

A Service of

ZBW

Leibniz-Informationszentrum Wirtschaft Leibniz Information Centre for Economics

García-Rodríguez, Abián et al.

# Working Paper A NUTS-2 European Union interregional system of Social Accounting Matrices for the year 2017: The RHOMOLO V4 dataset

JRC Working Papers on Territorial Modelling and Analysis, No. 01/2023

Provided in Cooperation with:

Joint Research Centre (JRC), European Commission

*Suggested Citation:* García-Rodríguez, Abián et al. (2023) : A NUTS-2 European Union interregional system of Social Accounting Matrices for the year 2017: The RHOMOLO V4 dataset, JRC Working Papers on Territorial Modelling and Analysis, No. 01/2023, European Commission, Joint Research Centre (JRC), Seville

This Version is available at: https://hdl.handle.net/10419/283086

#### Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.



WWW.ECONSTOR.EU

https://creativecommons.org/licenses/by/4.0/

#### Terms of use:

Documents in EconStor may be saved and copied for your personal and scholarly purposes.

You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.

If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.





JRC WORKING PAPER

# A NUTS-2 European Union interregional system of Social Accounting Matrices for the year 2017: The RHOMOLO V4 dataset

JRC Working Papers on Territorial Modelling and Analysis No 01/2023



This publication is a working paper by the Joint Research Centre (JRC), the European Commission's science and knowledge service. It aims to provide evidence-based scientific support to the European policymaking process. The contents of this publication do not necessarily reflect the position or opinion of the European Commission. Neither the European Commission nor any person acting on behalf of the Commission is responsible for the use that might be made of this publication. For information on the methodology and quality underlying the data used in this publication for which the source is neither European to other Commission services, users should contact the referenced source. The designations employed and the presentation of material on the maps do not imply the expression of any opinion whatsoever on the part of the European Union concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.

#### **Contact information**

Name: Simone Salotti Address: Edificio Expo, C/Inca Garcilaso 3,41092 Sevilla (Spain) Email: <u>simone.salotti@ec.europa.eu</u> Tel: +34 954488406

#### EU Science Hub

https://joint-research-centre.ec.europa.eu

JRC132883

Seville: European Commission, 2023

© European Union, 2023



The reuse policy of the European Commission documents is implemented by the Commission Decision 2011/833/EU of 12 December 2011 on the reuse of Commission documents (OJ L 330, 14.12.2011, p. 39). Unless otherwise noted, the reuse of this document is authorised under the Creative Commons Attribution 4.0 International (CC BY 4.0) licence (<u>https://creativecommons.org/licenses/by/4.0/</u>). This means that reuse is allowed provided appropriate credit is given and any changes are indicated.

How to cite this report: García-Rodríguez, A, Lazarou, N., Mandras, G., Salotti, S., Thissen, M., and Kalvelagen, E. (2023). A NUTS-2 European Union interregional system of Social Accounting Matrices for the year 2017: The RHOMOLO V4 dataset. JRC Working Papers on Territorial Modelling and Analysis No. 01/2023, European Commission, Seville, JRC132883.

The **JRC Working Papers on Territorial Modelling and Analysis** are published under the supervision of Simone Salotti, Andrea Conte, and Anabela M. Santos of JRC Seville, European Commission. This series mainly addresses the economic analysis related to the regional and territorial policies carried out in the European Union. The Working Papers of the series are mainly targeted to policy analysts and to the academic community and are to be considered as early-stage scientific papers containing relevant policy implications. They are meant to communicate to a broad audience preliminary research findings and to generate a debate and attract feedback for further improvements.

# A NUTS-2 European Union interregional system of Social Accounting Matrices for the year 2017: The RHOMOLO V4 dataset

Abián García-Rodríguez<sup>1</sup>, Nicholas Lazarou<sup>1</sup>, Giovanni Mandras<sup>2</sup>, Simone Salotti<sup>1</sup>, Mark Thissen<sup>3</sup>, and Erwin Kalvelagen<sup>4\*</sup>

#### 1. European Commission, Joint Research Centre (JRC) Seville, Spain

#### 2. Cassa Depositi e Prestiti, Rome, Italy

*3. PBL Netherlands Environmental Assessment Agency, The Hague, The Netherlands* 

4. Amsterdam Optimization, Washington DC, USA

**Abstract.** We describe the procedure used to construct a set of interregional NUTS-2 European Union Social Accounting Matrices for the year 2017, using official Eurostat national and regional account data, and auxiliary data on business and interregional trade flows derived from transport survey data. This procedure builds on the one presented by Thissen et al. (2019) for the year 2013. The new dataset is described by presenting some relevant features and the results of some characteristic simulations obtained with a new version of the RHOMOLO model, referred to as RHOMOLO V4, based on the new 2017 data.

**Keywords**: Regional data, Input-Output, social accounting matrices, trade flows, general equilibrium.

**JEL Codes**: C82, E16, R15, F14, F47.

<sup>\*</sup> The authors acknowledge funding through ZonMw project 10430-03201-0006 («The Resilient Region; Regional-Economic Impact Mitigation of Corona-related (De)escalation Policies») for the construction of the interregional IO-table.

# **1** Introduction

In the European Union (EU), a significant part of the budget is used for regional policy, called cohesion policy, making it relevant for policymakers and citizens (Crucitti et al., 2022). Recent evidence on regional discontent (Rodríguez-Pose, 2017, Los et al., 2017) emphasizes the political importance of regional policymaking. The literature on regional economics highlights the importance of the spatial character of economic systems to explain regional economic phenomena. However, despite the attention drawn to issues related to regional inequality and economic development, reliable data at the regional level is often lacking and not comparable to national data in terms of quality and quantity. In particular, interregional trade flows are generally not measured by statistical offices. As a result, we have to rely on estimates (see, for instance, Fournier Gabela, 2020, for Japan, Liu et al., 2015, for China, and Généreux and Langen, 2002, for Canada).

Based on the estimated trade flows among EU regions by Thissen et al. (2013a and 2013b), Thissen et al. (2019) describe the construction of a system of interregional Social Accounting Matrices (SAMs) with data from 2013 for all the NUTS-2 regions of the European Union (EU). NUTS stands for Nomenclature of Territorial Units for Statistics classification, and the NUTS-2 2016 definition is used in this analysis (see Table A1 in the appendix for the full list of regions).

SAMs are comprehensive, economy-wide datasets containing information on all the transactions between the economic agents of a specific economy for a certain period of time. SAMs are normally used for the calibration of multi-sectoral models like computable general equilibrium (CGE) ones (Mainar-Causapé et al., 2018). Stone (1947) was the first to work on data organised in SAMs, and the work by Pyatt and Thorbecke (1976) and Pyatt and Round (1985) led to their widespread use as a formal framework for economic analysis and planning.

The dataset described by Thissen et al. (2019) forms the basis for the calibration procedure of the spatial dynamic CGE RHOMOLO V3 model, whose complete mathematical description is offered by Lecca et al. (2018). The model, which has been developed by the JRC in collaboration with the Directorate-General for regional and urban policy (DG REGIO), is used for territorial ex-ante impact assessments of policies such as the cohesion and innovation policies (see Sakkas, 2018, on the European Social Fund; Di Comite et al., 2018, on the cohesion policy funds; and Christensen, 2018, on Horizon Europe). Several scientific articles also feature RHOMOLO V3 analyses (see, among others, Lecca et al., 2020; Di Pietro et al., 2021; Barbero et al., 2022a, 2022b, and 2023).

In this paper, we present a revised procedure to construct a similar dataset for 2017, which is used for the calibration of the latest version (V4) of the RHOMOLO model. We take advantage of recent developments in data availability and estimation techniques. First, Eurostat now publishes official EU intercountry supply, use and Input-Output tables (EU IC-SUIOTs – also referred to as FIGARO

tables<sup>1</sup>). These tables form an ideal starting point for producing EU regional SAMs. Second, we use an improved technique to estimate the interregional Supply and Use Tables (SUTs), which form the basis for the SAMs of all the NUTS-2 regions of the EU.

The FIGARO tables were published for the first time in 2021. The goal is to have these updated and enriched annually. They link national accounts with data on business, trade and jobs for EU Member States and 18 main EU trading partners (Argentina, Australia, Brazil, Canada, China, India, Indonesia, Japan, Republic of Korea, Mexico, Norway, Russian Federation, Saudi Arabia, South Africa, Switzerland, Türkiye, the United Kingdom, and the United States). A rest-of-the-world (ROW) entity completes the FIGARO tables. A full description of the methodology used to produce the tables is provided by Remond-Tiedrez and Rueda-Cantuche (2019).

The mostly parameter-free methodology proposed by Simini et al. (2012) is the starting point for the estimation of the interregional trade flows between the NUTS-2 regions of the EU. This approach is compatible with methods of data construction and overcomes the shortcomings of often-used gravity-style estimations. The process combines data from different sources (some of them survey-based) into a consistent and complete dataset of interregional accounts for production (Supply tables) and demand (Use tables). Interregional trade is derived from freight transport, business travel, and flight microdata taken from (Thissen et al., 2019). Notably, the existence of trans-shipment locations was taken into account. The resulting regional tables are consistent with the national account data as presented in the FIGARO intercountry SUTs.

In a nutshell, the procedure used to produce the inter-regional SAMs for the EU comprises the following five steps:

- 1. Starting from the FIGARO intercountry SUTs (at the level of 64 NACE sectors and associated CPA products<sup>2</sup>), we use regional data (mainly on production and consumption) to obtain regional SUTs. We aggregate several sectors due to data limitations, reducing the 64 NACE sectors to 56 categories. Table A2 in the appendix lists both the 64 and the aggregated 56 NACE sectors.
- 2. Using trade priors for the regional trade flows based on Thissen et al. (2019), we disaggregate the intercountry trade flows of the Figaro tables into regional trade flows within and between countries.
- 3. The resulting regional SUTs are combined into interregional IO (inputoutput) tables. Since we have rectangular SUTs (the number of sectors and products are not identical), we use the standard industry technology assumption to determine the IO table, according to which the distribution of inputs and Gross Value Added (GVA) of the product that is moved from

<sup>&</sup>lt;sup>1</sup> FIGARO stands for 'Full International and Global Accounts for Research in Input-Output analysis' and comprises the EU intercountry supply, use and Input-Output tables (EU IC-SUIOTs).

<sup>&</sup>lt;sup>2</sup> NACE (the term is derived from the French *nomenclature statistique des activités économiques dans la communauté Européenne*) is the classification of economic activities in the EU, where CPA stands for the Classification of Products by these Activities.

a column to another is assumed to follow the structure in the column from which the product is moved (see Miller and Blair, 2009, pp. 212-213). This conversion of SUTs into IO tables is done for analytical purposes (national accounts data are organised in SUTs, but the IO structure is better suited for economic modelling).

- 4. We aggregate the regional data of step 3 from 56 CPA sectors to 10 NACE Rev. 2 sectors and merge all the non-EU regions and countries into the residual entity ROW. Also, we redistribute the direct interregional imports of final demand categories such that the flows of final demand elements between regions (direct imports of households, government, and firms gross fixed capital formation, GFCF) are transferred to the corresponding final demand element and sector of the destination region, and to the corresponding sector as an intermediate output of the origin region.
- 5. We combine the interregional IO tables with data for the secondary distribution of income to create interregional SAM tables.

In the remainder of the paper, we provide more details on the procedure and we show some salient features of the new dataset. We also present the results of some basic simulations with the RHOMOLO V4 model calibrated with the 2017 data constructed here.

Section 2 briefly describes the intercountry FIGARO tables, and proceeds to explain the procedure in step 1 to regionalise them. Section 3 illustrates steps 2 and 3 of the procedure, which yield interregional SUTs for the goods and services categorised according to the 64 CPA and 56 NACE sectors. Section 4 illustrates the sectoral and geographical aggregation used for the RHOMOLO model (step 4 of the above list). Section 5 deals with step 5: the creation of the interregional SAMs starting from the IO tables. Finally, section 6 shows some features of the dataset, as well as some modelling simulations obtained with basic economic shocks. Section 7 concludes.

# 2 Regionalization of national SUTs

### 2.1 The FIGARO Tables

In this section, we provide a brief overview of the FIGARO data (Remond-Tiedrez and Rueda-Cantuche, 2019), the starting point of the first step of the procedure to produce inter-regional SAMs for the EU NUTS-2 regions.

The FIGARO data are organised in SUTs: these are matrices by sector and product categories describing how domestic production and imports of goods and services in an economy are used by industries for intermediate consumption and final use/demand. Products are classified according to the CPA system, while industries use the NACE Rev. 2 system. These classifications are fully aligned: at each level of aggregation, the CPA shows the primary and secondary products of the corresponding industries using the NACE classification.

The SUTs provide information on the structure of production and their costs and on the value added created during this production. They also show the flows of goods and services produced in the national economy, and between that economy and the rest of the world. As such, they combine all the information of three accounts: goods and services, production, and generation of income. Table 1 presents all the elements of the National Accounts that can be found in FIGARO.

| Code    | Description  |
|---------|--|
| P1      | Total Output   |
| P2      | Total Intermediate Consumption by Activity                     |
| D21X31  | Taxes less subsidies on products                               |
| D29X39  | Other net taxes on production                                  |
| OP_NRES | Purchases of non-residents in the domestic territory           |
| OP_RES  | Direct purchase abroad by residents                            |
| B2A3G   | Gross operating surplus  |
| D1      | Compensation of employees                                      |
| B1G     | Gross Value Added (GVA)  |
| P3_S13  | Government consumption   |
| P3_S14  | Household consumption  |
| P3_S15  | NPISH (non-profit institutions serving households) consumption |
| P51G    | Gross Fixed Capital Formation (GFCF)                           |
| P5M     | Changes in valuables and inventories                           |
|         |  |

#### Table 1: National accounts elements in FIGARO

Data in FIGARO are disaggregated at the product level in the 64 CPA categories presented in Table A2 in the appendix. The level of detail of the data requires some elements to be classified as confidential. These gaps in the data are corrected during the regionalization phase using complementary regional data.

The data in FIGARO cover the 45 countries listed in Table 2. Information on the EU members, the UK, and the US is built-up by linking national accounts and data on business, trade and jobs. The data for the remaining countries, which are the main trading partners of the EU, come from the Inter-Country IO (ICIO) tables of the OECD. There is also a ROW region which simply collects any remaining data.

| Belgium  | BE | Cyprus      | СҮ | Slovakia                    | SK | Russian<br>Federation    | RU  |
|----------|----|-------------|----|-----------------------------|----|--------------------------|-----|
| Bulgaria | BG | Latvia      | LV | Finland                     | FI | India                    | IN  |
| Czechia  | CZ | Lithuania   | LT | Sweden                      | SE | China                    | CN  |
| Denmark  | DK | Luxembourg  | LU | United<br>Kingdom           | GB | South<br>Africa          | ZA  |
| Germany  | DE | Hungary     | HU | Norway                      | NO | Japan                    | JP  |
| Estonia  | EE | Malta       | MT | Switzerland                 | СН | Korea,<br>Republic<br>of | KR  |
| Ireland  | IE | Netherlands | NL | Türkiye                     | TR | Indonesia                | ID  |
| Greece   | GR | Austria     | AT | United States<br>of America | US | Australia                | AU  |
| Spain    | ES | Poland      | PL | Canada                      | СА | Saudi<br>Arabia          | SA  |
| France   | FR | Portugal    | РТ | Mexico                      | МХ | Rest of the<br>World     | ROW |
| Croatia  | HR | Romania     | RO | Argentina                   | AR |                          |     |
| Italy    | IT | Slovenia    | SI | Brazil                      | BR |                          |     |

#### Table 2: Countries in the FIGARO database

# 2.2 Regionalization of production and use of country-level SUTs

Before we can start regionalising the FIGARO dataset, we have to make some minor corrections. The FIGARO dataset conforms to the official national account statistics of Eurostat and SUTs as constructed by the national Bureaus of Statistics. As a result, the data can pose problems for the regionalisation of the national tables since theoretically invalid numbers (mainly negative entries) are incidentally part of the tables. Although one can keep these negative numbers in the national tables, it makes little sense to regionalise them and spread erroneous values over the different regions. We, therefore, developed a procedure to correct for negative numbers where only positive numbers are theoretically possible.

This correction procedure is based on double bookkeeping since products produced in the Supply table are used in the Use table. Thus, all corrections must be made in two places of the original tables. The erroneous negative values have been set to zero, booking the associated correction in the row and column discrepancies of the original FIGARO tables. Subsequently, all elements of the row and column correction factors, including those in the original FIGARO tables, are set to zero and are booked in the columns of stocks that absorbed all the errors in the original tables.

After this preliminary step, step 1 in the procedure to construct the regional SAMs is the regionalisation of the country-level SUTs of the FIGARO dataset.

This procedure is based on mapping the national level data to publicly available NUTS-2 regional data as published by Eurostat in the regional accounts and the structural business statistics.

The Eurostat regional accounts provide data on GVA (NAMA\_10R\_3GVA – this can be seen as a proxy for Gross Domestic Product, GDP), household income (NAMA\_10R\_2HHINC), employment (NAMA\_10R\_3EMPERS in thousand persons, and NAMA\_10R\_2EMHRW in hours worked), and compensation of employees (NAMA\_10R\_2COE) for all the NUTS-2 regions of the EU and the 11 NACE Rev. 2 sectors included in Table 3 below. The classification is significantly less detailed than the FIGARO data, but it has the advantage of full geographical coverage and excellent availability over time (there are no missing values for 2017).

| Code | Nace Rev.2   |
|------|--|
| А    | Agriculture, forestry and fishing  |
| B-E  | Industry (except construction)   |
| С    | Manufacturing  |
| F    | Construction   |
| G-I  | Wholesale and retail trade, transport, accommodation and food service activities   |
| J    | Information and communication  |
| К    | Financial and insurance activities   |
| L    | Real estate activities   |
| M_N  | Professional, scientific and technical activities; administrative and support service activities                                     |
| O-Q  | Public administration, defence, education, human health and social work activities   |
| R-U  | Arts, entertainment and recreation; other service activities; activities of household and extra-territorial organizations and bodies |

#### Table 3: Sectoral classification of the Eurostat regional accounts

Note: The data are available also for the four following sectors which are aggregates of the ones in the Table: total economy, G-J, K-N, and O-U. Also, notice that sector B-E includes C, which is also available separately.

We use data from the Structural Business Statistics (SBS) dataset (also available from Eurostat) to obtain regional data with a more detailed sectoral disaggregation. We use the following NUTS-2 SBS data: wages (V13320, in millions of euros), employment (V16110, persons employed), and the number of firms (V11210, number of local units). The main drawback of the SBS dataset is that it contains missing values for some regions and divisions, mainly due to confidentiality issues caused by the granularity of the data or the strategic importance of certain subsectors. To fill in the gaps, we either performed imputations using the data on regions with similar levels of GDP per capita, or we used projections of SBS data from earlier years.

We use both the Eurostat regional accounts and the regional SBS data to regionalise the SUTs data, maintaining a high degree of sectoral granularity (we move from the 64 products of the national SUTs to 56 sectors in the resulting regional data – see Table A2 in the appendix). Due to the lack of SBS data for certain sectors, the regional accounts are used for the regionalization of Agriculture, forestry, and fishing (Sector A) and the public economic sectors. P, and Q). The SBS data are used for all the remaining economic sectors.

We outline below the strategy used to move from the square national SUTs having 64 NACE sectors and CPA products to the rectangular regional SUTs with 56 NACE sectors and 64 CPA products for all the FIGARO variables listed in Table 1. The precise definition and the sources of all the regional data used in the process are listed in Table A2 in the appendix. The first step is to aggregate the 64 sectors of the FIGARO tables into the 56 sectors for which the regional GVA data is available. Sectors A02 and A03 in FIGARO are aggregated into sector A02\_03 for the final dataset; sectors K64, K65 and K66 into K; and sectors R90T92, R93,\_S94,\_S95,\_S96, and T into R-T.

The formula used for the regionalization of the national SUTs elements is the following:

$$X_r = Y_l \cdot \frac{I_r}{\sum_{k \in S_l} I_k}$$

Indices r and k are used to indicate regions, and index l indicates countries.  $X_r$  is the column of the regional SUTs of region r,  $Y_l$  is the corresponding column of the national SUTs of country l that encompasses region r,  $I_k$  is the used indicator for region k, and  $S_l$  is the set of NUTS 2 regions of country l. The disaggregation formulas are used for all elements of the SUTs listed in Table 1, except for the changes in inventories and acquisitions less disposals of valuables. Please note that although the sectors in the columns have been aggregated into 56 sectors, the original classification of 64 CPA products is kept intact.

Different indicators  $I_k$  are used for the various columns of the SUTs which represent sector production and final demand (see Table A3 in the Appendix). Regional GVA is used to regionalise intermediate consumption and purchases of non-residents in the domestic territory, when available in the SBS data (for the agricultural sectors A01\_03, we use data from Eurostat's Economic accounts for agriculture; for Education P85, we use the number of students; for Health activities Q86, we use the number of hospital beds). Similarly, sectoral production is used to regionalize the data on taxes, gross operating surplus and compensation of employees. Regional household income is used to regionalise final consumption expenditure by the households; final consumption expenditure by the government, by non-profit institutions serving households (NPISH), and other government activities (O84, Q87\_88) are regionalised according to population levels; and for GFCF we use the available regional data on investments. Total regional output is simply the sum of regional GVA and the regionalised intermediate consumption. Changes in inventories is then used as a rebalancing element.

The columns of the regionalised supply and use tables have been split so that regional sector production and use add up to the national FIGARO SUTs. Therefore, the regionalised SUTs follow the format of the FIGARO tables (Rémond-Tiedrez and Rueda-Cantuche, 2019). However, also the origin of products in the Use table has to be taken into account as interregional and international trade is combined in the use of products. We discuss the regionalisation of interregional trade in the following section.

## **3** Construction of interregional SUTs and IO tables

The regionalised Use table obtained using the methodology described in the previous section has still to be regionalized for the origin of the products used. In other words, we still have to determine interregional trade given the total production of products from the supply tables and the total use of products in every region. We developed a standardized procedure to regionalize the trade within and between countries based on an error minimization function between a first estimate (the prior) and the final consistent estimate.

The information needed to regionalize the trade is a prior: a first estimate of the trade between different regions. We use a prior derived from transport micro data extensively described in Thissen et al. (2019). This trade prior P for the year 2013 was updated to the new NUTS-2 regional classification using the NUTS converter tool of the Urban data platform from the European Commission.<sup>3</sup> Subsequently, this prior has been made consistent with the regionalized Use tables in the following way.

$$\begin{split} P_{p,r,r',s} &= \tau_{p,c,r,r'} W_{p,c,r',s|r \in c} \\ \tau_{p,c,r,r'} &= \frac{T_{p,r,r'}}{\sum_{r \in c} T_{p,r,r'}} \end{split}$$

where  $T_{p,r,r'}$  is the trade of product p from region r to region r' as taken from Thissen et al. (2019), and  $\tau_{p,r,r'}$  is a multiplication factor that adds up to 1 for all producing regions r from the same country. P is the prior consistent with the format used in the Use table.

The trade between regions in the interregional Use table U is estimated by minimizing the root mean square weighted error and percentage error (RMSWEPE), a weighted combination of the root mean square error RMSE and

<sup>&</sup>lt;sup>3</sup> https://urban.jrc.ec.europe.eu/nutsconverter/

the root mean square percentage error RMSPE (used in Thissen et al., 2013c, 2014, and 2019) that can be written as follows:

$$Min\left(\sum \left(\frac{U_{p,r,r',s} - P_{p,r,r',s}}{P_{p,r,r',s}}\right)^{2} + \omega \sum \left(U_{p,r,r',s} - P_{p,r,r',s}\right)^{2}\right)$$

where  $\omega$  is a weight that makes the quadratic percentage error comparable to the quadratic error. This weight is equal to the squared average inverse of the average value  $\overline{P}$  of the elements of the prior matrix P. The weight can therefore be determined as:

$$\omega = \left(\frac{1}{\overline{P}}\right)^2$$

This minimization is done given the consistency constraints that the regionalised U adds up to the country Use tables of FIGARO and that the summation of all use by region of origin adds up to the production in the supply tables as described in the previous section.

The stocks have not been included in the minimization of the error described above. We do not take the priors of the stock changes into account since these are normally not related to trade flows but are commonly determined by a mismatch in timing between production and consumption, or created to match supply and demand. However, without being part of the optimization model, they would be determined by the estimation of all other trade flows. This could cause large stocks since the stocks can be both negative and positive with only national totals given. We, therefore, impose that all stock changes of regions within a country should have the same sign. Furthermore, we add an additional term to the objective function such that the sum of the squared negative final demand F (including stocks) is minimized. Finally, we add the minimization of the squared sum of positive and negative final demands to guarantee an even distribution of stocks when the negative numbers are minimized and prevent very small negative values. The exact formulation of the adjusted objective function is as follows

$$Min \quad \sum \left(\frac{U_{p,r,r',s} - P_{p,r,r',s}}{P_{p,r,r',s}}\right)^2 + \omega \sum \left(U_{p,r,r',s} - P_{p,r,r',s}\right)^2 + \sum_r \left(F_r^-\right)^2 + \frac{1}{2} \sum_r \left(F_r^- + F_r^+\right)^2$$

This model with a convex quadratic objective and linear constraints can be solved quickly and reliably using CPLEX as a solver on the GAMS software platform. The result is a regionalized interregional Use table that is both consistent with the regionalized supply table and the national FIGARO SUTs. In the final step, we create an interregional IO table from the interregional SUTs. Since we have an unequal number of sectors and products, our choice of methodologies to create an IO table from SUTs is limited. We follow the standard textbook approach based on the so-called industry technology assumption to determine the IO table. This methodology is described in detail in Miller and Blair (2009, pp. 212-213).

# 4 IO aggregation

The Interregional IO table (IRIO) with 306 regions and 56 sectors has to be completed with the distribution of income linking value added to consumption in order to be used as the RHOMOLO dataset. Since the RHOMOLO model is designed considering a more aggregated level of sectors and regions, we aggregate these ending up with a final IRIO with 236 regions and 10 sectors. All the EU regions are kept as they are, while all the other remaining regions are merged into one ROW region. The 56 sectors are aggregated by summation into 10 broad industries, as shown in Table 4.

| Final<br>sector | NACE Rev.2 sectors  |
|-----------------|---|
| A               | A01, A02-03   |
| B_E             | B, D35, E36, E37T39   |
| С               | C16, C17, C18, C19, C20, C21, C22, C23, C24, C25, C26, C27, C28, C29,<br>C30, C33, C10T12, C13T15, C31_32 |
| F               | F   |
| G_I             | G45, G46, G47, H49, H50, H51, H52, H53, I   |
| J               | J58, J61, J59_60, J62_63  |
| K_L             | K, L68  |
| M_N             | M71, M72, M73, M69_70, M74_75, N77, N78, N79, N80T82  |
| 0_Q             | O84, P85, Q86, Q87_88, O-Q  |
| R_U             | R_U   |

Table 4: Mapping between sectors in RHOMOLO and NACE Rev.2 sectors

The reason for using aggregate sectors in the RHOMOLO model is twofold. First, it reduces the dimensionality of the model, allowing for a significantly faster simulation of policy experiments. Second, more disaggregated sectoral data are less reliable because they are more likely to be affected by availability or confidentiality issues. It will always be possible to create alternative aggregations if more detailed reliable information is available, allowing for more detailed analysis of certain sectors or EU trading partners.

The last element is the handling of imports of final demand. The RHOMOLO model assumes that final demand (households, government consumption, GFCF,

and stock changes) takes place only in the region itself. All final demand has therefore been aggregated and the corresponding interregional demand elements have been proportionally added to the intermediate demand.

# **5** Conversion into SAMs

The final step in producing the RHOMOLO dataset is to transform our current IRIO table into a SAM. SAMs form the base of most CGE models like RHOMOLO. A SAM is a table representing flows of all the economic transactions that take place in a given economy, with each cell showing payments from its column account to its row account. This is not different from an IO table. SAMs expand over IO tables by linking final consumption expenditures by institutional sectors to income earned in production (GDP) taking the redistributive role of the government into account, among other things.

To transform the IRIO tables into SAMs, we need to combine the IO data with data on the secondary distribution of income. Eurostat produces yearly the non-financial Annual Sector Accounts (ASA), recording the economic flows of institutional sectors to illustrate their economic behaviour and interactions between them. The ASA also provides a list of balancing items, such as value-added, operating surplus, disposable income, and savings, which add valuable information and can be used to link back to the data in the IRIO tables.

The ASA produces data for several institutional sectors, but we focus on the sectors represented in the IRIO tables: households (S.14-S.15), general government (S.13), and the rest of the world (S.2). In terms of flows, we use data on Taxes on income and wealth (D5), Transfers (D7), Social benefits (D62), Gross savings (B8G) and Gross operating surplus (B2A3G). These data are available at the national level, thus, we need to regionalize them in order to combine them with the IRIO tables. We use regional GDP shares to distribute the different national flows to the regions within each country.

The last adjustment required is the disaggregation of the compensation of employees (COE) into the three different skill categories featured in the RHOMOLO model. The shares of COE going to each of the skill categories for each region and sector are calculated by combining data on employment from the Regional accounts with the more granular data from the Labour Force Survey (LFS). The use of LFS microdata is required to obtain employment figures with both a sectoral and educational attainment level of disaggregation.

In the RHOMOLO model, we assume that there are three skill levels for employment, which are mapped from Educational attainment in the LFS data (as for the chosen sectoral aggregation, data availability dictates some of the modelling choices). The LFS presents three aggregates, High, Medium, and Low, based on the ISCED2011 categorization. In cases where there is no data for a particular combination of region, sector, and skill, the country-wide skill share is used. Wage shares are calculated by combining the region-sector-skill employment shares with country-level data for median hourly earnings by educational attainment level. The process is described in detail below.

# 5.1 Employment and wage shares by educational attainment

We initially set the constraints regarding the working population of the regions. These are defined by the hours worked for the employed, which will ultimately vary between 35-45 hours per week depending on the regions and sectors. The associated skill shares from the LFS corresponding to these hours are then used to extract the skill-specific employed populations using the Eurostat series "Employment (thousand persons) by NUTS 3 regions [nama\_10r\_3empers]".

The first step is to import the hours worked and employment and fix any problematic cases. Zero values are replaced with missing values due to data paucity (respondents in the survey report that they are employed, but work zero hours). In some cases, not all skill categories are available within regions and sectors. In occurrences like this, the regional average across sectors is applied for each skill. If this is not available, the country average is applied. The same procedure is used when some sectors are missing.<sup>4</sup>

From the hours and level of employment, we construct hours per week per region per sector. We obtain the 95 and 25 percentiles of the distribution of hours per week to be used to get rid of outliers and unreliable values. For values exceeding these percentiles, we replace them with the region values and recheck the percentiles. If necessary, country values are used to replace extreme values leading to a distribution of hours worked between 35 and 45 hours. The replacements could affect either or both the level of employment and the hours worked. This is to ensure that the updated hours worked per week per employee fall between 95 and 25 percentiles of the distribution.

Then we obtain the employment shares as the share of the population working as Low, Medium or High skilled within a region-sector.

### 5.2. Wage shares and employment by region-sector-skill

The wage shares are calculated using the Eurostat "median hourly earnings, all employees (excluding apprentices) by educational attainment level [earn\_ses\_pub2i]" and the employment share. These wage shares are used to alter the compensation of employees and the wages and salaries in the SAMs.

Regional-sector employment is reported in the national accounts series "Employment (thousand persons) by NUTS 3 regions [nama\_10r\_3empers]". These are then broken down into skills using the employment shares.

<sup>&</sup>lt;sup>4</sup> The Netherlands publish LFS data only at the country level. Thus, 12 copies of the country level hours and employment are created (each region representing 1/12th as there is no additional weighting applied).

# 6 Results

#### 6.1 Data showcase: regional export analysis

The regional granularity of the new dataset allows for levels of analysis that are not possible to perform with publicly available data. As an example, in this subsection we analyse the destination of exports at the regional level. In particular, what share of the exports of a given region has its own country as a final destination? Figure 1 provides an answer to this question.

Figure 1: Share of trade with a region within the same country as destination



Source: authors' calculations.

Figure 1 shows the within-country export intensity, meaning the share of trade flow volume that has the region as origin and a region in the same country as destination. Some regularities are immediately apparent. Capital regions tend to have a comparatively larger share of exports going to their own countries.

These exports come with particular intensity from services sectors, in particular Professional, administrative and support activities (M-N sectors) and Information and communication (J sector). In these sectors, the volume of the flows going from the capital region to the other regions in the country is larger than what we could expect given the GVA share of these sectors in the capital regional economy (not shown for simplicity). The economies of scale and network associated with these sectors and the ease of selling these services in other regions within a country would explain their tendency to agglomerate in the

most populated regions. The map also shows many large non-capital regions that are very dependent on their national markets, making them amenable to policies aimed at supporting the internationalization of their industries.

At the other end of the spectrum, we observe some regions with relatively low dependency on their national market as destination of their exports. While there are many reasons, we briefly explore two. First, Figure 2 shows the share of exports in a given region that has the German market as destination. A significant number of European regions are deeply connected to the German market. This includes most neighbouring areas to Germany in Austria, the Czech Republic, Hungary, Western Poland, Eastern Netherlands and Northeast France. In all cases, these exports are concentrated in the Manufacturing sector, either as intermediate inputs for the German manufacturing sector or as final goods for consumption: as in the case above, the size of the flows is larger than what we could expect given the GVA share of the manufacturing sector in the origin regions.





Source: authors' calculations.

#### Figure 3: share of trade with outside the EU as destination



Source: authors' calculations.

Second, Figure 3 shows the share of exports from a given region that have the ROW, understood as outside the EU, as destination. The regions with higher export intensity to the ROW are scattered around Europe, and a deeper analysis allows us to distinguish many different typologies. In some cases, this high intensity is simply the case of a strong relation with neighbouring countries outside the EU, like in the Baltics, Cyprus or Northern Sweden. Other regions have specialised in exporting manufactured goods, like cars for some regions in Hungary and Czechia or electronics in Southwest Ireland and Southern Netherlands. On the other hand, some regions have specialised in exporting services: financial services in Malta, Luxembourg and Cyprus; Information and communication services in Dublin or Trade related services in the Netherland or Denmark.

#### 6.2 Model simulations

We now provide a series of results from simulation exercises performed with the macroeconomic RHOMOLO model based on the latest dataset (RHOMOLO V4). Being able to produce macroeconomic consistent results with the new dataset on a well-established model like RHOMOLO provides a definitive check of the data constructed according to the procedure explained above, both of the internal consistency of the data and how it relates to the actual data observed in the real world. We produce simulation results for the following three macroeconomic

shocks: i) a total factor productivity (TFP) shock (purely supply-side); ii) a government consumption shock (purely demand-side); and iii) a transport cost shock (purely supply-side).

The results are dependent on the calibration of the RHOMOLO model, using a set of auxiliary data which is described in detailed in Lecca et al. (2018). Of particular relevance for the shocks described below is the calibration of the interregional transport costs. The costs are estimated as the populationweighted average costs of road transport between pairs of cities within the NUTS 2 regions. These costs correspond to the generalized transport costs (GTC) in euros, capturing the distance and time-related costs of the optimal route between each pair of regions for a representative truck, also taking into account the actual geography. These costs are subsequently mapped into a matrix of iceberg transport costs. A full explanation of the methodology can be found in Persyn et al. (2022), and an application to the transport infrastructure investments of the 2014-2020 European cohesion policy is described by Persyn et al. (2023).

• Shock i): 1% permanent increase of TFP

The results from simulating a 1% permanent increase of TFP in all regions of the EU can be seen in Figures 4 and 5. The left panel in Figure 4 shows the deviations from the baseline in percentage over a 20-year horizon for a set of basic indicators at the EU level: GDP, household consumption, investment, employment, and the consumer price index (CPI). The right panel shows a histogram with the distribution of the 10-year deviation from baseline of each region's GDP.



Figure 4: permanent increase of TFP (a) percent deviations from baseline, (b) 10-year GDP deviation from baseline distribution

A TFP shock immediately increases production, as TFP is part of the production function. The increased productivity makes labour and capital more valuable. Firms hire more of both, leading to an improvement of the labour market and

Source: authors' calculations.

more investment. Rising employment leads to higher wages, allowing the now wealthier households to increase their consumption, further stimulating the economy. The all-around improvements in technology enhance trade and lead to lower prices.

All the EU regions benefit from the shock, with a relatively compact distribution of the positive economic effect. Among other determinants, there is a moderate negative correlation between the saving rate in a region and the size of the GDP impact, a consequence of the aforementioned second-round demand effects: in regions with a low savings rate, households will tend to consume more of the newly created wages.

Also at the regional level, Figure 5 shows the GDP impact on the year following the shock. This exercise allows us to see results which are more directly linked to the dataset, less influenced by the dynamics of the model. On this very short run, one of the main determinants of the effect of increases to TFP on regional GDP is the labour share of the region. On impact, regions with higher labour shares experience larger effects on GDP, as labour demand increase more than in regions with lower shares, and capital has had no time to adjust through investment. Over time this effect reverses and regions with lower labour shares, and which are therefore more capital intensive, experience larger GDP increases. Following the shock, firms start adjusting their capital towards their desired levels by increasing investment. In more capital-intensive regions the demand for capital will increase more following the TFP shock. Consequently, all else equal, regions with lower labour shares will see larger levels of investment and subsequent larger increases to their regional GDP in the long term.

#### Figure 5: 1-year GDP deviation from baseline following a 1% TFP increase



Source: authors' calculations.

#### • Shock ii): 1% permanent increase in government consumption

The second shock is a 1% permanent increase in government consumption in all EU regions. Contrary to the previous shock, which affects the economy primarily through the supply side, this shock is fundamentally a demand shock. The increased government consumption stimulates the economy as the firms increase production to cover the new demand. The extra production requires of additional workers and investment to be met, raising both. Furthermore, the extra demand also results in an increase in prices as the economy heats up.



# Figure 6: 1% permanent increase of Government consumption (a) per cent deviations from baseline, (b) 10-year GDP deviation from baseline distribution

Source: author's calculations

As per Figure 6 (right panel), in terms of distribution, most regions appear concentrated around an increase of 0.05 per cent in GDP after 10 years, with a substantial number of regions to the right of that increase. Some negative values are also observed. Most of the negative cases can be explained by the loss of competitiveness induced by the increased prices mentioned above, combined with a relatively high dependence on exports outside the EU.

On impact (see Figure 7), the regions that benefit the most are those with a larger private consumption to GDP ratio. These regions present a larger propensity to consume and, therefore, the newly created government consumption will have a larger effect in those regions relative to other regions with lower shares.

# Figure 7: 1-year GDP deviation from baseline following a 1% Government consumption increase



Source: authors' calculations.

#### • Shock iii): 1% permanent decrease in transportation costs

Finally, we show in Figures 8 and 9 the results for a permanent 1% decrease in transportation costs in all EU regions, another supply-side shock. Both firms and consumers benefit from the shock. On the firms' side, cheaper inputs lead to increased production, followed by higher investment and employment. Consumers now have access to cheaper imports, together with some additional wages due to the increased production. As for prices, we observe two competing effects: on one hand, the increased activity will tend to push prices up, while on the other hand, lower transportation costs translate to potential efficiency gains as producers can have access to cheaper inputs. At first, we see the former effect slightly dominating, but as time passes and firms have time to adjust, the latter dominates and prices go down.



Figure 8: 1% permanent decrease of transport costs (a) per cent deviations from baseline, (b) 10-year GDP deviation from baseline distribution

Source: authors' calculations.

In terms of regions, the most interesting feature is the existence of some relatively extreme positive values. The impact of decrease in transportation costs has the largest effect on those regions that initially have relatively large transportation costs (islands like Madeira or Açores, mountain regions like the Aosta Valley in Italy, etc.) and in the regions whose imports come mainly from the EU. A similar picture can be seen on impact, as shown in Figure 9: regions with large relative transport costs have larger gains. However, we also observe relatively high gains in regions in and around Germany; these are regions with relatively strong trade flows as a percentage of GDP that benefit from the suddenly lower transport costs.

#### Figure 9: 1-year GDP deviation from baseline following a 1% reduction in transport costs



Source: authors' calculations.

# 7 Conclusions

We presented a procedure to construct a set of inter-regional SAMs for the whole EU for the year 2017. The FIGARO inter-country SUTs published by Eurostat constitute the starting point of the procedure followed to obtain the dataset. Eurostat regional data are used to regionalise those, and together with inter-regional estimated trade flows they are used to produce SAMs with additional information on the secondary distribution of income.

The resulting dataset is consistent with the Eurostat regional and national data used as inputs. We showed some of the unique features of the data related to the estimated trade flows, namely the proportion of regional trade directed towards, and coming from, the rest of the regions of their countries, or the economies abroad.

These data are used for the calibration of the latest version (V4) of the RHOMOLO model. We illustrated the results of three simple simulations carried out with the RHOMOLO V4 model, shocking TFP, government consumption, and transport costs.

Regional datasets are the basis of regional economic models such as the RHOMOLO model and are crucial for the economic analysis of regional systems and the spatial distribution of economic activity.

## References

Barbero, J., Diukanova, O., Gianelle, C., Salotti, S., and Santoalha, A. (2022a). Economic modelling to evaluate Smart Specialisation: an analysis of research and innovation targets in Southern Europe. *Regional Studies* 56(9), 1496-1509.

Barbero, J., Conte, A., Crucitti, F., Lazarou, N.J., Sakkas, S., and Salotti, S. (2022). The impact of the Recovery Fund on EU regions. A spatial general equilibrium analysis. *Regional Studies*, online <u>https://doi.org/10.1080/00343404.2022.2123467</u>

Barbero, J., Christensen, M., Conte, A., Lecca, P., Rodríguez-Pose, A., and Salotti, S. (2023). Improving government quality in the regions of the EU and its system-wide benefits for Cohesion policy. *JCMS: Journal of Common Market Studies*, 61(1), 38-57.

Christensen, M. (2018). Assessing the regional socio-economic impact of the European R&I programme. JRC Working Papers on Territorial Modelling and Analysis No. 05/2018, JRC114347.

Crucitti, F., Lazarou, N., Monfort, P., and Salotti, S. (2022). The RHOMOLO impact assessment of the 2014-2020 cohesion policy in the EU regions. JRC Working Papers on Territorial Modelling and Analysis No. 01/2022, JRC128208.

Di Comite, F., Lecca, P., Monfort, P., Persyn, D., and Piculescu, V. (2018). The impact of Cohesion policy 2007-2015 in EU regions: Simulations with the RHOMOLO interregional dynamic general equilibrium model. JRC Working Papers on Territorial Modelling and Analysis No. 03/2018, JRC114044.

Di Pietro, F., Lecca, P., and Salotti, S. (2021). Regional economic resilience in the European Union: a numerical general equilibrium analysis. *Spatial Economic Analysis* 16(3), 287-312.

Fournier Gabela, J.G. (2020). On the accuracy of gravity-RAS approaches used for inter-regional trade estimation: evidence using the 2005 inter-regional inputoutput table of Japan. *Economic Systems* 32(4), 521-539.

Généreux, P.A., and Langen, B. (2002). The derivation of provincial (interregional) trade flows: The Canadian experience. Statistics Canada working paper #98.

Lecca, P., Barbero, J., Christensen, M., Conte, A., Di Comite, F., Diaz-Lanchas, J., Diukanova, O., Mandras, G., Persyn, D., and Sakkas, S. (2018). RHOMOLO V3: A spatial modelling framework. EUR 29229 EN, Publications Office of the European Union, Luxembourg, 2018, ISBN 978-92-79-85886-4, doi: 10.2760/671622, JRC118661.

Lecca, P., Christensen, M., Conte, A., Mandras, G., and Salotti, S. (2020). Upward pressure on wages and the interregional trade spillover effects under demand-side shocks. *Papers in Regional Science* 99(1), 165-182.

Liu, W., Li, X., Liu, H., Tang, Z., and Guan, D. (2015). Estimating inter-regional trade flows in China: A sector-specific statistical model. *Journal of Geographical Sciences* 25, 1247-1263.

Los, B., McCann, P., Springford, J., and Thissen, M. (2017). The mismatch between local voting and the local economic consequences of Brexit. *Regional Studies* 51(5), 786-799.

Mainar-Causapé, A.J., Ferrari, E., and McDonald, S. (2018). Social Accounting Matrices: basic aspects and main steps for estimation. EUR 29297 EN, JRC Technical Reports. doi: 10.2760/010600

Miller, R.E., and P.D. Blair, P.D. (2009). *Input–Output Analysis: Foundations and Extensions*. Cambridge University Press, Cambridge.

Persyn, D., Barbero, J., Díaz-Lanchas, J., Lecca, P., Mandras, G., and Salotti, S. (2023). The ripple effects of large-scale transport infrastructure investment. *Journal of Regional Science*, https://doi.org/10.1111/jors.12639

Persyn, D., Díaz-Lanchas, J., and Barbero, J. (2022). Estimating distance and road transport costs between and within European Union regions. *Transport Policy* 124, 33-42.

Pyatt, G., and Round, J. (1985). *Social Accounting Matrices: a Basis for Planning*. The World Bank, Washington.

Pyatt, G., and Thorbecke, E. (1976). *Planning Techniques for a Better Future*. International Labour Office, Geneva.

Remond-Tiedrez, I., and Rueda-Cantuche, J.M. (2019). *EU Inter-Country Supply, Use and Input-Output Tables – Full International and Global Accounts for Research in Input-Output Analysis (FIGARO) 2019 Edition*. Luxembourg: Publications Office of the European Union.

Rodríguez-Pose, A. (2017). The revenge of the places that don't matter (and what to do about it). *Cambridge Journal of Regions, Economy and Society* 11(1), 189-209. ISSN 1752-1378. DOI: 10.1093/cjres/rsx024

Sakkas, S. (2018). The macroeconomic implications of the European Social Fund: An impact assessment exercise using the RHOMOLO model. JRC Working Papers on Territorial Modelling and Analysis No. 01/2018, European Commission, JRC113322.

Simini, F., González, M.C., Maritan, A., and Barabási, A. (2012). A universal model for mobility and migration patterns. *Nature* 484, 96-100.

Stone, R. (1947). *Measurement of National Income and the Construction of Social Accounts*. Geneva, United Nations.

Thissen, M., Diodato, D., and van Oort, F.G. (2013a). Integrated regional Europe: European regional trade flows in 2000. The Hague: PBL Netherlands Environmental Assessment Agency.

Thissen, M., Diodato, D., and van Oort, F.G. (2013b). Integration and convergence in regional Europe: European regional trade flows from 2000 to 2010. The Hague: PBL Netherlands Environmental Assessment Agency.

Thissen, M., Van Oort, F., Diodato, D., and Ruijs, A. (2013c). *European Regional Competitiveness and Smart Specialization; Regional Place-Based Development Perspectives in International Economic Networks*. Cheltenham: Edward Elgar.

Thissen, M., Di Comite, F. Kancs, D., and Potters, L. (2014). Modelling interregional trade flows: Data and methodological issues in RHOMOLO. Working Paper 02/2014, ISBN: 978-92-79-44509-5, doi: 10.2776/871154, European Commission, Directorate General for Regional and Urban Policy, Brussels.

Thissen, M., Ivanova, O., Mandras, G., and Husby, T. (2019). European NUTS 2 regions: construction of interregional trade-linked Supply and Use tables with consistent transport flows. JRC Working Papers on Territorial Modelling and Analysis No. 01/2019, European Commission, Seville, JRC115439.

## List of abbreviations

- ASA Annual sector accounts
- CGE Computable general equilibrium
- COE Compensation of employees
- CPA Classification of products by activity
- CPI Consumer price index
- EU European Union

FIGARO – Full international and global accounts for research in input-output analysis

- GAMS General algebraic modelling system
- GDP Gross domestic product
- GFCF Gross fixed capital formation
- GTC Generalised transport cost
- GVA Gross value added
- IC Intercountry
- ICIO Intercountry input-output
- IO Input-output
- IRIO Interregional input-output
- LFS Labour force survey

NACE - Nomenclature statistique des activités économiques dans la communauté Européenne

- NPISH Non-profit institutions serving households
- NUTS Nomenclature of territorial units for statistics
- OECD Organization for economic cooperation and development
- RMSPE Root mean square percentage error
- RMSWEPE Root mean square weighted error and percentage error
- ROW Rest of the world
- SAM Social accounting matrix
- SBS Structural business statistics
- SUIOT Supply, use and input-output tables
- SUT Supply and use table
- TFP Total factor productivity

# Appendix

DE26

Unterfranken

| EU 235 regions | Region Name                    | DE27 | Schwaben                    |
|----------------|--------------------------------|------|-----------------------------|
| AT11           | Burgenland (AT)                | DE30 | Berlin                      |
| AT12           | Niederösterreich               | DE40 | Brandenburg                 |
| AT13           | Wien                           | DE50 | Bremen                      |
| AT21           | Kärnten                        | DE60 | Hamburg                     |
| AT22           | Steiermark                     | DE71 | Darmstadt                   |
| AT31           | Oberösterreich                 | DE72 | Gießen                      |
| AT32           | Salzburg                       | DE73 | Kassel                      |
| AT33           | Tirol                          | DE80 | Mecklenburg-Vorpommern      |
| AT34           | Vorarlberg                     | DE91 | Braunschweig                |
| BE10           | Région de Bruxelles-Capitale / | DE92 | Hannover                    |
|                | Brussels Hoofdstedelijk Gewest | DE93 | Lüneburg                    |
| BE21           | Prov. Antwerpen                | DE94 | Weser-Ems                   |
| BE22           | Prov. Limburg (BE)             | DEA1 | Düsseldorf                  |
| BE23           | Prov. Oost-Vlaanderen          | DEA2 | Köln                        |
| BE24           | Prov. Vlaams-Brabant           | DEA3 | Münster                     |
| BE25           | Prov. West-Vlaanderen          | DEA4 | Detmold                     |
| BE31           | Prov. Brabant Wallon           | DEA5 | Arnsberg                    |
| BE32           | Prov. Hainaut                  | DEB1 | Koblenz                     |
| BE33           | Prov. Liege                    | DEB2 | Trier                       |
| BE34           | Prov. Luxembourg (BE)          | DEB3 | Rheinhessen-Pfalz           |
| BE35           | Prov. Namur                    | DEC0 | Saarland                    |
| BG31           | Severozapaden                  | DED2 | Dresden                     |
| BG32           | Severen tsentralen             | DED4 | Chemnitz                    |
| BG33           | Severoiztochen                 | DED5 | Leipzig                     |
| BG34           | Yugoiztochen                   | DEE0 | Sachsen-Anhalt              |
| BG41           | Yugozapaden                    | DEF0 | Schleswig-Holstein          |
| BG42           | Yuzhen tsentralen              | DEG0 | Thüringen                   |
| CY00           | Kypros                         | DK01 | Hovedstaden                 |
| CZ01           | Praha                          | DK02 | Sjælland                    |
| CZ02           | Strední Cechy                  | DK03 | Syddanmark                  |
| CZ03           | Jihozápad                      | DK04 | Midtjylland                 |
| CZ04           | Severozápad                    | DK05 | Nordjylland                 |
| CZ05           | Severovýchod                   | EE00 | Eesti                       |
| CZ06           | Jihovýchod                     | EL30 | Attiki                      |
| CZ07           | Strední Morava                 | EL41 | Voreio Aigaio               |
| CZ08           | Moravskoslezsko                | EL42 | Notio Aigaio                |
| DE11           | Stuttgart                      | EL43 | Kriti                       |
| DE12           | Karlsruhe                      | EL51 | Anatoliki Makedonia, Thraki |
| DE13           | Freiburg                       | EL52 | Kentriki Makedonia          |
| DE14           | lubingen                       | EL53 | Dytiki Makedonia            |
| DE21           | Oberbayern                     | EL54 | Thessalia                   |
| DE22           | Niederbayern                   | EL61 | Ipeiros                     |
| DE23           | Oberpfalz                      | EL62 | Ionia Nisia                 |
| DE24           | Oberfranken                    | EL63 | Dytiki Ellada               |
| DE25           | Mittelfranken                  | EL64 | Sterea Ellada               |

#### Table A1: NUTS2 regions in the dataset (NUTS 2016 Classification)

| EL65  | Peloponnisos               | HU12   | Pest                               |
|-------|----------------------------|--------|------------------------------------|
| ES11  | Galicia                    | HU21   | Közép-Dunántúl                     |
| ES12  | Principado de Asturias     | HU22   | Nyugat-Dunántúl                    |
| ES13  | Cantabria                  | HU23   | Dél-Dunántúl                       |
| ES21  | País Vasco                 | HU31   | Észak-Magyarország                 |
| ES22  | Comunidad Foral de Navarra | HU32   | Észak-Alföld                       |
| ES23  | La Rioja                   | HU33   | Dél-Alföld                         |
| ES24  | Aragón                     | IE04   | Northern and Western               |
| ES30  | Comunidad de Madrid        | IE05   | Southern                           |
| ES41  | Castilla y León            | IE06   | Eastern and Midland                |
| ES42  | Castilla-La Mancha         | ITC1   | Piemonte                           |
| ES43  | Extremadura                | ITC2   | Valle d'Aosta/Vallée d'Aoste       |
| ES51  | Cataluña                   | ITC3   | Liguria                            |
| ES52  | Comunidad Valenciana       | ITC4   | Lombardia                          |
| ES53  | Illes Balears              | ITF1   | Abruzzo                            |
| ES61  | Andalucía                  | ITF2   | Molise                             |
| ES62  | Región de Murcia           | ITF3   | Campania                           |
| ES63  | Ciudad Autónoma de Ceuta   | ITF4   | Puglia                             |
| ES64  | Ciudad Autónoma de Melilla | ITF5   | Basilicata                         |
| ES70  | Canarias                   | ITF6   | Calabria                           |
| FI19  | Länsi-Suomi                | ITG1   | Sicilia                            |
| FI1B  | Helsinki-Uusimaa           | ITG2   | Sardegna                           |
| FI1C  | Etelä-Suomi                | ITH1   | Provincia Autonoma di              |
| FI1D  | Pohjois- ja Itä-Suomi      |        | Bolzano/Bozen                      |
| FI20  | Åland                      |        | Vonete                             |
| FR10  | Ile-de-France              |        | Friuli Vanazia Ciulia              |
| FR B0 | Centre — Val de Loire      |        |                                    |
| FRC1  | Bourgogne                  |        |                                    |
| FRC2  | Franche-Comté              |        |                                    |
| FRD1  | Basse-Normandie            | III2   | Marcho                             |
| FRD2  | Haute-Normandie            |        |                                    |
| FRE1  | Nord-Pas de Calais         |        | Sostinàs regionas                  |
| FRE2  | Picardie                   |        | Vidurio invokoru Lietuvos regionas |
| FRF1  | Alsace                     | L102   |                                    |
| FRF2  | Champagne-Ardenne          |        | Latvija                            |
| FRF3  | Lorraine                   | LV00   |                                    |
| FR G0 | Pays de la Loire           | NI 1 1 | Groningen                          |
| FRH0  | Bretagne                   | NL12   |                                    |
| FRI1  | Aquitaine                  | NI 13  |                                    |
| FRI2  | Limousin                   | NI 21  | Overilesel                         |
| FRI3  | Poitou-Charentes           | NL 2 2 | Gelderland                         |
| FRJ1  | Languedoc-Roussillon       | NI 23  | Elevoland                          |
| FRJ2  | Midi-Pyrénées              | NL 31  |                                    |
| FRK1  | Auvergne                   | NL22   | Neord Helland                      |
| FRK2  | Rhône-Alpes                | NL 22  |                                    |
| FRLO  | Provence-Alpes-Côte d'Azur |        | Zeeland                            |
| FR M0 | Corse                      |        | Noord-Brabant                      |
| HR03  | Jadranska Hrvatska         | NI / 7 |                                    |
| HR04  | Kontinentalna Hrvatska     | DI 01  |                                    |
| HU11  | Budapest                   | PL21   | таторовкие                         |

| PL22 | Śląskie                      | RO11 | Nord-Vest           |
|------|------------------------------|------|---------------------|
| PL41 | Wielkopolskie                | R012 | Centru              |
| PL42 | Zachodniopomorskie           | R021 | Nord-Est            |
| PL43 | Lubuskie                     | R022 | Sud-Est             |
| PL51 | Dolnośląskie                 | RO31 | Sud-Muntenia        |
| PL52 | Opolskie                     | R032 | București-Ilfov     |
| PL61 | Kuja wsko-pomorskie          | RO41 | Sud-Vest Oltenia    |
| PL62 | Warmińsko-mazurskie          | R042 | Vest                |
| PL63 | Pomorskie                    | SE11 | Stockholm           |
| PL71 | Łódzkie                      | SE12 | Östra Mellansverige |
| PL72 | Świętokrzyskie               | SE21 | Småland med öarna   |
| PL81 | Lubelskie                    | SE22 | Sydsverige          |
| PL82 | Podkarpackie                 | SE23 | Västsverige         |
| PL84 | Podlaskie                    | SE31 | Norra Mellansverige |
| PL91 | Warszawski stołeczny         | SE32 | Mellersta Norrland  |
| PL92 | Mazowiecki regionalny        | SE33 | Övre Norrland       |
| PT11 | Norte                        | SI03 | Vzhodna Slovenija   |
| PT15 | Algarve                      | SI04 | Zahodna Slovenija   |
| PT16 | Centro (PT)                  | SK01 | Bratislavský kraj   |
| PT17 | Área Metropolitana de Lisboa | SK02 | Západné Slovensko   |
| PT18 | Alentejo                     | SK03 | Stredné Slovensko   |
| PT20 | Região Autónoma dos Açores   | SK04 | Východné Slovensko  |
| PT30 | Região Autónoma da Madeira   | _    |                     |
|      | -                            |      |                     |

| Code (64<br>activities) | Description   | Code (56<br>activities) |
|-------------------------|---|-------------------------|
| A01                     | Crop and animal production, hunting and related service activities  |                         |
| A02                     | Forestry and logging  | A02-A03                 |
| A03                     | Fishing and aquaculture   | A02-A03                 |
| В                       | Mining and quarrying  | В                       |
| C10T12                  | Manufacture of food products, beverages, and tobacco products   | C10T12                  |
| C13T15                  | Manufacture of textiles, wearing apparel, and leather and related products  | C13T15                  |
| C16                     | Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials               | C16                     |
| C17                     | Manufacture of paper and paper products   | C17                     |
| C18                     | Printing and reproduction of recorded media   | C18                     |
| C19                     | Manufacture of coke and refined petroleum products  | C19                     |
| C20                     | Manufacture of chemicals and chemical products  | C20                     |
| C21                     | Manufacture of basic pharmaceutical products and pharmaceutical preparations  |                         |
| C22                     | Manufacture of rubber and plastic products  | C22                     |
| C23                     | Manufacture of other non-metallic mineral products  | C23                     |
| C24                     | Manufacture of basic metals   | C24                     |
| C25                     | Manufacture of fabricated metal products, except machinery and equipment  | C25                     |
| C26                     | Manufacture of computer, electronic and optical products  | C26                     |
| C27                     | Manufacture of electrical equipment   | C27                     |
| C28                     | Manufacture of machinery and equipment n.e.c.   | C28                     |
| C29                     | Manufacture of motor vehicles, trailers and semi-trailers   | C29                     |
| C30                     | Manufacture of other transport equipment  | C30                     |
| C31_32                  | Manufacture of furniture and other manufacturing  | C31_32                  |
| C33                     | Repair and installation of machinery and equipment  | C33                     |
| D35                     | Electricity, gas, steam and air conditioning supply   | D35                     |
| E36                     | Water collection, treatment and supply  | E36                     |
| E37T39                  | Sewerage; waste collection, treatment and disposal activities; materials recovery; remediation activities and other waste management services | E37T39                  |
| F                       | Construction  | F                       |
| G45                     | Wholesale and retail trade and repair of motor vehicles and motorcycles   | G45                     |
|                         |   | ÷                       |

#### Table A2: NACE elements in FIGARO (64 at the national level, 56 after regionalisation)

| G46    | Wholesale trade, except of motor vehicles and motorcycles  | G46    |
|--------|--|--------|
| G47    | Retail trade, except of motor vehicles and motorcycles   | G47    |
| H49    | Land transport and transport via pipelines   | H49    |
| H50    | Water transport  | H50    |
| H51    | Air transport  | H51    |
| H52    | Warehousing and support activities for transportation  | H52    |
| H53    | Postal and courier activities  | H53    |
| Ι      | Accommodation and food service activities  | Ι      |
| J58    | Publishing activities  | J58    |
| 359_60 | Motion picture, video and television programme production, sound recording and music publishing activities ; programming and broadcasting activities               | 359_60 |
| J61    | Telecommunications   | J61    |
| J62_63 | Computer programming, consultancy and related activities; information service activities   | J62_63 |
| K64    | Financial service activities, except insurance and pension funding   | к      |
| K65    | Insurance, reinsurance and pension funding, except compulsory social security  | к      |
| K66    | Activities auxiliary to financial services and insurance activities  | к      |
| L68    | Real estate activities   | L68    |
| M69_70 | Legal and accounting activities; activities of head offices; management consultancy activities   | M69_70 |
| M71    | Architectural and engineering activities; technical testing and analysis   | M71    |
| M72    | Scientific research and development  | M72    |
| M73    | Advertising and market research  | M73    |
| M74_75 | Other professional, scientific and technical activities; veterinary activities   | M74_75 |
| N77    | Rental and leasing activities  | N77    |
| N78    | Employment activities  | N78    |
| N79    | Travel agency, tour operator and other reservation service and related activities  | N79    |
| N80T82 | Security and investigation activities; services to buildings and landscape activities; office administrative, office support and other business support activities | N80T82 |
| 084    | Public administration and defence; compulsory social security  | 084    |
| P85    | Education  | P85    |
| Q86    | Human health activities  | Q86    |

| Q87_88 | Residential care activities; social work activities without accommodation  | Q87_88 |
|--------|--|--------|
| R90T92 | Creative, arts and entertainment activities; libraries, archives, museums and other cultural activities; gambling and betting activities | R-T    |
| R93    | Sports activities and amusement and recreation activities  | R-T    |
| S94    | Activities of membership organisations   | R-T    |
| S95    | Repair of computers and personal and household goods   | R-T    |
| S96    | Other personal service activities  | R-T    |
| Т      | Activities of households as employers; undifferentiated goods - and services - producing activities of households for own use            | R-T    |

| Data source  | Availability | Sectoral/commo<br>dity details  | Geographic<br>al details  | Notes   |
|--|--------------|---|---|---|
| Eurostat regional<br>accounts – GDP,<br>households' incomes,<br>employment and wages | 2000-2019    | 11 NACE Rev. 2<br>sectors (covering<br>the whole<br>economy)              | NUTS 1<br>2016 and<br>NUTS 2<br>2016<br>regions of<br>EU27 + NO<br>+ CH + IS<br>+ MK + TR<br>+ UK |   |
| Eurostat SBS –<br>employment and wages   | 2008-2019    | 89 NACE Rev. 2<br>divisions (covering<br>sectors and private<br>services) | NUTS 1<br>2016 and<br>NUTS 2<br>2016<br>regions of<br>EU27 + UK                                   | The 89<br>divisions are<br>aggregated up<br>to the 56<br>sectors used in<br>the regional<br>dataset |
| Eurostat - Economic<br>accounts for agriculture<br>(agr_r_accts)                     | 1980-2019    | Detailed A sector<br>products   | NUTS 1<br>2016 and<br>NUTS 2<br>2016<br>regions of<br>EU27 + UK                                   |   |
| Eurostat - Hospital beds<br>by NUTS 2 regions<br>(hlth_rs_bdsrg)                     | 1993-2020    |   | NUTS 1<br>2016 and<br>NUTS 2<br>2016<br>regions of<br>EU27 + NO<br>+ CH + IS<br>+ MK + TR<br>+ RS | Used to<br>regionalize Q<br>sector GVA  |
| Eurostat - Students<br>enrolled by education<br>level<br>(educ_uoe_enra11)           | 2013-2020    |   | NUTS 1<br>2016 and<br>NUTS 2<br>2016<br>regions of<br>EU27 + NO<br>+ CH + IS<br>+ MK + TR<br>+ RS | Used to<br>regionalize P<br>sector GVA  |

#### Table A3: List of NUTS-2 statistics for EU27

#### **GETTING IN TOUCH WITH THE EU**

#### In person

All over the European Union there are hundreds of Europe Direct centres. You can find the address of the centre nearest you online (<u>european-union.europa.eu/contact-eu/meet-us\_en</u>).

#### On the phone or in writing

Europe Direct is a service that answers your questions about the European Union. You can contact this service:

- by freephone: 00 800 6 7 8 9 10 11 (certain operators may charge for these calls),
- at the following standard number: +32 22999696,
- via the following form: european-union.europa.eu/contact-eu/write-us en.

#### FINDING INFORMATION ABOUT THE EU

#### Online

Information about the European Union in all the official languages of the EU is available on the Europa website (<u>european-union.europa.eu</u>).

#### **EU publications**

You can view or order EU publications at <u>op.europa.eu/en/publications</u>. Multiple copies of free publications can be obtained by contacting Europe Direct or your local documentation centre (<u>european-union.europa.eu/contact-eu/meet-us en</u>).

#### EU law and related documents

For access to legal information from the EU, including all EU law since 1951 in all the official language versions, go to EUR-Lex (<u>eur-lex.europa.eu</u>).

#### Open data from the EU

The portal <u>data.europa.eu</u> provides access to open datasets from the EU institutions, bodies and agencies. These can be downloaded and reused for free, for both commercial and non-commercial purposes. The portal also provides access to a wealth of datasets from European countries.

# The European Commission's science and knowledge service Joint Research Centre

### **JRC Mission**

As the science and knowledge service of the European Commission, the Joint Research Centre's mission is to support EU policies with independent evidence throughout the whole policy cycle.



EU Science Hub joint-research-centre.ec.europa.eu

- 9 @EU\_ScienceHub
- **f** EU Science Hub Joint Research Centre
- in EU Science, Research and Innovation
- EU Science Hub

O EU Science