR}). Moreover, indirect links connecting the area originating the first flow to the one absorbing the product via its final demand may involve complex combinations of interregional and international patterns. Regions and countries have to be disentangled from each other while tracking direct and indirect links. Furthermore, within the interregional blocks of the global inverse *B*, purely domestic segments of GVC (B_{ss}^{d}) have to be distinguished from feedbacks with respect to international activation ($B_{ss} - B_{ss}^{d}$).

Here we present the equations for the bilateral flows connecting region *s* and region *r* (gross outflows) and derive separately the domestic value added (DVA_{sr}), the returned value added ($RDVA_{sr}$) and the foreign value added, divided into FVA of national or international origin (respectively NVA_{sr} and IVA_{sr}), having in mind that:

$E_{sr} = DVA_{sr} + RDVA_{sr} + NVA_{sr} + IVA_{sr} +$ *double counted terms.*

In particular DVA_{sr} can be written as follows:

$$
\begin{aligned}
DVAsr &= V_s B_{ss}^d f_{sr} + V_s(B_{ss} - B_{ss}^d) f_{sr} \\
&+ V_s B_{ss}^d R_{sr}\left[\hat{B}_{rr}^{\phi d} f_{rr} + \sum_{k\neq s,r}^{G} \hat{B}_{rk}^{\phi d} f_{kk} + \left(\hat{B}_{rr}^{\phi} - \hat{B}_{rr}^{\phi d}\right) f_{rr} + \sum_{k\neq s,r}^{G}\left(\hat{B}_{rk}^{\phi} - \hat{B}_{rk}^{\phi d}\right) f_{kk}\right. \\
&\left. + \sum_{K}^{G} \hat{B}_{rK}^{\phi} Y_{KK}\right] \\
&+ V_s(B_{ss} - B_{ss}^d) R_{sr}\left[\hat{B}_{rr}^{\phi d} f_{rr}\right. \\
&\left. + \sum_{k\neq s,r}^{G} \hat{B}_{rk}^{\phi d} f_{kk} + \left(\hat{B}_{rr}^{\phi} - \hat{B}_{rr}^{\phi d}\right) f_{rr} + \sum_{k\neq s,r}^{G}\left(\hat{B}_{rk}^{\phi} - \hat{B}_{rk}^{\phi d}\right) f_{kk} + \sum_{K}^{G} \hat{B}_{rK}^{\phi} Y_{KK}\right] \\
&+ V_s B_{ss}^d R_{sr}\left[\sum_{l\neq s,r}^{g} \hat{B}_{rr}^{\phi d} f_{rl} + \sum_{k\neq s,r,l}^{g}\sum_{l\neq s}^{g} \hat{B}_{rk}^{\phi d} f_{kl} + \sum_{l\neq s,r}^{g}\left(\hat{B}_{rr}^{\phi} - \hat{B}_{rr}^{\phi d}\right) f_{rl}\right. \\
&+ \sum_{k\neq s,r,l}^{g}\sum_{l\neq s}^{g}\left(\hat{B}_{rk}^{\phi} - \hat{B}_{rk}^{\phi d}\right) f_{kl} + \sum_{K}^{G}\sum_{l\neq s}^{g} \hat{B}_{rK}^{\phi} f_{Kl} + \sum_{L}^{G} \hat{B}_{rr}^{\phi d} f_{rL} \\
&+ \sum_{k\neq s,r}^{g}\sum_{L}^{G} \hat{B}_{rk}^{\phi d} f_{kL} + \sum_{L}^{G}\left(\hat{B}_{rr}^{\phi} - \hat{B}_{rr}^{\phi d}\right) f_{rL} \\
&\left. + \sum_{k\neq s,r}^{g}\sum_{L}^{G}\left(\hat{B}_{rk}^{\phi} - \hat{B}_{rk}^{\phi d}\right) f_{kL} + \sum_{K\neq L}^{G}\sum_{L}^{G} \hat{B}_{rK}^{\phi} f_{KL}\right] \\
&+ V_s(B_{ss} - B_{ss}^d) R_{sr}\left[\sum_{l\neq s,r}^{g} \hat{B}_{rr}^{\phi d} f_{rl} + \sum_{k\neq s,r,l}^{g}\sum_{l\neq s}^{g} \hat{B}_{rk}^{\phi d} f_{kl} + \sum_{l\neq s,r}^{g}\left(\hat{B}_{rr}^{\phi} - \hat{B}_{rr}^{\phi d}\right) f_{rl}\right. \\
&+ \sum_{k\neq s,r,l}^{g}\sum_{l\neq s}^{g}\left(\hat{B}_{rk}^{\phi} - \hat{B}_{rk}^{\phi d}\right) f_{kl} + \sum_{K}^{G}\sum_{l\neq s}^{g} \hat{B}_{rK}^{\phi} f_{Kl} + \sum_{L}^{G} \hat{B}_{rr}^{\phi d} f_{rL} \\
&+ \sum_{k\neq s,r}^{g}\sum_{L}^{G} \hat{B}_{rk}^{\phi d} f_{kL} + \sum_{L}^{G}\left(\hat{B}_{rr}^{\phi} - \hat{B}_{rr}^{\phi d}\right) f_{rL} \\
&\left. + \sum_{k\neq s,r}^{g}\sum_{L}^{G}\left(\hat{B}_{rk}^{\phi} - \hat{B}_{rk}^{\phi d}\right) f_{kL} + \sum_{K\neq L}^{G}\sum_{L}^{G} \hat{B}_{rK}^{\phi} f_{KL}\right]
\end{aligned} \tag{2}
$$

The main differences between DVA of equations (2) and (1) are the following: i) regions and countries are treated as different groups of areas of completion and/or absorption of goods and services; ii) pure domestic segments of GVC are disentangled from international parts both backwards and forwards with respect to the links connecting s and r, throughout the B^d and the $\hat{B}^{\phi d}$. In order to facilitate reading, goods and services that are absorbed by international final demand (DVAX) are left in blue, whereas the goods and services absorbed by national final demand (DVAO items) are in orange.

Returned domestic value added is defined as follows:

$$
\begin{aligned}
RDVA_{sr} = {} & V_s B_{ss}^d R_{sr} \Bigg[\widehat{B}_{rr}^{\phi d} f_{rs} + \sum_{k \neq s,r}^{g} \widehat{B}_{rk}^{\phi d} f_{ks} + \left(\widehat{B}_{rr}^{\phi} - \widehat{B}_{rr}^{\phi d} \right) f_{rs} \\
& + \sum_{k \neq s,r}^{g} \left(\widehat{B}_{rk}^{\phi} - \widehat{B}_{rk}^{\phi d} \right) f_{ks} \sum_{K}^{G} \widehat{B}_{rK}^{\phi} f_{Ks} \Bigg] \\
& + V_s (B_{ss} - B_{ss}^d) R_{sr} \Bigg[\widehat{B}_{rr}^{\phi d} f_{rs} + \sum_{k \neq s,r}^{g} \widehat{B}_{rk}^{\phi d} f_{ks} + \left(\widehat{B}_{rr}^{\phi} - \widehat{B}_{rr}^{\phi d} \right) f_{rs} \\
& + \sum_{k \neq s,r}^{g} \left(\widehat{B}_{rk}^{\phi} - \widehat{B}_{rk}^{\phi d} \right) f_{ks} \sum_{K}^{G} \widehat{B}_{rK}^{\phi} f_{Ks} \Bigg] + V_s B_{ss}^d R_{sr} \left[\widehat{B}_{rs}^{\phi d} f_{ss} + \left(\widehat{B}_{rs}^{\phi} - \widehat{B}_{rs}^{\phi d} \right) f_{ss} \right] \\
& + V_s (B_{ss} - B_{ss}^d) R_{sr} \left[\widehat{B}_{rs}^{\phi d} f_{ss} + \left(\widehat{B}_{rs}^{\phi} - \widehat{B}_{rs}^{\phi d} \right) f_{ss} \right]
\end{aligned} \tag{3}
$$

As to NVA_{sr} and IVA_{sr}, we follow the alternative methods suggested by BM (2017b) to compute FVA, since it better describes the geographical structure of external value added of exports and outflows of each region. By substituting $V_s B_{ss}^d$ and $V_s(B_{ss} - B_{ss}^d)$ in equations (2) and (3) with $\sum_{t \neq s}^{g} V_t B_{ts}^d$, $\sum_{t \neq s}^{g} \left(B_{ts} - B_{ts}^d \right)$ and $\sum_{T}^{G} V_T B_{Ts}$ it is possible to retrieve, respectively, NVA_{sr} in (up to s) domestic segments of GVC, and NVA_{sr} in (up to s) international segments of GVC and IVA_{sr}.

3. Italian macro-areas and regions

Macro-areas (NUTS 1)	Regions (NUTS 2)	Region abbreviations
North-West	Piedmont	Pie
	Valle d'Aosta	Vda
	Lombardy	Lom
	Liguria	Lig
North-East	Veneto	Ven
	Friuli-Venezia Giulia	Fvg
	Trentino-Alto Adige	Taa
	Emilia-Romagna	Ero
Centre	Tuscany	Tos
	Umbria	Umb
	Marche	Mar
	Lazio	Laz
South	Abruzzo	Abr
	Molise	Mol
	Campania	Cam
	Apulia	Pug
	Basilicata	Bas
	Calabria	Cal
Islands	Sicily	Sic
	Sardinia	Sar

The Mezzogiorno includes South and Islands.

4. Bilateral decomposition of foreign value added

Composition of foreign value added by exporting regions (row) and by source regions/countries of value added (2012; % of exporting areas' foreign value added)

Source of FVA area / Exporting area	pie	vda	lom	taa	ven	fvg	lig	ero	tos	umb	mar	laz
Piedmont	-	0.8	21.4	0.7	4.6	0.5	4.0	5.5	3.1	0.5	1.2	3.7
Valle d'Aosta	14.1	-	21.4	0.9	5.7	0.5	2.9	3.8	3.0	0.6	1.4	4.6
Lombardy	6.5	0.3	-	1.4	7.7	0.8	2.7	6.0	3.2	0.7	0.9	4.5
Liguria	2.8	0.1	15.5	-	8.4	0.7	1.3	4.9	3.3	0.6	1.3	4.5
Veneto	2.9	0.1	19.7	2.4	-	1.3	1.0	6.6	3.3	0.5	0.8	4.1
Friuli-Ven. G.	2.8	0.1	14.0	1.1	16.2	-	1.0	5.2	3.3	0.6	1.3	4.9
Trentino-A.A.	7.8	0.3	19.7	1.0	5.2	0.6	-	4.0	7.9	0.8	1.3	8.7
Emilia-Rom.	3.6	0.1	16.5	0.9	8.5	0.6	1.5	-	5.4	1.3	1.4	4.3
Tuscany	3.2	0.1	12.5	1.2	4.5	0.7	2.0	5.6	-	2.1	1.2	10.3
Umbria	2.7	0.1	9.9	0.9	2.5	0.5	1.1	4.4	6.6	-	2.8	19.4
Marche	3.3	0.1	9.4	1.2	2.4	0.6	1.2	5.2	3.9	1.8	-	10.9
Lazio	2.4	0.1	11.8	0.7	2.2	0.5	1.3	4.5	4.0	1.0	1.7	-
Abruzzo	3.8	0.1	12.1	0.9	1.9	0.6	1.2	4.3	3.4	0.9	3.7	16.1
Molise	3.7	0.1	13.9	1.1	2.1	0.7	1.4	5.8	5.0	1.1	2.8	11.6
Campania	4.5	0.1	12.2	0.7	1.7	0.5	1.2	6.7	3.6	0.8	1.5	16.9
Apulia	4.0	0.1	14.1	0.8	2.2	0.7	1.2	5.5	3.7	0.7	1.8	11.5
Basilicata	4.2	0.2	14.6	1.3	2.7	0.8	1.7	6.3	4.5	1.1	2.8	10.5
Calabria	3.7	0.1	16.8	1.4	2.3	0.8	1.5	5.1	4.8	1.2	2.2	12.3
Sicily	5.5	0.2	16.0	1.3	2.4	0.8	2.1	7.6	4.8	1.0	2.4	8.9
Sardinia	3.9	0.1	17.0	1.2	2.4	0.7	1.7	5.2	4.5	0.9	2.2	6.7

Source: Our calculations based on IRIC-IOT.

(continued) Composition of foreign value added by exporting regions (row) and by source regions/countries of value added (2012; % of exporting areas' foreign value added)

Source of FVA area / Exporting area	abr	mol	cam	pug	bas	cal	sic	sar	ue28	us	can	jap
Piedmont	0.7	0.1	1.9	1.5	0.5	0.5	1.6	0.8	41.5	3.5	0.7	0.7
Valle d'Aosta	1.0	0.1	1.8	1.3	0.7	0.7	1.9	1.2	29.3	2.2	0.4	0.3
Lombardy	0.7	0.1	1.8	1.3	0.5	0.8	2.0	1.1	50.3	5.4	0.5	0.7
Liguria	0.9	0.1	1.8	1.3	0.8	0.8	1.9	0.8	45.0	2.3	0.4	0.6
Veneto	0.6	0.1	1.5	1.1	0.3	0.5	1.3	0.7	46.9	3.0	0.6	0.6
Friuli-Ven. G.	0.9	0.1	1.9	1.2	0.5	0.5	1.3	0.5	36.3	4.7	0.9	0.6
Trentino-A.A.	1.0	0.1	2.3	1.9	0.6	0.8	1.9	1.3	26.9	5.0	0.8	0.4
Emilia-Rom.	0.7	0.1	1.6	1.6	0.4	0.7	1.4	0.8	44.0	3.2	0.5	0.8
Tuscany	0.8	0.2	2.6	1.2	0.4	0.8	1.6	1.0	42.2	4.2	0.8	0.7
Umbria	1.6	0.3	4.0	1.9	0.7	1.2	2.2	0.8	31.3	4.4	0.5	0.4
Marche	4.9	0.3	2.8	4.2	0.7	1.0	2.0	0.7	38.3	3.9	0.5	0.8
Lazio	1.8	0.3	5.7	2.0	0.7	0.9	1.6	0.6	50.1	4.9	0.5	0.7
Abruzzo	-	0.5	3.5	4.1	0.9	0.9	1.7	0.7	33.9	3.2	0.8	1.0
Molise	2.2	-	7.0	3.4	0.9	0.9	2.1	0.8	29.6	2.9	0.4	0.5
Campania	1.2	0.4	-	3.5	1.2	1.5	2.4	0.6	32.6	5.0	0.7	0.5
Apulia	2.1	0.3	7.3	-	3.7	2.7	3.2	0.7	27.9	4.7	1.0	0.4
Basilicata	2.1	0.3	8.2	6.4	-	1.6	2.8	0.9	24.8	1.7	0.3	0.3
Calabria	1.9	0.3	6.9	5.2	1.7	-	7.3	1.1	20.0	2.9	0.3	0.2
Sicily	1.5	0.2	4.7	3.4	1.2	4.0	-	1.0	27.5	2.9	0.3	0.4
Sardinia	1.4	0.2	2.7	1.9	0.6	0.8	2.3	-	39.3	3.4	0.4	0.5

Source: Our calculations based on IRIC-IOT.