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Regionalisation of Social Accounting Matrices for the EU-28 in 2010

A regional database for RHOMOLO at NUTS 2 level

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Abstract

This paper presents the regionalisation methodology followed to build a regional database for RHOMOLO, the spatial computable general equilibrium model developed by the European Commission to evaluate the impact of Cohesion Policy. This report describes the methodology used to develop two sets of regional Social Accounting Matrices for the EU-28 at NUTS 2 level, according to both the NUTS 2006 and the NUTS 2010 classifications. The starting point is the set of national SAMs developed for the model by Álvarez-Martínez and López-Cobo (2016). The national SAMs are subsequently regionalised by means of non-survey techniques using the available regional statistical data from Eurostat, inter-regional bilateral trade flows developed ad hoc for this project and inter-regional transport cost data from the TRANSTOOLS project. The initial regional data prepared for RHOMOLO v2 included only the EU-27 and NUTS 2006, but following the accession of Croatia to the European Union on January 1st 2013, in this paper we also include a national SAM and two regional SAMs for Croatia.

Keywords: social accounting matrices, regional database, EU-28.

JEL Codes: D57, E16, R12, R13.

1. Introduction

RHOMOLO-v2 is a spatial computable general equilibrium model developed by the Directorate General Joint Research Centre (DG JRC) and the Directorate General for Regional and Urban Policy (DG REGIO) of the European Commission. This model has been designed to evaluate the effects of Cohesion Policy on economic growth for all the regions of the European Union. In fact, RHOMOLO has already been used to assess the impact of Cohesion Policy for the 2007-2013 Programming period and will be used for the ex-ante impact assessment for the period 2014-2020. A full description of the model can be found in Mercenier et al. (2016). As usual in CGE models, RHOMOLO data are organised in the form of Social Accounting Matrices (SAMs).

In order to capture the characteristics of regions and interregional connections, the database has been built at the NUTS 2 level. The Nomenclature of Territorial Units for Statistics, abbreviated NUTS (from the French version *Nomenclature des unités territoriales statistiques*), is a hierarchical classification system to divide the EU territory for the purpose of collection, development and harmonisation of EU regional statistics, and socio-economic analyses of the regions and for the framing of EU regional policies. The NUTS 2 level corresponds to regions for the application of regional policies (Eurostat, 2011). The first NUTS classification system was adopted in May 2003 – NUTS 2003 – and since then three major revisions have been implemented – NUTS 2006, NUTS 2010 and NUTS 2013.

For the ex-post evaluation of the Cohesion Policy for the 2007-2013 Programming period, RHOMOLO uses the NUTS 2006 classification, while for the ex-ante evaluation for the period 2014-2020, the NUTS 2010 classification has been used. Between the two versions of the classification some regions have split, merged or shifted boundaries, and therefore the regionalisation procedure has considered these changes to produce two sets of regional SAMs. More detailed information on the conversion between NUTS classifications can be found in López-Cobo, 2016.

Following the adhesion of Croatia to the European Union on January 1st 2013, we have also produced a national SAM and two regional SAMs for Croatia, which have been included in the data set for the ex-ante evaluation under NUTS 2010.

This report describes the methodology used to develop two sets of regional SAMs, one according to the NUTS 2006 classification for the EU-27, the other according to the NUTS 2010 classification for the EU-28.

2. Data sources

The starting point is the set of national SAMs developed for the model. The national SAMs are subsequently regionalised by means of non-survey techniques using the available regional statistical data from Eurostat and inter-regional bilateral trade flows.

The data used to build the regional SAMs come from several sources, often developed under different sectoral (activity) or regional classifications, as shown in Figure 1. The available regional data from Eurostat for the year 2010 follows the NUTS 2010 classification and NACE¹ Rev. 2; while the interregional trade flows have been built under the NUTS 2006 version and NACE Rev. 1. In the national SAMs, data related to productive sectors are compiled according to NACE Rev. 1 based on WIOD. As a consequence, the resulting regional SAMs are produced according to NACE Rev. 1 and the regional classification more appropriate for their use: NUTS 2006 for the ex-post evaluation of the programming period 2007-2013, and NUTS 2010 for the ex-ante evaluation of the period 2014-2020.

Figure 1. Data availability with respect to regional and sectoral classifications

Source	Economic activity classification	Region classification
National SAM	NACE Rev.1	
Cohesion Funds		NUTS 2006
Regional data (Eurostat)	NACE Rev. 2	NUTS 2010
Transport cost	NACE Rev. 1	NUTS 2006
Inter-regional trade	NACE Rev. 1	NUTS 2006

Source: Own elaboration

2.1 National Social Accounting Matrices for the EU-27

The national SAMs the EU-27 are elaborated with publicly available data. The main data sources are the World Input-Output Database (WIOD)² and Eurostat. The original SAMs for the 27 EU countries are balanced square matrices of 85-by-85 (Álvarez-Martínez and López-Cobo, 2016). In each economy there are four agents: households, the corporate sector, the government, and the foreign sector, which is divided into the EU and the ROW. There are 59 productive sectors, wages and employers' social contributions by skill level (high, medium and low) and an account for capital. There are two accounts for taxes: direct taxes (households' income tax and corporate income tax), and taxes on production. Additionally, the SAMs contain current transfers, an account for investment, one for savings and three for trade and transport margins, international trade and transport margins and re-exports, correspondingly. The last three accounts are explicitly included in WIOD in order to match bilateral trade flows between countries. Table A. 1 and Table A. 2 in Annex provide the list of the accounts of the SAMs, and the 59 productive sectors, respectively.

¹ Statistical classification of economic activities in the European Community.

² WIOD is a project funded by the European Commission, Research Directorate General as part of the 7th Framework Programme, Theme 8: Socio-Economic Sciences and Humanities. Grant Agreement no: 225 281.

Figure 2. Main structure of SAMs

	Industries (59)	Primary factors (4)	Auxiliary accounts (12)	Agents* (10)
Industries	Intermediate consumption			Final demand
Primary factors	Labour and capital income			Labour and capital income from EU and ROW
Auxiliary accounts	Social Security Contributions and Taxes			Transfers and Taxes
Agents*	Imports and Re-exports	Redistribution of income	Redistribution of taxes and Transfers	

* Other accounts that are not agents in the economy are also included in these sub-matrices.
 Note: numbers in brackets account for the number of accounts (rows/columns) in the SAM.
 Source: Álvarez-Martínez and López-Cobo (2016).

2.2 National Social Accounting Matrix for Croatia

Due to the lack of coverage of Croatia by WIOD, a separate SAM has been elaborated for this country relying on data on National Accounts from Eurostat and a preliminary version of the Eurostat IOT for Croatia developed by Rueda-Cantucho et al. (2016) in the context of the EU-GTAP project³. Bilateral trade with Croatia has been estimated using the Global Trade analysis Project (GTAP) database.

The starting point is the Input-Output table for Croatia 2010⁴. It is valued at basic prices and uses the CPA/NACE Rev. 2 classification at millions of national currency. The SAMs for the 27 EU countries have been constructed at purchasers' prices, aggregated into five sectors and valued at million euros; therefore a number of modifications are required to adapt the preliminary Croatian IOT to the needs of the model. The 65 sectors in the IOT are aggregated into the five RHOMOLO macro-sectors (Figure 4) at the exchange rate of 7.289 HRK per euro.

The net taxes on products (NTPR) are included in the IOT, and split into taxes on products which are used as intermediate demand and as final demand. In the SAM for RHOMOLO the intermediate demand and final demand are valued at purchaser's prices. The IOT is changed from basic prices to purchasers' prices. For this transformation, the values in the row of NTPR detailed by demand type in the IOT are allocated across their corresponding columns. The main idea is to include the net taxes paid by each agent in the demand of each product, which can be used both for intermediate and final purposes.

Imports, which are valued at CIF, need to be disaggregated into their value FOB plus the international trade and transport margins. This is done using GTAP's

³ The European Commission's DG TRADE and DG Joint Research Centre (DG JRC) worked together in the so called EU-GTAP Project. The main outcome of this project is the submission to GTAP of a set of Input-Output Tables for the 28 Member States for the year 2010 under the new European System of Accounts (ESA2010) methodology.

⁴ The IOT available at the moment of the construction of the national SAM for Croatia was a preliminary version of the one published by Eurostat in September 2016. This version did not include certain break downs as the value added components or imports/exports disaggregated by area of origin/destination (EU and rest of the world). Therefore, these data needed to be estimated for this purpose.

proportion of imports FOB over imports CIF at sector level. These proportions are applied to the import CIF provided by the IOT. Imports and exports also need to be broken down between the EU and the rest of the world. To that end, we use detailed GTAP data on trade by country of origin and destination for 2011 at Million US\$. The aim is to produce a matrix of imports by country of origin and by sector and a matrix of exports by country of destination and sector. We apply an iterative proportional fitting procedure (IPFP, also known as RAS algorithm) where the value of total imports by sector (or target row) is given by the estimation of imports FOB from the IOT described above; total imports by country of origin (or target column) is given by applying to the total imports FOB the shares of total imports by country of origin given by GTAP. The seed for the RAS is given by the imports by country and sector in the GTAP database. From this we get the values for imports from the EU and the ROW by sector. We proceed equally for the matrix of exports.

The estimation of trade between Croatia and other EU countries forces us to modify the trade data already computed for the remaining 27 EU countries. The trade between EU countries and Croatia is considered trade with the rest of the world in the RHOMOLO database 2010 which does not include Croatia. That dataset has been built to be used for the ex-post evaluation of the Cohesion Policy for the 2007-2013 programming period. In the database including Croatia, to be used for the ex-ante evaluation of the 2014-2020 programming period, these trade values need to be reallocated into trade within the EU. Therefore, the imports and exports estimated for Croatia are deducted from the 27 EU countries' trade with the ROW and added to their trade with the EU.

Other adjustments include the disaggregation of gross operating surplus plus net taxes on production (GOS plus NTP) into its two components. For the 27 EU countries for which we have data we compute the average share of GOS over GOS plus NTP by sector, these shares are applied to the aggregated data and NTP is computed as a residual.

To complete the SAM, data on primary allocation and secondary distribution of household accounts are used, as in the construction of the national SAMs for the EU27. This process and the adjustments required to keep the SAM balanced are described in Álvarez-Martínez and López-Cobo (2016).

2.3 Regional data

2.3.1 Availability

Regional Statistics from Eurostat

The availability of Regional Accounts statistics from Eurostat at NUTS 2 level is limited. The available data at the region-sector level include:⁵

- Value added (VA).⁶
- Gross fixed capital formation (GFCF).⁷
- Compensation of employees (COMP).⁸

⁵ At the time of writing this report, these datasets (built according to the European System of Accounts 1995) are not available anymore. They have been substituted by equivalent datasets under the European System of Accounts 2010, with names: nama_10r_3gva, nama_10r_2gfcf and nama_10r_2coe respectively.

⁶ Eurostat (2015). Regional economic accounts– ESA95. Gross value added at basic prices by NUTS 3 regions 2010 (nama_r_e3vab95r2) [Data file]. Downloaded on 2015 July 27. Available from <http://ec.europa.eu/eurostat/data/database>.

⁷ Eurostat (2015). Regional economic accounts– ESA95. Gross fixed capital formation by NUTS 2 regions 2010 (nama_r_e2gfcfr2) [Data file]. Downloaded on 2015 July 27. Available from <http://ec.europa.eu/eurostat/data/database>.

The available data at the regional level include:

- Allocation of primary income account of households (HHp): Property income paid and received (PI_p and PI_r).⁹
- Secondary distribution of income account of households (HHs): Social benefits other than social transfers in kind received (WFB_r), Other current transfers paid and received (TR_p and TR_r), Current taxes on income paid (DTX_p), Social contributions paid (SSCHSU_p) and Net disposable income (NDI).¹⁰

All regional data are currently available from Eurostat according to the NUTS2010 geographical classification. All sectoral data referring to 2010 are available according to NACE Rev. 2. However, the national SAMs were constructed mainly from WIOD, which was built when NACE Rev. 1 was in use. Therefore, the first set of regional SAMs is built according to NUTS 2006 and NACE Rev.1. The second set is built according to NUTS 2010 and NACE Rev.1.

Inter-regional trade flows

The inter-regional trade flows are built in an iterative process. Data from Thissen et al. (2015) are used as a first estimate, later adjusted to make the trade flows consistent with country totals from the national SAMs. This is done by a generalised RAS method, which keeps the structure of bilateral trade flows as much unchanged as possible. The disarrangement between country trade totals in national SAMs and inter-regional trade matrix arises because Thissen et al. (2015) correct flows for re-exports before estimating bilateral trade flows. As a consequence, total imports and exports by country are different from those in WIOD's international SUT used to build the national SAMs.

In a second step, this resulting matrix is used to produce a seed matrix to feed a 3-step RAS procedure to generate the final bilateral trade flows matrix (Section 3.3).

Inter-regional transport cost

Transport costs for trade between and within regions are assumed to be of the iceberg type and are sector- and region-pair specific. To that end, an asymmetric trade cost matrix is derived from the European Commission's transport model TRANSTOOLS¹¹. In principle, the transport cost matrix is another input for RHOMOLO, but not part of the regional SAMs per se. However, the transport cost matrix is used here in the process of re-estimation of the inter-regional trade flows, as explained in Section 3.3.

2.3.2 Data cleaning and imputation

Overall, the quality of regional data seems to be satisfactory, although minor inconsistencies and missing values persist. In order to organise the data cleaning,

⁸ Eurostat (2015). Regional economic accounts– ESA95. Compensation of employees by NUTS 2 regions 2010 (nama_r_e2remr2) [Data file]. Downloaded on 2015 July 27. Available from <http://ec.europa.eu/eurostat/data/database>.

⁹ Eurostat (2015). Regional economic accounts– ESA95. Allocation of primary income account of households by NUTS 2 regions (nama_r_ehh2p) [Data file]. Downloaded on 2015 July 27. Available from <http://ec.europa.eu/eurostat/data/database>.

¹⁰ Eurostat (2015). Regional economic accounts– ESA95. Secondary distribution of income account of households by NUTS 2 regions (nama_r_ehh2s) Downloaded on 2015 July 27. [Data file]. Available from <http://ec.europa.eu/eurostat/data/database>.

¹¹ TRANS-TOOLS ("TOOLS for TRansport Forecasting ANd Scenario testing") is a European transport network model that has been developed in collaborative projects funded by the European Commission Joint Research Centre's Institute for Prospective Technological Studies (IPTS) and DG TREN. <http://energy.jrc.ec.europa.eu/transtools/>

data are organised in two sets: "Data by sector and region", split into VA, GFCF and COMP; "Data by region", for HHp and HHs.

Identifying missing values

In "Data by sector and region" most missing values correspond to macro-sectors. In those cases, they are computed as aggregation of individual sectors. However, some missing values remain in GFCF in the following countries and in all sectors: Ireland, Spain, France, Cyprus and Hungary. In "Data by region" there are missing values in Italy and Malta for HHp and Italy, Cyprus and Malta for HHs. The remaining missing values are dealt with at a later stage.

Inconsistencies

In the dataset of compensation of employees *nama_r_e2remr2* downloaded from Eurostat there was an inconsistency in Romania in sectors *TrTrade* (all regions except RO12), *BusServ* (all regions) and *OthServ* (all regions except RO12 and RO21). The values showed in the dataset were one order of magnitude larger than the actual value (ten times larger). This affected only the aggregated macro-sectors G.J, K.N and O.U, but not the individual ones. Therefore, new values are recomputed as the aggregation of the individual sectors.

Imputing missing values in GFCF

If available, GFCF data from European System of Accounts 2010 (ESA 2010) are used as a proxy for ESA 1995 data¹². When comparing data from ESA95 and ESA2010 for the countries and regions for which there are data for both methodologies, we can see some discrepancies in relative terms, mostly in the sector F. Construction, but which are not important in absolute terms due to the relatively low values of GFCF. Therefore, data from ESA2010 are considered valid to impute GFCF from ESA1995. The availability of ESA2010 data covers Ireland, France and Hungary, but there are no data for Spain and Cyprus.

After transforming GFCF into NUTS 2006, the missing values for a region r in Spain and Cyprus are imputed using the country GFCF from the national SAM, $GFCF_{Cr}$, weighted by the regional VA: $GFCF_r = GFCF_{Cr} \cdot \frac{VA_r}{VA_{Cr}}$

Imputing missing values in Household accounts

There are only three regions with missing values in HHp: the Italian ITH5, ITI3 and Malta and the same plus Cyprus in HHs. For the Italian regions, these are the only regions with missing values. Therefore, we first estimate the aggregated ITH5 + ITI3 as the difference between the country data and the sum of the remaining regions, then we split this amount between ITH5 and ITI3 using the weight of these regions in 2011 data from ESA1995. For Malta and Cyprus the country values from national SAMs are used.

2.3.3 Transformation between NUTS classifications

For the regional SAMs according to NUTS 2010 we use regional data from Eurostat. To build the regional SAMs according to NUTS 2006, regional data are transformed from NUTS 2010 to NUTS 2006, following the methodology described in López-Cobo (2016).

¹² The reference year for the RHOMOLO is 2010, therefore the data used was produced under the European System of Accounts 1995 (ESA95). Data according to ESA95 are not available anymore from Eurostat's website. The data used to that end corresponds to dataset *nama_10r_2gfcf*.

Notice that, when the regional classifications are amended, the time series are revised backwards and data according to the previous classification are not available anymore from the Eurostat's website. Due to this break in the series, if there is a need to use data according to an old version of the NUTS, a conversion procedure has to be applied. There are mainly three types of changes that affect data: regions can merge, split or change boundaries. Changes in region names or codes do not affect data integrity; this is the case of all Greek and some Italian regions. Figure 3 summarises the changes between NUTS 2006 and NUTS 2010 that need to be addressed. Table A. 3 in Annex shows the complete list of changes from NUTS 2006 to NUTS 2010 at NUTS-2 level.

Figure 3. Regions with changes between 2006 and 2010

Change from 2006 to 2010	NUTS 2006 code (old)	NUTS 2010 code (new)	Explanation (new = old)	Action to transform NUTS 2010 into NUTS 2006
Split	FI18	FI1B, FI1C	FI1B + FI1C = FI18, recalculation by NSI	Aggregate data
Merged	DE41, DE42	DE40	DE40 = DE41 + DE42	Disaggregate data using observed VA shares of regions existing in 2006 (using NUTS 3 level data)
	FI13, FI1A	FI1D	FI1D = FI13 + FI1A	
Boundary shift	DED1, DED3	DED4, DED5	recalculation by NSI	1. Aggregate data 2. Disaggregate data using estimated VA shares of regions existing in 2006 (using NUTS 3 level data)
	ITD5, ITE3	ITH5, ITI3		
	UKD2, KD5	UKD6, UKD7		

Source: López-Cobo, 2016.

A specific action is put in place to address each of the three types of changes described above. The procedure applied in each case differs, as does the accuracy of data obtained.

When a region splits into two regions, like is the case of FI18, which splits into FI1B and FI1C, the simple aggregation of data of these two NUTS 2010 regions provides the numbers corresponding to the original NUTS 2006 region. Whatever regional data we deal with, by aggregating we can reconstruct the original region data.

In the case of merged regions (for example the new FI1D in 2010 is the aggregation of FI13 and FI1A in 2006), we need to use more detailed information to estimate data for the two old regions. Here, value added data at NUTS 3 level are used to produce NUTS 2 level data. If the target data is VA, we can reproduce exactly the data according to the NUTS 2006 classification, but when trying to reproduce other variables such as COMP or GFCF we can only get an estimated value by applying regional shares of VA.

In the case of boundary shifts, there are two possibilities:

- a) first, cases in which the reproducibility of NUTS 2006 regions from NUTS 2010 cannot be reached despite the availability of NUTS 3 level data. This happens when at least one NUTS 3 region changed its boundaries between both classifications, capturing now part of the territory of another NUTS 3 region belonging to a different old NUTS 2 region. Therefore, since there is not full correspondence between NUTS 3 level regions of 2006 and 2010 versions of the classification, the old NUTS 2 region cannot be fully reproduced. Here we neglect the boundary shift and assume that data of the older region are approximately equal to data of the newer region.

- b) second, instances where the reproducibility depends on the availability of information at NUTS 3 level and the direction in which we want to make the transformation (i.e., from NUTS 2006 to NUTS 2010 or backwards). This is the case where an entire NUTS 3 region switches between two NUTS 2 regions but keeps its boundaries unchanged, only the boundaries of the NUTS 2 regions change. Still, there is not full correspondence at NUTS 3 level between classifications, since the transferred NUTS 3 region becomes only a part of an existing NUTS 3 region. Consequently, even if we had NUTS 3 level data for the NUTS 2010 regions, we would not be able to reconstruct the NUTS 2006 NUTS 2 regions. Here we estimate the amount of the new region due to the transferred NUTS 3 region and then use the VA shares obtained to estimate VA and other variables of the old NUTS 2006 region. On the contrary, if we were interested in the conversion in the other direction, from NUTS 2006 to NUTS 2010, we would be able to reconstruct entirely data for the NUTS 2 new regions using NUTS 3 level data of NUTS 2006 regions.

The computations carried out for the transformation of data for regions included in Figure 3 can be consulted in López-Cobo, 2016.

3. Methodology for regionalisation

The regionalisation of the national SAMs is based on a non-survey commodity-balance method. This method is the best suited among different non-survey techniques due to the indirect allocation of imports in the IOT produced by Eurostat. The indirect allocation of imports consists in their allocation as imports in the sector that produces similar goods, rather than to the sector that uses them (direct allocation) (Kronenberg, 2012).

The national SAMs are first aggregated from 59 to 5 sectors plus R&D. Then, a first estimate of regional SAMs is computed with the available information, including the R&D sector and making use of the cleaned and imputed regional data. Finally, bilateral trade-flows are adjusted to fit the regional supply-demand balance.

The methodology described in this section has been applied to the EU-28 countries. For Croatia, the method required some adaptations due to the specificities of the available data sources. For a description of the inter-regional trade data between Croatia and other EU regions, see sub-section 3.4.

3.1 Arranging the national SAMs

Aggregation into five macro-sectors

The symmetric IOT in the national SAM contains 59 homogenous sectors. However, regional data are only available at an aggregate level (six sectors available for all regions). As a consequence, national SAMs have to be aggregated before regionalisation. The consequences of the economic crisis on the construction sector investments in our baseline year (2010) make it advisable to aggregate it with the manufacturing sector to avoid distortions in model output (Mercenier et al., 2016).

Although an overall comparison between NACE Rev. 2 and NACE Rev. 1 is not possible, the aggregation into five macro-sectors minimises the impact of changes in the structure. Figure 4 shows the correspondence between the six macro sectors and the NACE codes for both Rev. 1 and Rev. 2, as well as with respect to the 59 sectors in the original national SAM.

Figure 4. RHOMOLO macro sectors

Sector acronym	Sector description	NACE Rev. 1 sections	NACE Rev. 2 sections	Sectors in national SAM
<i>Agricul</i>	Agriculture, hunting, forestry + Fishing	AB	A	1-3
<i>ManuCon</i>	Mining and quarrying + Manufacturing + Electricity and Gas	CDE	BCDE	4-33
	Construction	F	F	34
<i>TrTrade</i>	Wholesale and retail trade; repair of motor vehicles, motorcycles + Hotels and restaurants + Transport + Communications	GHI	GHIJ	35-43
<i>BusServ</i>	Financial intermediation + Real estate and business services (R&D)	JK	KLMN	44-51 (50)
<i>OthServ</i>	Non-Market Services	LMNOP	OPQRSTU	52-59

Source: Mercenier et al. (2016)

Correction of negative values in GFCF at aggregated level

The Use tables from WIOD contain negative values in gross fixed capital formation for some sectors in Denmark, Slovakia and United Kingdom. These hold after aggregation into the five RHOMOLO macro sectors in Denmark and Slovakia. The documentation of WIOD does not explain the origin of these negative values that could help fixing the issue. We have decided to set to 0 those which were still negative after aggregation and aggregate the difference to the column for stock variation, keeping this way total investments unchanged. This affects to the sector *Agricul* in Denmark and *OthServ* in Slovakia.

Trade and Transport Matrix account

The row TTM (Trade and transport margins) is aggregated into the row of intermediate uses of sector Trade and transport, *TrTrade*. In the national SAMs, the row for TTM had been previously modified as follows: the negative values in TTM showed in the columns of industries of the Trade and transport sector, *TrTrade*, TTM is set to 0. This does not create any imbalance in the SAMs, since this only happens in the diagonal.

3.2 First estimate of regional SAMs according to NUTS 2006

The estimation of regional SAMs consists of the estimation of several components of the matrix: intermediate demand; value added components and taxes; domestic final demand; foreign sector; transfers between agents. The R&D sector is introduced at regional level even if in RHOMOLO-v2 it is treated as national.

3.2.1 Value added and taxes

In a first step, the VA by sector is estimated using a bi-proportional RAS algorithm to match the data available by region and sector, as shown in Figure 5. The constraints are two: first, the sum by region – or sector marginal target – must coincide with country VA by sector (from the national SAM); second, the sum by sector – or region marginal target – is given by the estimation of the total regional VA as the product of country total VA (from the national SAM) multiplied by regional VA shares (from Eurostat regional data in Section 2.3). The prior matrix or seed used is the original regional VA data from Eurostat after treatment described in Section 2.3.

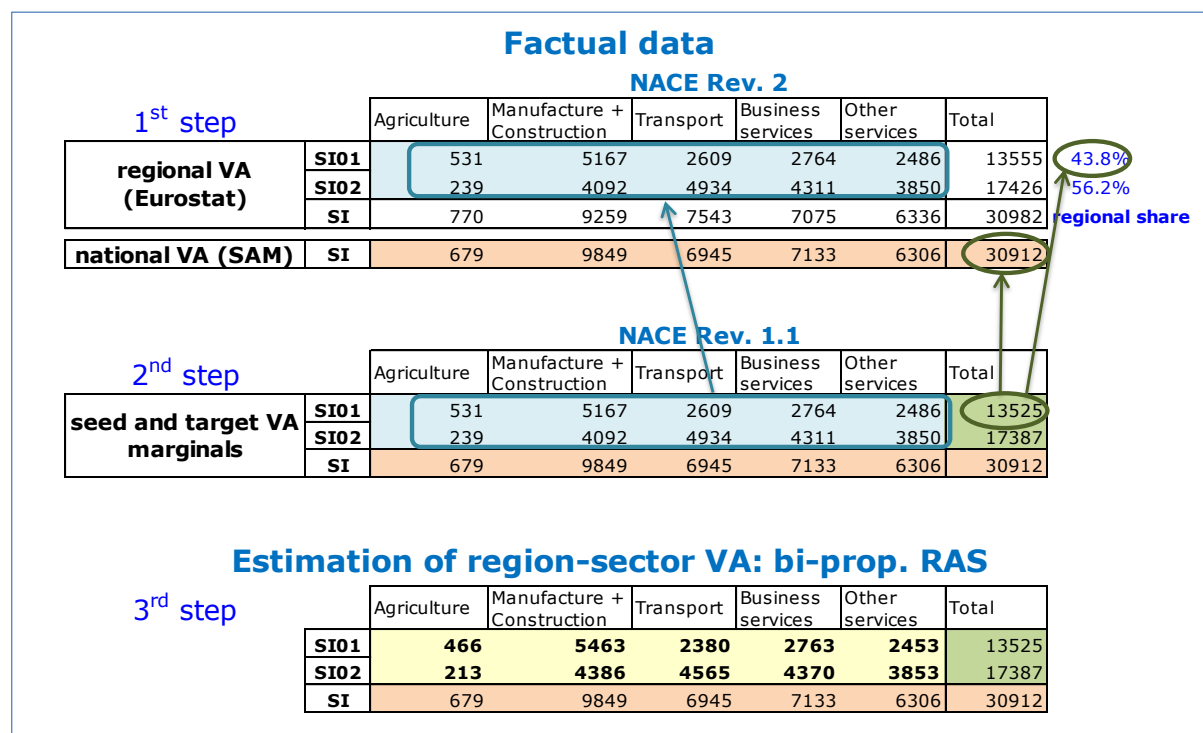
By imposing the national sectoral distribution from the national SAMs (NACE Rev. 1), the sectoral regional data, which are available by NACE Rev. 2 at aggregated macro-sector level, are re-weighted into the NACE Rev. 1 classification. The unavailability of more disaggregated sectoral data does not allow us to make a better transformation between the two sectoral classifications.

Secondly, the VA is decomposed in two stages into the components of VA in the SAMs, namely:

- Compensation of employees (COMP):
 - Wages and salaries (WS);
 - Employer's social contributions (SSCE).
- Gross operating surplus plus Other net taxes on production (GOS + NTP).

The same approach as the one used for estimating VA is applied to obtain regional estimates of Compensation of employees by sector. Residually we obtain $GOS + NTP = VA - COMP$. It is assumed that the regional VA composition maintains the national distribution, that is, the ratio between WS and SSCE over COMP is the same as in the national SAM, for each skill level: high, medium, and low. Similarly, the aggregated GOS + NTP is broken down into its two components.

Figure 5. Example of estimation of VA figures in Slovenian regions



Source: Own elaboration

This methodology results in negative values for GOS in Agriculture in two German regions, DE30 and DE42. This might be partly due to the imputation of DE42 data during the transformation procedure between NUTS classifications.¹³ A detailed analysis of the resulting values for VA, COMP and GOS+NTP shows extremely high labour shares over VA in these two regions, greater than 1, and hence the negative GOS + NTP, which are computed as residual. To fix this, we increase VA for these regions to set the labour share to 0.9. This threshold is chosen because it is close to the maximum shares below 1 observed in other German regions: 0.95 for DE50, 0.91 for DED1 and DEG0. In order to keep the region total unchanged, the same amounts are deducted from VA in sector Transport and Trade, which entails an insignificant decrease in this sector. On the other hand, to keep country totals by sector unchanged, the same amounts are deducted and added in sectors Agriculture and Transport and Trade respectively in region DE94. This region has been chosen for having the highest VA in Agriculture, hence the impact of the modification becomes not significant (Table A. 4 in Annex provides detailed information).

Net taxes on products are computed maintaining national ratios over total output. For the estimation of regional total output, we impose the assumption that the ratio VA/Output is constant across regions and equal to the ratio in the national SAM. For each region r (and corresponding country C_r) and sector s , we assume the following equality:

$$\frac{VA_{r,s}}{Z_{r,s}} = \frac{VA_{C_r,s}}{Z_{C_r,s}}$$

¹³ DE42 is one of the regions resulting from the split of DE40 into DE41 and DE42.

from which regional output, Z_{r,s_t} , is deducted.

3.2.2 Intermediate demand

For the estimation of regional intermediate input matrix, ID_r , national technical coefficients are applied. For each region r and sectors s_1 and s_2 , the ratio of intermediate demand of sector s_2 of products from sector s_1 over total output of sector s_2 is kept constant across regions and equal to the ratio in national SAM:

$$\frac{ID_{r,s_1,s_2}}{Z_{r,s_2}} = \frac{ID_{C_r,s_1,s_2}}{Z_{C_r,s_2}}$$

3.2.3 R&D sector

Regional R&D sector is implemented at the national level, though R&D services are consumed regionally. It uses only high-skill labour (WSh) and is demanded by all the other sectors as intermediate inputs. The R&D sector is isolated from the *Business Services* sector, where it is embedded in the national SAMs (Figure 4). First, the R&D sector is treated as any other sector, meaning that it contains data of all factors, taxes, trade, etc. In a second step, the R&D sector at the regional level is simplified to labour inputs only.

To regionalise the labour demand of the R&D sector, the national R&D high-skill labour factor is multiplied by the regional share of VA of sector *BusServ*:

$$WSh_{r,s=RnD} = WSh_{C_r,s=RnD} \frac{VA_{r,s=BusServ}}{VA_{C_r,s=BusServ}}$$

To regionalise the intermediate inputs of R&D by other industries, the former figure is distributed among sectors following the sectoral shares of intermediate use of R&D products at the national level.

$$ID_{r,s_1=RnD,s_2} = ID_{C_r,s_1=RnD,s_2} \frac{WSh_{r,s=RnD}}{WSh_{C_r,s=RnD}}$$

3.2.4 Domestic final demand and foreign sector

In order to estimate household demand, H , data on regional net disposable income, NDI_r , are used as a proxy of H . We assume that savings and the consumption behaviour of consumers within country follow the same pattern and are independent of income levels (that is, their preferences are considered homothetic as is the case in the model). More precisely, regional household demand, H_r , is obtained by multiplying national household demand by the regional share of NDI . Total household demand is then distributed among sectors using the structure observed at national level.

$$H_{r,s} = H_{C_r,s} \frac{NDI_r}{NDI_{C_r}}$$

Government demand, GOV , is estimated as a proportion of household demand: the ratio is assumed to be constant across regions and equal to the national ratio, in other words, country government demand is broken down by the share of regional household demand or regional NDI .

$$GOV_{r,s} = H_{r,s} \frac{GOV_{C_r,s}}{H_{C_r,s}} = GOV_{C_r,s} \frac{NDI_r}{NDI_{C_r}}$$

In order to estimate gross fixed capital formation, regional data on GFCF are used to produce regional estimates. As with value added and compensation of employees, where regional data from Eurostat are available, a bi-proportional RAS algorithm is applied to fulfil the constraints imposed by national sectoral data and regional shares.

Stock variations are estimated as a proportion of regional GFCF, we assume the ratio constant across regions and equal to the national ratio.

$$SV_{r,s} = SV_{C_r,s} \frac{GFCF_{r,s}}{GFCF_{C_r,s}}$$

In this first step, imports and exports are taken from Thissen et al. (2015).

3.2.5 Transfers

In order to estimate intra-region transfers among agents, regional data from Eurostat are used (PI, DTX, WFB...) in the form of regional shares applied to national values. Inter-regional transfers are considered negligible and therefore not included in the database.

Transfers from/to EU and ROW are estimated as follows. For the compensation of employees (WS, SSCE), payments from the foreign sector are assumed to have the same ratio as domestic payments observed at the national level. For the transfers received by the foreign sector, first, column totals for WS and SSCE are computed (from the previous step), and then distributed among agents -HH, GOV, EU and ROW- according to national shares. A similar approach is used for SSCHSU (Social contributions), PI (Property income), DTX (Current taxes on income, wealth, etc.), TR (Other current transfers), NTP (Other net taxes on production), NTPR (Net taxes on products) and WFB (Social benefits other than social transfers in kind).

3.3 Re-estimation of inter-regional bilateral trade flows according to NUTS 2006

The regional SAMs built with this methodology add up to the national SAM. Some balancing is nevertheless necessary, because each individual regional SAM may be unbalanced, with excess supply from one region being compensated by excess demand in another region of the same country. The assumption is made that inter-regional trade flows need to be re-adjusted. An algorithm is used to redistribute trade among the regions for the three flow types: within the country¹⁴, with the rest of EU¹⁵ and with the rest of the world, meeting the constraints:

- keeping country totals by flow type unchanged;
- imports and exports inside EU must be positive for all combinations sector-region1-region2;
- for two-region countries, Ireland and Slovenia, the trade flows also need to satisfy that imports (exports) within the country of one region equal exports (imports) within the country of the other region;
- the domestic part of absorption, or the diagonal elements of the bilateral trade matrix, is always positive so as to avoid inflating re-exports.¹⁶

Once the aggregated trade flows by type are adjusted, a new bilateral trade flows matrix is built.

3.3.1 Re-estimation of trade flows by type

The algorithm aims to estimate, for each region and sector, the aggregated imports and the aggregated exports from and to the rest of the country (Imp_{wthn} , Exp_{wthn}),

¹⁴ Trade within the country is defined as trade with other regions in the same country, but outside the region itself.

¹⁵ Trade with the rest of the EU is meant to represent only international trade, thus excluding trade within the country.

¹⁶ Re-exports are goods that are imported by and exported from a region, without any transformation or added value in the process.

the rest of the EU (Imp_{EU}, Exp_{EU}) and the rest of the world (Imp_{ROW}, Exp_{ROW}). It is an iterative process composed by the following steps, repeated until all the constraints are met. We denote the imports by flow type as: Imp_{type} and Exp_{type} , where $type$ is one of the following: $Wthn, EU, ROW$.

i. Non-positive domestic component of absorption: Z-Export ≤ 0

The domestic component of absorption is defined as the amount of goods and services produced and consumed locally: $Z - Export$, where Z is total output and $Export$ equals total exports. If a region r_1 has $Z_{r_1} - Export_{r_1} \leq 0$, then exports need to be reduced. The amount to be reduced is:

$$reduceExp_{r_1} = -(Z_{r_1} - Export_{r_1}) + x_{r_1}, \text{ where } x_{r_1} \in (0, Z_{r_1}).$$

Our choice is $x_{r_1} = 0.1 \cdot Z_{r_1}$, which leaves us with:

$$reduceExp_{r_1} = Export_{r_1} - 0.9 \cdot Z_{r_1}$$

This way, the amount of domestic component of absorption will be at least 10% of total output.

The reduction of the amount $reduceExp_{r_1}$ is spread among flow types according to their weights into total exports:

$$weightExp_{type,r_1} = \frac{Exp_{type,r_1}}{Export_{r_1}}$$

According to this, the new exports would be:

$$\widehat{Exp}_{type,r_1} = Exp_{type,r_1} - reduceExp_{r_1} \cdot weightExp_{type,r_1}$$

This reduction is compensated by an equivalent increase in the remainder regions of the country, $r_j \in \{C_r - r_1\}$, (to keep country total exports unchanged) which have non-negative Supply-Demand (S-D) balance¹⁷. To spread the effect among regions, they are weighted according to their positive S-D imbalance or their total Exports value (when S-D is zero):

$$Exp_{type,r \in \{C_r - r_1\}} = Exp_{type} - reduceExp \cdot weightExp_{type}$$

$$\widehat{Exp}_{type,r_j} = Exp_{type,r_j} + reduceExp_{type,r_1} \cdot \frac{S_{r_j} - D_{r_j}}{\sum_{r_j} (S_{r_j} - D_{r_j})}, \forall r_j \in \{C_r - r_1\} \text{ with } S_{r_j} - D_{r_j} \geq 0$$

ii. Supply-Demand imbalance: S-D $\neq 0$

In order to balance S-D in both Imp_{type} and Exp_{type} , weighting the burden in each component depending on their value (the bigger the trade flow, the bigger the impact they can absorb), the imputation rule used for countries with more than one region is the following:

$$\widehat{Imp}_{type,r} = Imp_{type,r} + weightImp_{type,r} \cdot \delta_{Imp,r}$$

$$\widehat{Exp}_{type,r} = Exp_{type,r} + weightExp_{type,r} \cdot \delta_{Exp,r}$$

where:

¹⁷ Exports are not increased in regions with negative S-D imbalance to avoid inflating it.

$$weightImp_{type,r} = \frac{Imp_{type,r}}{Import_r}$$

$$weightExp_{type,r} = \frac{Exp_{type,r}}{Export_r}$$

$$\delta_{Imp,r} = -\tilde{w}_{Imp,r} \cdot (S_r - D_r)$$

$$\delta_{Exp,r} = (1 - \tilde{w}_{Imp,r}) \cdot (S_r - D_r)$$

$$w_{Imp,r} = \frac{Import_r}{Import_r + Export_r}$$

if $S_r - D_r > 0$:

$$w_{SD,r} = 0.9 \cdot \frac{Import_r}{S_r - D_r}$$

$$\tilde{w}_{Imp,r} = \min\left(\max\left(w_{Imp,r}, 1 - 0.9 \cdot \frac{Z_r - Exp_r}{S_r - D_r}\right), w_{SD,r}\right)$$

if $S_r - D_r < 0$:

$$w_{SD,r} = -0.9 \cdot \frac{Export_r}{S_r - D_r}$$

$$\tilde{w}_{Imp,r} = 1 - \min(1 - w_{Imp,r}, w_{SD,r})$$

The introduction of w_{SD} is made to avoid getting negative imports or exports. Therefore the reduction is limited by its possible maximum (decreased by 10%), the maximum being total imports or exports (depending on the sign of S-D).

With these weights, if S-D > 0, imports decrease and exports increase. if S-D < 0, imports increase and exports decrease.

This step solves the imbalances, but country totals may have been altered.

iii. Rebalance keeping Country Totals

Here the idea is to rescale the trade flows obtained to the actual country totals. This is needed because the previous steps have altered the original correct values of imports and exports by flow type. If we use O to denote original correct values and C for current values after steps i and ii, we compute:

$$\widehat{Imp}_{EU,r} = Imp_{EU,r}^c \frac{Imp_{EU,C_r}^o}{Imp_{EU,C_r}^c}$$

$$\widehat{Imp}_{ROW,r} = Imp_{ROW,r}^c \frac{Imp_{ROW,C_r}^o}{Imp_{ROW,C_r}^c}$$

$$\widehat{Exp}_{EU,r} = Exp_{EU,r}^c \frac{Exp_{EU,C_r}^o}{Exp_{EU,C_r}^c}$$

$$\widehat{Exp}_{ROW,r} = Exp_{ROW,r}^c \frac{Exp_{ROW,C_r}^o}{Exp_{ROW,C_r}^c}$$

$$\widehat{Imp}_{Wthn,r} = Imp_{Wthn,r}^c \frac{\sum_{type} Imp_{type,C_r}^o - Imp_{EU,C_r}^c - Imp_{ROW,C_r}^c}{Imp_{Wthn,C_r}^c}$$

$$\widehat{Exp}_{Wthn,r} = Exp_{Wthn,r}^c \frac{\sum_{type} Exp_{type,C_r}^o - Exp_{EU,C_r}^c - Exp_{ROW,C_r}^c}{Exp_{Wthn,C_r}^c}$$

iv. If new imbalances arise, they are small: apply algorithm ii on intra-country trade only

As the new imbalances created by step iii are small, they can be solved on Imp_{Wthn} and Exp_{Wthn} with only slight changes in the trade flows structure:

$$\widehat{Imp}_{Wthn,r} = Imp_{Wthn,r} - \tilde{w}_{Imp_{Wthn,r}} \cdot (S_r - D_r)$$

$$\widehat{Exp}_{Wthn,r} = Exp_{Wthn,r} + (1 - \tilde{w}_{Imp_{Wthn,r}}) \cdot (S_r - D_r)$$

Where:

$$w_{Imp_{Wthn,r}} = \frac{Imp_{Wthn,r}}{Imp_{Wthn,r} + Exp_{Wthn,r}}$$

if $S_r - D_r > 0$:

$$w_{SD_{Wthn,r}} = 0.9 \cdot \frac{Imp_{Wthn,r}}{S_r - D_r}$$

$$\tilde{w}_{Imp_{Wthn,r}} = \min(w_{Imp_{Wthn,r}}, w_{SD_{Wthn,r}})$$

if $S_r - D_r < 0$:

$$w_{SD_{Wthn,r}} = -0.9 \cdot \frac{Exp_{Wthn,r}}{S_r - D_r}$$

$$\tilde{w}_{Imp_{Wthn,r}} = 1 - \min(1 - w_{Imp_{Wthn,r}}, w_{SD_{Wthn,r}})$$

Steps i to iv are repeated if needed until the constraints are met.

v. Zero imports or exports

The original inter-regional trade matrix included zero imports or exports at aggregated level in some regions, for example, no imports at all within the country ($Imp_{Wthn} = 0$), no exports with other EU regions ($Exp_{EU} = 0$). As we understand this as a flaw of the data, we re-impute values in those cases, to have positive values of imports and exports for each type of flow in each region.

In the case of trade within the country for a region r_1 , imports and exports are increased by 10% of the difference between total output and total exports.

$$\widehat{Imp}_{Wthn,r_1} = Imp_{Wthn,r_1} + 0.1 \cdot (Z_{r_1} - Export_{r_1})$$

$$\widehat{Exp}_{Wthn,r_1} = Exp_{Wthn,r_1} + 0.1 \cdot (Z_{r_1} - Export_{r_1})$$

In the case of trade with the rest of EU, that is at least Imp_{EU} or Exp_{EU} are zero, imports and exports of region r_1 are increased by 10% of Z-Export, limited by a total amount per region, computed as 90% of the maximum amount a country could absorb, weighted by the sum of imports and exports to the EU in the region:

$$\widehat{Imp}_{EU,r_1} = Imp_{EU,r_1} + increase_{r_1}$$

$$\widehat{Exp}_{EU,r_1} = Exp_{EU,r_1} + increase_{r_1}$$

where:

$absorb_{r_1} = \min(Imp_{EU,r_1}, Exp_{EU,r_1})$ represents the maximum the region r_1 may absorb,

$absorb_{C_{r_1}} = \sum_{r \in C_{r_1}} absorb_r$ is the maximum the country of region r_1 may absorb,

$$increase_{r_1} = \min(0.9 \cdot absorb_{C_{r_1}} \cdot \frac{Imp_{EU,r_1} + Exp_{EU,r_1}}{Imp_{EU,\widetilde{C}_{r_1}} + Exp_{EU,\widetilde{C}_{r_1}}}, 0.01 \cdot (Z_{r_1} - Export_{r_1}))$$

Where $Imp_{EU,\widetilde{C}_{r_1}} + Exp_{EU,\widetilde{C}_{r_1}}$ represents the sum of imports and exports to the EU for the regions in the country where at list Imp_{EU} or Exp_{EU} are zero.

Then imports and exports in the remainder regions, $r_j \in \{C_{r_1} - r_1\}$, are reduced by the same amount that has been increased, so that country totals are kept unchanged. Regions are weighted by the amount they are able to absorb, computed as the minimum between Imp_{EU} and Exp_{EU} :

$$\widehat{Imp}_{EU,r_j} = Imp_{EU,r_j} - increase_{\widetilde{C}_{r_1}} \cdot \frac{absorb_{r_j}}{absorb_{C_{r_j}}}$$

$$\widehat{Exp}_{EU,r_j} = Exp_{EU,r_j} + increase_{\widetilde{C}_{r_1}} \cdot \frac{absorb_{r_j}}{absorb_{C_{r_j}}}$$

Where $increase_{\widetilde{C}_{r_1}}$ refers to the sum of the total amount increased in the regions $r \in \{C_{r_1}\}$ for which $Imp_{EU,r}$ or $Exp_{EU,r}$ are zero.

vi. Special case: zero trade with the EU for OthServ in Romania

In Romania the sector *Other services* happens not to have trade at all with the rest of the EU for the whole country. We cannot apply the same algorithm described above, since this would mean to increase imports and exports in all regions, and therefore there would not be any region to compensate the increase. Here we develop a specific procedure consisting on adding a small amount (0.01) to both Imp_{EU} and Exp_{EU} in each Romanian region. We have to take into account that this affects the balance of other countries' Imp_{EU} and Exp_{EU} , which would need to be increased by the same amounts to make them consistent with this increase in trade between Romania and the rest of the EU. This 0.08 (Romania has eight regions) has to be distributed among other countries' Imp_{EU} and Exp_{EU} , assigning the same amount to each region: $0.08/259$. Hence, in each of the remaining 259 regions, Imp_{EU} and Exp_{EU} is increased by $0.08/259$ and the same amount is deducted from Imp_{ROW} and Exp_{ROW} respectively, to keep the SAMs balanced. If Imp_{ROW} is zero in some regions, the amount is deducted from Imp_{Wthn} and compensated in other regions of the country to keep intra-country trade constant. Exp_{ROW} is treated in the same way. This latter happens in two Spanish regions, ES63, ES64 (compensated in ES51), in one region in Finland, FI20 (compensated in FI19), France, FR83 (compensated in FR22) and Italy, ITC2 (compensated in ITC4).

The national SAMs are updated accordingly, adding $0.08/259$ multiplied by the number of regions to total Imp_{EU} and total Exp_{EU} . The same amount is deducted from Imp_{ROW} and Exp_{ROW} respectively, to keep the SAMs balanced.

The resulting balanced trade flows, per flow type, also meet the following conditions: a) sum across countries of Imp_{EU} equals sum across countries of Exp_{EU} ; b) sum across regions in a country of Imp_{Wthn} equals sum across regions in a country of Exp_{Wthn} for all countries and sectors.

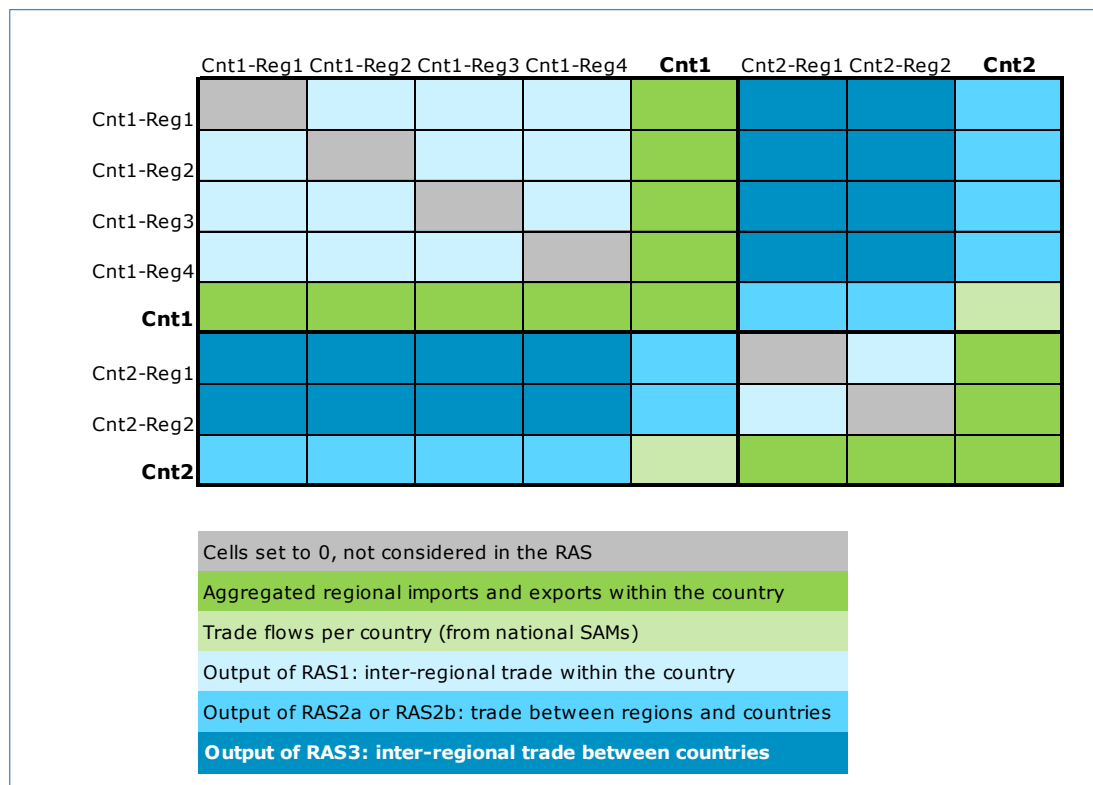
3.3.2 Re-estimate the bilateral trade flows matrix

We have to re-estimate a new bilateral trade matrix consistent with the trade flows by flow type estimated in the previous sub-section. We do that by applying three successive bi-proportional RAS. The input data we need are:

- Aggregated regional imports and exports within the country: trade totals by flow type and sector as estimated in sub-section 3.3.1 (dark green cells in Figure 6).
- Trade flows per country from the national SAMs (light green cells).
- A bilateral matrix of trade and transport cost rates in the Manufacturing and Construction sector, $TCRates$, used as basis for the bilateral trade flows seed. This matrix is derived from the TRANSTOOLS model, the transport cost rate between two regions is correlated with the distance between them. The values of the rates are between 0.00797 and 0.30339; the closer the regions, the lower the TC rate. The data actually used as a seed is $TCRates_{inverted} = \frac{1}{1 + TCRates}$, which ranges from 0.7672301 and 0.9920930; the closer the regions, the higher the TC inverted.

Figure 6 presents the scheme followed to re-estimate the bilateral trade flows matrix using the available information. It shows the procedure for two countries, Cnt1 and Cnt2, with four and two regions respectively: Cnt1-Reg1 to Cnt1-Reg4 and Cnt2-Reg1 to Cnt2-Reg2.

Figure 6. Scheme for the RAS procedures to obtain the inter-regional trade flows matrix



Source: Own elaboration

i. RAS1: Inter-regional trade within the country

Figure 7. RAS1: inter-regional trade within the country

RAS1	Cnt1-Reg1	Cnt1-Reg2	Cnt1-Reg3	Cnt1-Reg4	ExpWthn
Cnt1-Reg1	0				
Cnt1-Reg2		0			
Cnt1-Reg3			0		
Cnt1-Reg4				0	
ImpWthn					

Cells set to 0, not considered in the RAS
Aggregated regional imports and exports within the country
Output of RAS1: inter-regional trade within the country

Source: Own elaboration

This RAS is country and sector specific and then looped over sector and country: 5 x 27 times.

Seed (size: $numregTot \times numregTot$): BiTrade_seed. The objective is to produce a bilateral trade flows matrix that considers two data features: a) the distance between regions; b) the amount of trade between them. The distance between region r1 and region r2 would makes exports from r1 to r2 to be low, but if r2 imports more than other regions, then this would make exports from r1 to r2 higher than exports to other destinations. We capture this twofold relationship by multiplying each column of the matrix TCRates_inverted ($1/(1+TCRates)$) by the amount of total imports of the region of destination. The cells of the diagonal are set to 0, so that they are not modified by the RAS (grey cells). They will be later substituted by their actual values: domestic component of absorption or the difference between total output and total exports.

Target row ($1 \times numregCnt1$): Imp_{Wthn} . Total imports of each region from the rest of the country.

Target column ($numregCnt1 \times 1$): Exp_{Wthn} . Total exports from each region to the rest of the country.

The output of this procedure gives us, for each sector and country, the inter-regional trade within the country (light blue cells in Figure 7).

ii. RAS2: Trade between regions and countries

a) Exports from regions to EU countries

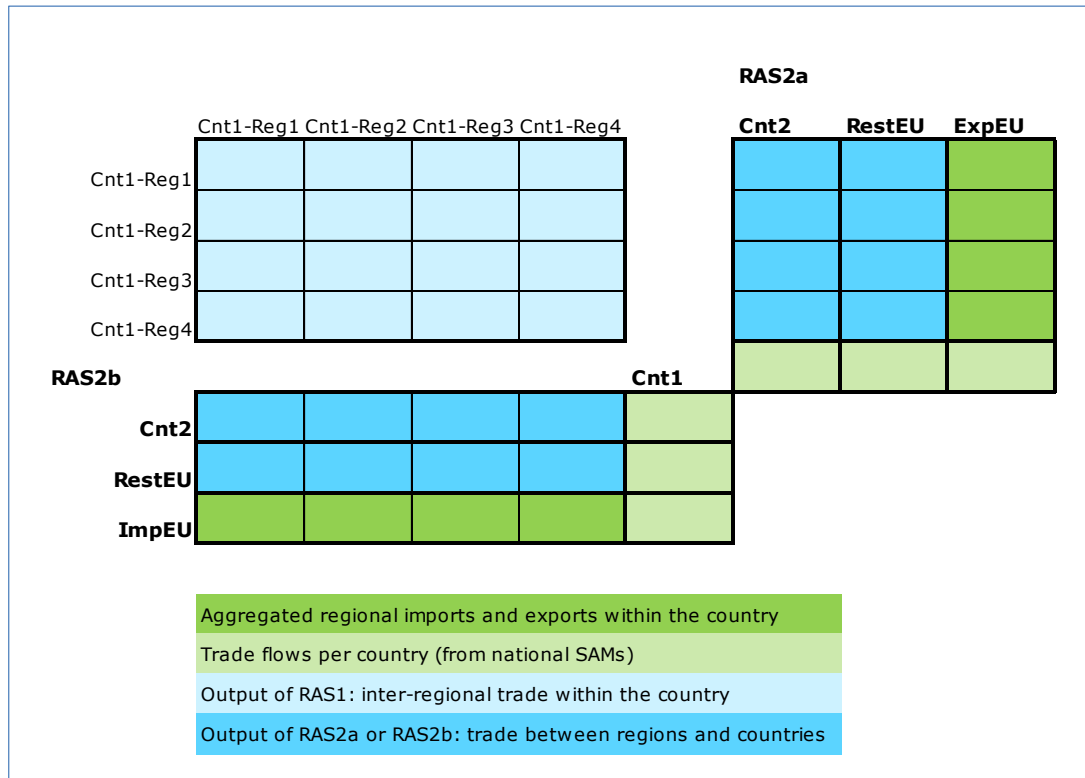
This RAS2a is looped over sector and country of origin: 5 x 27 times.

Seed ($numregCnt1 \times numCnt$): BiTrade_seed, the same as in RAS1, aggregated by country of destination.

Target row (1 x numCnt): Exports of Cnt1 to the other 26 EU countries. This information is taken from the bilateral trade flows at country level developed for the creation of the national SAMs from WIOD, Álvarez-Martínez and López-Cobo (2016) (light green cells in Figure 8, RAS2a).

Target column (numregCnt1 x 1): ExpEU of each region of Cnt1, as estimated in sub-section 3.3.1 (dark green cells in Figure 8, RAS2a).

Figure 8. RAS2a and RAS2b: trade between regions and countries



Source: Own elaboration

b) Imports of regions from EU countries

Similarly, this RAS2b is looped over sector and country of origin: 5 x 27 times.

Seed (numCnt x numregCnt1): BiTrade_seed aggregated by country of origin.

Target row (1 x numregCnt1): Imp_{EU} of each region of Cnt1, as estimated in sub-section 3.3.1. (dark green cells in Figure 8, RAS2b).

Target column (numCnt x 1): Imports of Cnt1 from the other 26 EU countries. This information is taken, as above, from the bilateral trade flows at country level (light green cells in Figure 8, RAS2b).

The output of this procedure gives us, for each sector and country, the trade between its regions and other EU countries (medium blue cells in Figure 8).

iii. RAS3: Inter-regional trade between countries

In this case the procedure is specific for each pair country of origin (Cnt1) – country of destination (Cnt2), looped 27 x 27 times.

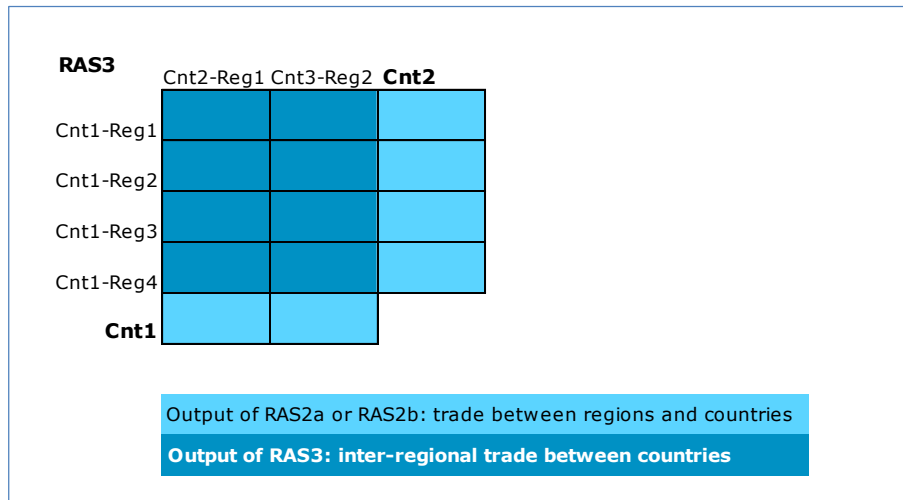
Seed (numregCnt1 x numregCnt2): BiTrade_seed, the same as in RAS1.

Target row (1 x numregCnt2): Exports from Cnt1 to each region in Cnt2. This is the output of RAS2b.

Target column ($numregCnt1 \times 1$): Exports from each region in Cnt1 to Cnt2. This is the output of RAS2a.

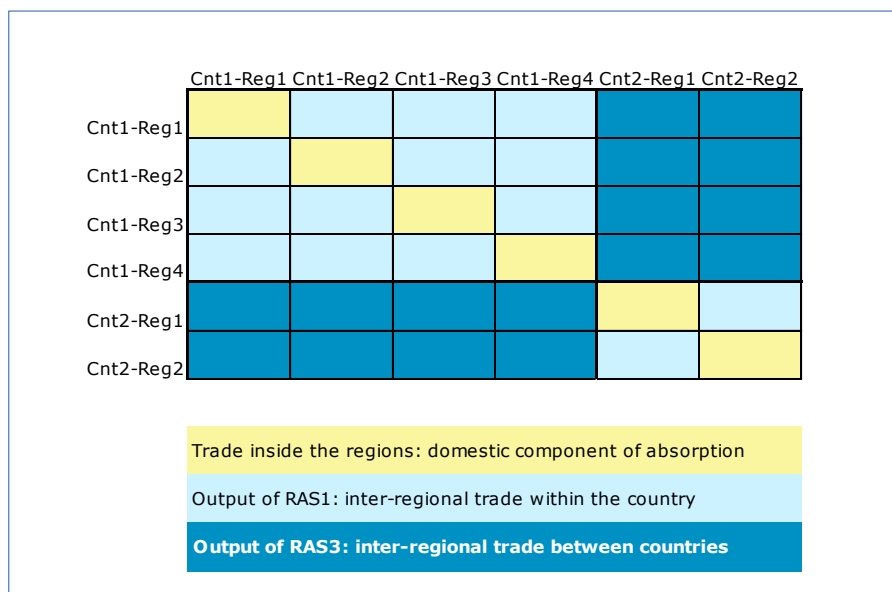
The output of this procedure gives us, for each sector and pair Cnt1-Cnt2, the trade between regions in Cnt1 and regions in Cnt2 (dark blue cells in Figure 9).

Figure 9. RAS3: inter-regional trade between countries



Source: Own elaboration

Figure 10. Re-estimated inter-regional trade flows



Source: Own elaboration

Now, with the output from RAS1 and the output from RAS3 we can assemble the inter-regional bilateral trade matrix. The diagonal cells (yellow cells in Figure 10), which were set to 0 before, are taken from the regional SAMs. Each diagonal cell in the bilateral trade matrix shows the trade inside one region, in other words, the amount of products and services produced and consumed inside the region. Therefore, for the diagonal of the bilateral trade matrix we use the domestic component of absorption, computed as output (Z) minus total exports: $Z - Exp$. The

inter-regional trade flows matrix built is consistent with the balanced regional SAMs constructed so far. Hence, we have created a set of balanced regional Social Accounting Matrices under the NUTS 2006 classification.

3.4 SAMs according to NUTS 2010

In order to construct a set of SAMs according to the NUTS 2010, we need to transform two of the data sources from NUTS 2006, that is, inter-regional trade matrix and the inter-regional transport cost rates matrix or TCRates matrix used also at a later stage in the model. In addition, Croatia needs to be included in both matrices.

3.4.1 Conversion of inter-regional bilateral trade flows

For the inter-regional trade matrix we have followed the methodology described in López-Cobo (2016) with minor adaptations. For most of the cells data are the same, only the cells corresponding to regions affected by changes need recalculation. This includes trade between regions in Figure 3 and the remaining regions, as well as intra-region trade of the former. Also trade between Croatian regions and the rest needs to be computed.

Trade involving regions which were merged between NUTS 2006 and NUTS 2010 only need to be added up to get the trade with the new merged region. Trade involving regions which were split is broken down using the shares of GVA. This adjustment involves FI18 which was split into FI1B and FI1C. Trade involving regions which shifted boundaries are first added up and then broken down using the shares of GVA of the former regions. This change affects regions DED1 and DED3, which became DED4 and DED5 respectively.

There are two cases that deserve special attention. First, the trade flows between DED4 and DED5. Second the trade flows between FI1B and FI1C. Both cases are tackled through a RAS procedure. For the German regions, the seed is the intra-country trade between the old DED1 and DED3 regions. The target column, that is the exports from each region to the aggregated DED4 + DED5, is given by the sum of exports from DED1 + DED3 to DED1 + DED3, weighted by the GVA share of each region DED4 and DED5. These weights are adjusted to reflect the openness of the regional economies to account for the fact that the shares of GVA do not coincide with the shares of exports from these regions. For example, if the GVA share of DED1 over DED1 + DED3 in Agriculture is 0.541 and its share in terms of total exports to DED1 + DED3 is 0.515, then we compute the ratio of Exports share / GVA share, 0.953. This ratio is multiplied by the share of DED4 over DED4 + DED5 in Agriculture (0.584) to get the adjusted weight of 0.557. The target row, or imports from DED4 + DED5, is set equal to exports to DED4 + DED5. To compute the intra-country trade between FI1B and FI1C we follow a similar approach, simplified by the fact that the GVA weights are not adjusted because there is no way to disentangle the openness of the economy of the former region FI18 into the new regions' openness.

3.4.2 Conversion of inter-regional transport cost rates matrix

For the inter-regional transport cost matrix or TCRates matrix, the underlying idea is that new regions created by splitting or shifting boundaries of former regions share the same values as their predecessors – if the transport cost between regions A and B is 0.18, then the transport cost rate between A and B' is kept equal. In the case of regions which are the consequence of the merging of two former regions, the new transport cost rate is computed as their arithmetic mean.

Transport costs for the Croatian regions are equal to those of the Slovenian regions. Slovenia has been chosen as a source due to its geographical proximity to Croatia and the circumstance of being composed by two regions, as Croatia.

3.4.3 Inter-regional trade with Croatian regions

To estimate inter-regional trade with Croatian regions we make use of the following information: trade between Croatia and the EU27 member states; GVA regional shares for Croatia; imports and exports from/to EU for all other 266 regions.

First, Croatian imports from a country, say Belgium, are broken down by Belgian regions using the shares of Belgian regions exports to the EU. For example if a Belgian region exports 20% of total EU exports in Belgium, the same proportion is used with respect exports to Croatia. Second, the GVA regional shares of Croatia are applied to split the imports between the two Croatian regions. Similarly, we estimate exports from Croatian regions to the remaining 266 EU regions. The amounts estimated are then deducted from the trade between the 266 regions and the rest of the world.

4. Conclusion

This technical report describes the methodology designed and followed to produce two sets of Regional Social Accounting Matrices for the EU27 and EU28. Although they have been tailored to be used as an input for RHOMOLO-v2, they still constitute unique and consistent data sources per se for regional economic modelling that can be used by other researchers as well. The inclusion of Croatia and the conversion of the previous database into the NUTS 2010 classification are additional valuable characteristics.

All the steps taken to produce the dataset and the choices to be made to resolve inconsistencies are discussed in detail to allow the reader to fully grasp the complexity of the exercise and the reasoning behind each part of the dataset. The only parts of the dataset not described in full are those derived from external sources, such as the inter-regional trade matrix, whose documentation can be found in Thissen et al. (2015) and the interregional transport cost matrix, derived from the TRANSTOOLS.¹⁸

¹⁸ <http://energy.jrc.ec.europa.eu/transtools/documentation.html>

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Annex

Table A. 1 Accounts in the national SAMs for EU-27 in 2010

Acronym	Name
Industries (59)	
I1-I59	59 industries / products (see Error! Reference source not found.)
Primary Factors (4)	
WS_h	Gross wages and salaries (high skill)
WS_m	Gross wages and salaries (medium skill)
WS_l	Gross wages and salaries (low skill)
GOS	Gross operating surplus / Gross mixed income
Auxiliary Accounts (12)	
SCE_h	Employers' social contributions (high skill)
SCE_m	Employers' social contributions (medium skill)
SCE_l	Employers' social contributions (low skill)
SCHSU	Social contributions paid by employees, self-employed and unemployed
NTP	Other net taxes on production
NTPR	Net taxes on products
PI	Property income
DTX	Current taxes on income, wealth, etc.
TR	Other current transfers (which include unemployment benefits)
AJ	Adjustment for the change in net equity of households in pension funds reserves
WFB	Social benefits other than social transfers in kind
SA	Gross savings
Agents (10)*	
H	Households and Non-Profit Institutions Serving Households
CORP	Corporate sector
GOV	Government
EU	European Union
ROW	Rest of the world
*	
GFCF	Gross fixed capital formation
SV	Stock variations
TTM	Trade and transport margins
REX	Re-exports
ITM	International trade margins
* Other accounts that are not agents in the economy are also included in these sub-matrices. Source: own elaboration	

Table A. 2 Productive sectors in the national SAMs for EU-27 in 2010

SAMs	CPA	Name
I1	1	Agriculture, hunting and related service activities
I2	2	Forestry, logging and related service activities
I3	5	Fishing, operating of fish hatcheries and fish farms; service activities incidental to fishing
I4	10	Mining of coal and lignite; extraction of peat
I5	11	Extraction of crude petroleum and natural gas; service activities incidental to oil and gas extraction excluding surveying
I6	12	Mining of uranium and thorium ores
I7	13	Mining of metal ores
I8	14	Other mining and quarrying
I9	15	Manufacture of food products and beverages
I10	16	Manufacture of tobacco products
I11	17	Manufacture of textiles
I12	18	Manufacture of wearing apparel; dressing and dyeing of fur
I13	19	Tanning and dressing of leather; manufacture of luggage, handbags, saddlery, harness and footwear
I14	20	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
I15	21	Manufacture of pulp, paper and paper products
I16	22	Publishing, printing and reproduction of recorded media
I17	23	Manufacture of coke, refined petroleum products and nuclear fuels
I18	24	Manufacture of chemicals and chemical products
I19	25	Manufacture of rubber and plastic products
I20	26	Manufacture of other non-metallic mineral products
I21	27	Manufacture of basic metals
I22	28	Manufacture of fabricated metal products, except machinery and equipment
I23	29	Manufacture of machinery and equipment n.e.c.
I24	30	Manufacture of office machinery and computers
I25	31	Manufacture of electrical machinery and apparatus n.e.c.
I26	32	Manufacture of radio, television and communication equipment and apparatus
I27	33	Manufacture of medical, precision and optical instruments, watches and clocks
I28	34	Manufacture of motor vehicles, trailers and semi-trailers
I29	35	Manufacture of other transport equipment
I30	36	Manufacture of furniture; manufacturing n.e.c.
I31	37	Recycling
I32	40	Electricity, gas, steam and hot water supply
I33	41	Collection, purification and distribution of water
I34	45	Construction
I35	50	Sale, maintenance and repair of motor vehicles and motorcycles; retail sale services of automotive fuel
I36	51	Wholesale trade and commission trade, except of motor vehicles and motorcycles

I37	52	Retail trade, except of motor vehicles and motorcycles; repair of personal and household goods
I38	55	Hotels and restaurants
I39	60	Land transport; transport via pipelines
I40	61	Water transport
I41	62	Air transport
I42	63	Supporting and auxiliary transport activities; activities of travel agencies
I43	64	Post and telecommunications
I44	65	Financial intermediation, except insurance and pension funding
I45	66	Insurance and pension funding, except compulsory social security
I46	67	Activities auxiliary to financial intermediates
I47	70	Real estate activities
I48	71	Renting of machinery and equipment without operator and of personal and household goods
I49	72	Computer and related activities
I50	73	Research and development
I51	74	Other business activities
I52	75	Public administration and defence; compulsory social security
I53	80	Education
I54	85	Health and social work
I55	90	Sewage and refuse disposal, sanitation and similar activities
I56	91	Activities of membership organisation n.e.c.
I57	92	Recreational, cultural and sporting activities
I58	93	Other service activities
I59	95	Private households with employed persons

Source: WIOD.

Table A. 3 Changes from NUTS 2006 to NUTS 2010 at NUTS-2 level

Code 2006	Code 2010	Label	Change	Explanation (new = old)
DE41	DE40 (part)	Brandenburg - Nordost	Merged	
DE42	DE40 (part)	Brandenburg - Südwest	Merged	
	DE40	Brandenburg	New region	DE40 = DE41 + DE42
DED1		Chemnitz	Boundary shift	
	DED4	Chemnitz	New region	recalculation by NSI
DED3		Leipzig	Boundary shift	
	DED5	Leipzig	New region	recalculation by NSI
GR11	EL11	Ανατολική Μακεδονία, Θράκη	Code change	EL11 = GR11
GR12	EL12	Κεντρική Μακεδονία	Code change	EL12 = GR12
GR13	EL13	Δυτική Μακεδονία	Code change	EL13 = GR13
GR14	EL14	Θεσσαλία	Code change	EL14 = GR14
GR21	EL21	Ήπειρος	Code change	EL21 = GR21
GR22	EL22	Ιόνια Νησιά	Code change	EL22 = GR22
GR23	EL23	Δυτική Ελλάδα	Code change	EL23 = GR23
GR24	EL24	Στερεά Ελλάδα	Code change	EL24 = GR24
GR25	EL25	Πελοπόννησος	Code change	EL25 = GR25
GR30	EL30	Αττική	Code change	EL30 = GR30
GR41	EL41	Βόρειο Αιγαίο	Code change	EL41 = GR41
GR42	EL42	Νότιο Αιγαίο	Code change	EL42 = GR42
GR43	EL43	Κρήτη	Code change	EL43 = GR43
GRZZ	ELZZ	Extra-Regio NUTS 2	Code change, label change	ELZZ = GRZZ
ITD1	ITH1	Provincia Autonoma di Bolzano/Bozen	Code change, label change	ITH1 = ITD1
ITD2	ITH2	Provincia Autonoma di Trento	Code change, label change	ITH2 = ITD2
ITD3	ITH3	Veneto	Code change	ITH3 = ITD3
ITD4	ITH4	Friuli-Venezia Giulia	Code change	ITH4 = ITD4
ITE4	ITI4	Lazio	Code change	ITI4 = ITE4
ITE1	ITI1	Toscana	Code change	ITI1 = ITE1
ITE2	ITI2	Umbria	Code change	ITI2 = ITE2
ITD5		Emilia-Romagna	Boundary shift	
	ITH5	Emilia-Romagna	New region	recalculation by NSI
ITE3		Marche	Boundary shift	
	ITI3	Marche	New region	recalculation by NSI
FI13	FI1D (part)	Itä-Suomi	Merged	
FI1A	FI1D (part)	Pohjois-Suomi	Merged	
	FI1D	Pohjois- ja Itä-Suomi	New region	FI1D = FI13 + FI1A
FI18		Etelä-Suomi	Split	

FI18 (part)	FI1B	Helsinki-Uusimaa	New region	FI1B + FI1C = FI18, recalculation by NSI
FI18 (part)	FI1C	Etelä-Suomi	New region	FI1B + FI1C = FI18, recalculation by NSI
UKD2		Cheshire	Boundary shift	
UKD5		Merseyside	Boundary shift	
	UKD6	Cheshire	New region	recalculation by NSI
	UKD7	Merseyside	New region	recalculation by NSI

Source: Eurostat

Table A. 4 Negative gross operating surplus in German regions

Region	Agriculture						Transport and Trade	
	First estimation				Imputed values		First estimation	Imputed values
	VA	COMP	GOS + NTP	COMP / VA (%)	VA	COMP / VA (%)	VA	VA
Total DE	19388	9129	10259	0.47	19388		402436	402436
DE11	655	244	411	0.37	655	0.37	20541	20541
DE12	310	135	175	0.44	310	0.44	15540	15540
DE13	509	169	340	0.33	509	0.33	9401	9401
DE14	461	169	292	0.37	461	0.37	7543	7543
DE21	918	257	662	0.28	918	0.28	30630	30630
DE22	637	133	504	0.21	637	0.21	4320	4320
DE23	507	103	403	0.20	507	0.20	4381	4381
DE24	327	90	236	0.28	327	0.28	3920	3920
DE25	389	115	274	0.30	389	0.30	8131	8131
DE26	521	146	375	0.28	521	0.28	6778	6778
DE27	615	172	443	0.28	615	0.28	7887	7887
DE30	7	14	-7	1.99	15	0.90	16027	16019
DE41	540	334	206	0.62	540	0.62	3037	3037
DE42	452	492	-40	1.09	547	0.90	4811	4717
DE50	10	9	0	0.95	10	0.95	6021	6021
DE60	79	24	55	0.30	79	0.30	23286	23286
DE71	338	185	153	0.55	338	0.55	27158	27158
DE72	187	69	117	0.37	187	0.37	3724	3724
DE73	399	137	262	0.34	399	0.34	5567	5567
DE80	1048	632	415	0.60	1048	0.60	5622	5622
DE91	410	141	269	0.34	410	0.34	5538	5538
DE92	401	176	225	0.44	401	0.44	10469	10469
DE93	869	391	479	0.45	869	0.45	5919	5919
DE94	1441	561	880	0.39	1338	0.42	11004	11107
DEA1	479	332	148	0.69	479	0.69	34273	34273
DEA2	317	197	120	0.62	317	0.62	27681	27681
DEA3	719	259	459	0.36	719	0.36	10553	10553
DEA4	372	149	223	0.40	372	0.40	9879	9879
DEA5	302	180	122	0.60	302	0.60	14049	14049
DEB1	397	165	231	0.42	397	0.42	6382	6382
DEB2	278	81	198	0.29	278	0.29	1856	1856
DEB3	801	383	418	0.48	801	0.48	7921	7921
DECO	64	35	28	0.56	64	0.56	4450	4450
DED1	277	252	26	0.91	277	0.91	4231	4231
DED2	348	301	48	0.86	348	0.86	4873	4873
DED3	282	214	68	0.76	282	0.76	4306	4306
DEE0	1004	639	364	0.64	1004	0.64	6608	6608
DEF0	1064	446	618	0.42	1064	0.42	12359	12359
DEGO	654	596	58	0.91	654	0.91	5760	5760

Source: Own elaboration.

List of abbreviations and definitions

CIF	Cost, insurance and freight
COMP	Compensation of employees
CPA	Statistical classification of products by activity in the European Economic Community
DTX _p	Current taxes on income paid
ESA	European System of Accounts
EU	European Union
Exp _{EU}	Exports to the rest of the EU (other countries)
Exp _{ROW}	Exports to the rest of the world
Exp _{Wthn}	Intra-country exports
FOB	Free on board
GFCF	Gross fixed capital formation
GOS	Gross operating surplus
GOV	Government
GTAP	Global trade analysis project
GVA	Gross value added
HH	Households
HHp	Allocation of primary income account of households
HHs	Secondary distribution of income account of households
Imp _{EU}	Imports from the rest of the EU (other countries)
Imp _{ROW}	Imports from the rest of the world
Imp _{Wthn}	Intra-country imports
IOT	Input-output table
IPFP	Iterative proportional fitting procedure
ITM	International trade and transport margins
NACE	Statistical classification of economic activities in the European Community
NDI	Net disposable income
NTP	Net taxes on production
NTPR	Net taxes on products
NUTS	Nomenclature of territorial units for statistics
PI _p	Property income paid
PI _r	Property income received
R&D	Research and development
ROW	Rest of the world
SAM	Social accounting matrix
S-D	Supply-Demand
SSCE	Employer's social contributions
SSCHSU	Social contributions
SSCHSU _p	Social contributions paid
TC	Transport cost
TCRates	Transport cost rates matrix
TR _p	Other current transfers paid
TR _r	Other current transfers received
TTM	Trade and transport margins
VA	Value added
WFB _r	Social benefits other than social transfers in kind received
WIOD	World input-output database
WS	Wages and salaries
Z	Total output

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