Global Trade Analysis Project
https://www.gtap.agecon.purdue.edu/

This paper is from the
GTAP Annual Conference on Global Economic Analysis
https://www.gtap.agecon.purdue.edu/events/conferences/default.asp

The EU28 GTAP Input-Output Tables

Rueda-Cantuche, José M.[a], Revesz, T.[b], Amores, Antonio F.[a], Mraz, M.[a], Ferrari, E.[a], Mainar, A.[a], Montinari, L.[a] and Saveyn, B.[a]

[a]European Commission, Joint Research Centre, Institute for Prospective Technological Studies

[b]Corvinus University of Budapest

Abstract

This paper describes the so called EU-GTAP conversion method developed by the European Commission to produce a set of Input-Output Tables for the 28 Member States for the reference year 2010 under the new European System of Accounts methodology (ESA2010, complying with UN SNA2008) and in compliance with GTAP submission requirements. Such conversion method allows the transformation of the ESTAT Input-Output Tables from NACE Rev.2/ISIC Rev.4 into the GTAP sectorial classification by means of several steps. The resulting EU GTAP IO tables fully comply with Eurostat aggregates and subtotals at a certain common level of aggregation as well as with other official statistics on gross output, value added and foreign trade statistics.

Keywords: GTAP Data Base; Input-Output Tables; European Union

Contents

1. Background

The European Commission (EC) is presently working on the so called EU-GTAP Project, which aims to ensure that the Commission bases its trade modelling analysis on the most reliable and recent Supply, Use and Input-Output tables as inputs to its modelling tools, mainly the GTAP database. Bearing this in mind, the main outcome of this project is the submission (to GTAP) of a set of Input-Output (IO) Tables for the 28 Member States for the year 2010 under the new European System of Accounts methodology (ESA2010/SNA2008) and in compliance with GTAP submission requirements (Huff et al, 2000).

With such purpose, we have used the most recent ESA2010 Eurostat's Supply, Use and IO Tables (with NACE Rev.2 / CPA 2008 resolution) for 2010 and for each Member State (EU28) to make the conversion from NACE/CPA classification into the GTAP classification. The final IO database is expected to be delivered to GTAP by the end of June 2016. For missing countries, we have followed a set of good practice guidelines developed by Eurostat and the EC's Joint Research Centre (Rueda-Cantuche et al, 2013) and, wherever necessary,wehave also projected missing IO tables using an adapted version of the EURO method (Eurostat, 2008). Those guidelines have already been endorsed by the EU Member States through the regular meetings of the Eurostat Technical Group on the Consolidation of European Supply, Use and Input-Output Tables. The IO tables to be delivered to GTAP will include matrices of domestic and import flows distinguishing between intermediate and final uses by activity.

As supplementary tasks, the EU-GTAP Project will investigate the differences in Supply and Use tables for 2010 between the last two European accounting systems (ESA95 and ESA10). Besides, the project will also provide fully-fledged matrices of Taxes less Subsidies on Products that may be split, depending on data availability, into: Value Added Tax; Other taxes on products (excises), excluding import tariffs; Import tariffs, Subsidies on agricultural products; and Other subsidies on products. However, these two tasks fall beyond the scope of this paper and will be reported separately.

2. Eurostat's role in the EU-GTAP Project

The Project counts with the support of Eurostat on the quality of the European Statistics used. They have provided the most recent IO tables available by March 3, 2016 (see details by countries in section 3). Moreover, not only have we used the most recent Eurostat data (IO tables) but we have followed the Eurostat's good practice recommendations for the estimation of missing IO tables (Rueda-Cantuche et al, 2013). Eurostat has been consulted throughout the different stages of the Project. However, in order to assess correctly the role of Eurostat in the EU-GTAP Project, it is important to separate the resulting final GTAP IO database (obtained through the EU-GTAP conversion method) from the original input statistics (IO tables and Supply and Use tables) provided by Eurostat.

3. Methodology

This section introduces the GTAP requirements for the outcome of the EU-GTAP Project (Section 3.1) and describes the main features of the processes of constructing the missing ESTAT Input-Output Tables (Section 3.2) and the GTAP Input-Output Tables (Section 3.3). This section basically describes how we make sure that the most recent updated Eurostat data and methods are incorporated in the results of the Project.

3.1. GTAP requirements

The main objective of the EU-GTAP Project is twofold: the Input-Output Tables produced must be in line with GTAP requirements and must include the most recent updated Supply, Use and Input-Output Tables (and methods) from Eurostat.As regard the compliance with GTAP requirements, Huff et al (2000) describe the requirements of the Input-Output databases contributions. They refer to the following aspects:

a) The construction of Input-Output tables (Huff et al, 2000, section 2)
b) The product breakdown should match GTAP sectorial classification and the IO table should have GTAP's format (Huff et al, 2000, sections 3 and 4)
c) Treatment of imports (Huff et al, 2000, section 5)
d) Checking accounting identities and non-negativity (Huff et al, 2000, section 6)
e) Reporting data sources and problems encountered should be included into documentation (Huff et al, 2000, section 8)

In line with these requirements, the final dataset will consist of a set of IOTs for the 28 Member States for 2010 in the new ESA2010/SNA2008 and the GTAP classification, to be delivered by June 2016. In particular, this submission will correspond to the so called UF tables (strictly IO tables with a distinction between domestic and import uses) and UP tables (IO tables plus Taxes less Subsidies on Products). A final report will be written describing the methodology, data sources and problems encountered, of which its final version will also be submitted by the same date.

3.2. Process of estimation: ESTAT IO tables

The Regulation (EU) No 549/2013 of the European Parliament and of the Council of 21 May 2013 on the European System of National and Regional Accounts in the European Union implemented the European System of National Accounts (ESA 2010). This regulation determines the methodology to be used for the compilation of national accounts data to be submitted to Eurostat, as well as the data transmission programme. The transmission of data related to the Supply, Use and Input-Output Tables (SUIOTs) from the Member States and EFTA countries is defined in this regulation (annual for Supply and Use Tables and five-yearly for Input-Output Tables).

The European System of National and Regional Accounts (ESA 2010) is the newest internationally compatible EU accounting framework for a systematic and detailed description of an economy (it follows closely the SNA2008). ESA 2010 was published in the Official Journal on 26 June 2013 and it was implemented as from September 2014; from that date onwards the data transmission from Member States to Eurostat follows ESA 2010 rules. The ESA2010 Transmission programme (TP) of data describes the programme of national accounts data delivery within the framework of the new ESA 2010, as defined in Annex B of the Council Regulation (EU) No 549/2013 of the European Parliament and of the Council of 21 May 2013 (cf. also Article 3 of this regulation).

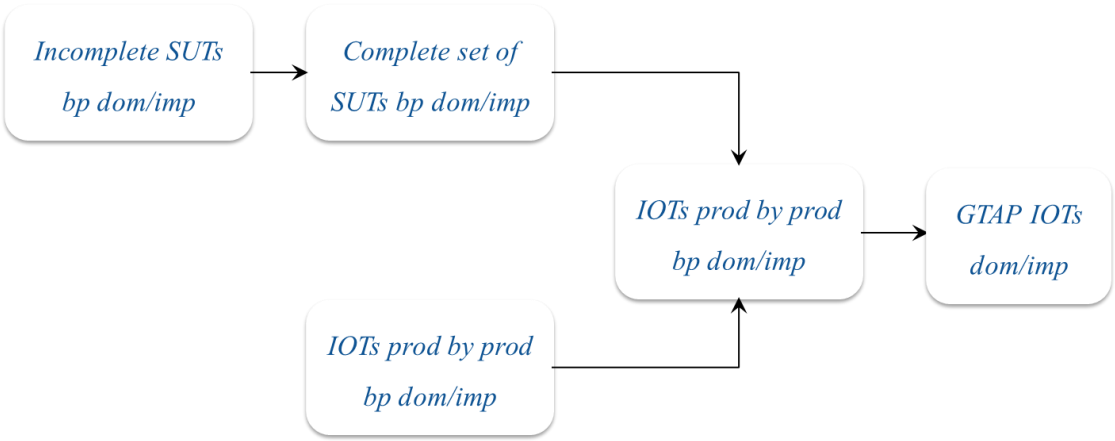
The ESA2010 TP establishes that Member States must deliver on an annual basis Supply Tables at basic prices, including a transformation into purchasers' prices and Use Tables at purchasers' prices; and on a five-yearly basis (for reference years ending in 0 or 5) Input-Output Tables at basic prices. With the new ESA2010 TP, the following five additional tables at current prices must also be delivered starting from the reference year 2010 onwards:

— Use table at basic prices;
— Use table for domestic output at basic prices;
— Use table for imports at basic prices;
— Table of trade and transport margins;
— Table of taxes less subsidies on products

This project therefore relies on the submissions of the EU Member States and estimates the missing IO tables using as much as possible official statistics and the Eurostat and the EC's JRC expertise coming from their current and past experience in the construction of the EU and euro area consolidated SUIOTs (Rueda-Cantuche et al, 2013 and Eurostat, 2008).

The process of construction of the IO (UF) tables is therefore different depending on the available information (Figure 1). Wherever official product by product IO tables were available with a proper distinction between domestic and import uses, we have directly transformed them into the GTAP classification. But the most demanding task was to produce IO tables out from official Supply and Use Tables (SUTs) at basic prices. Indeed, although there were official SUTs available for some countries, it was not the case for others. In such cases, we adopted the good practice guidelines developed by the EC's JRC for Eurostat (Rueda-Cantuche et al, 2013) and an adapted version of the so called EURO method (Eurostat, 2008) for the estimation and projection of SUTs, respectively. Compared with other projection methods like those using cross-entropy functions or the minimum information loss principle, the EURO method has the advantage of assuming the Leontief input-output model to make the projections, rather than minimising the distance between the resulting table and the initial one. Further details on the methodology can be found in previous reports of the Project (Rueda-Cantuche et al, 2015, pp. 10-20)

Figure 1 Construction of the UF (IO) tables



Once SUTs have been projected or estimated, product by product IO tables were constructed using the industry technology assumption (Model B, in Eurostat, 2008). Those IO tables were eventually transformed into UF tables complying with the GTAP classification.If the distinction between domestic and import uses was missing, we have used again the Eurostat's good practice guidelines (Rueda-Cantuche et al, 2013) to estimate separately domestic and import SUTs before making the conversion to the GTAP classification.

As of March 3, 2016 Eurostat provided 19 official IO tables (Germany, the Czech Republic, Estonia, Greece, France, Hungary, Ireland, Italy, Sweden, Slovenia, Slovakia, Romania, Denmark, Spain, the United Kingdom, Lithuania, Poland, Austria and Croatia). Other four countries (Finland, Latvia , Malta and the Netherlands) provided Supply and Use Tables at basic prices, which were used to estimate IO tables using the so called industry technology assumption (Model B, in Eurostat (2008)). With respect to the remaining five countries: (1) by using the EURO method (Eurostat, 2008) we projected the SUTs at basic prices from 2009 up to 2010 for Cyprus; subsequently, we used the industry technology assumption to estimate the Cypriot IO tables; and (2) by using a set of Eurostat's good practice guidelines (Rueda-Cantuche et al, 2013), we estimated Supply and Use Tables at basic prices for the following countries: Bulgaria, Luxembourg, Belgium and Portugal, which were further used for the estimation of their corresponding IO tables. All Supply, Use and IO tables have been used in Euro currency (converted from national currency whenever necessary by using the Eurostat's official annual exchange rate).

3.3. Process of estimation: GTAP IO tables (UF tables)

The conversion of ESTAT IO tables into GTAP IO tables implies (dis)aggregations of four different types:

a) **One-to-one** cases; where one single ESTAT sector corresponds to one single GTAP sector, such as Insurance (isr), Water transport (wtp), Air transport (atp), among others. In all these cases, GTAP IO values fully match those of ESTAT.

b) **Many-to-one** cases; where many ESTAT sectors correspond to one single GTAP sector, such as Trade (trd), which gathers "wholesale and retail trade; repair of motor vehicles and motorcycles" (G45, G46, G47), "accommodation" (I55) and "repair of computers and personal and household goods" (S95). In such cases, the conversion is nothing else than just a simple aggregation.

c) **One-to-many** cases**;** where one single ESTAT sector corresponds to many GTAP sectors, such as the "electricity, gas, steam and air conditioning supply" (D35), which has to be split up into "electricity" (ely) and "gas manufacture distribution" (gdt); and the "crop and animal production, hunting and related service activities" (A01), which has to be broken down into twelve different GTAP sectors. In those cases, different allocation shares have been used to make the splits (see detailed description in the next section).

d) **Many-to-many** cases; where many ESTAT sectors correspond to many GTAP sectors, such as "motion picture, video and television programme production, sound recording and music publishing activities" (J59), of which "sound recording and music publishing activities" (J59.2) must be allocated to the GTAP sector "paper products publishing" (ppp) and "motion picture, video and television programme activities" (J59.1) that has to be allocated to "recreational and other services" (ros). Besides, the GTAP sector "ppp" is also made up of contributions from ESTAT sectors such as "paper and paper products" (C17), "printing and recording services" (C18) and "publishing activities" (J58); and the GTAP sector "ros" is made up of contributions from "creative, arts and entertainment services; library, archive, museum and other cultural services; gambling and betting services" (R90 to R92), "sporting services and amusement and recreation services" (R93), "other personal services" (S96) and "services of households as employers" (T97).In those cases, different allocation shares have been used to make the splits (see detailed description in the next section).

Evidently, the first two cases do not entail a big difficulty and does not deserve additional comments. The third case requires knowing certain allocation shares that one way or the other will have to be searched through more detailed statistics. However, the solution given to the fourth type of cases needs further explanation. The procedure designed to deal with them have been denoted as **GTAP-Profile cleaning process** and it aims to elaborate a sort of intermediate classification (IMC) under which there are no "many-to-many" cases any more[1].

For instance, "man-made fibres"(C20.6) are considered chemical products (C20) in the ESTAT IO tables but they are considered instead textile products (tex) in the GTAP classification. This implies that a part of the ESTAT sector C20 (i.e. C20.6) has to be

[1]This idea was initially suggested by Badri Narayanan (Purdue University) and supported by Zornitsa Kutlina-Dimitrova (European Commission, DG TRADE).

reallocated to the ESTAT sector C13 (Textiles) because the GTAP sector (tex) includes "man-made fibres". As a result, the adjusted (or modified) new ESTAT sector C13 should now include all of the same (textile) commodities as the GTAP sector "tex", leading to a one-to-one correspondence (i.e. GTAP-Profile cleaned sector C13 vs. GTAP sector "tex"). Ultimately, the rest (remaining part) of the ESTAT sector C20 would fully correspond to the GTAP sector of chemical products (crp).

The GTAP-Profile cleaning process turned out to be highly time and resource consuming, mainly due to the fact that the GTAP classification has a clear correspondence to the NACE Rev.1.1/ISIC Rev.3 Classification but not to the new NACE Rev.2/ISIC Rev.4 Classification. Hence, it is very urgent for future GTAP database releases (or updates) to revise the GTAP classification and re-arrange it in line with newer classification systems in order to avoid "many-to-many" cases. Countries are progressively moving into NACE Rev.2/ISIC Rev.4 and it will be very difficult to update future GTAP IO tables still based on old versions of previous systems of classifications.

The appendix provides the eventual *GTAP-Profile cleaned (IMC)* ESTAT sectors and their correspondence to the GTAP sectors. To elaborate such a mapping we used Narayanan et al (2009) correspondences between NACE Rev.1.l and the list of 57 GTAP sectors, the ESTAT's official correspondence tables from NACE Rev.1.1 to NACE Rev.2 at 6-digit level and the specific correspondence table between NACE Rev.2 (4-digit) and GTAP sectors produced (although more aggregated) by the APRAISE research project (EPU-NTUA, 2013). The necessary data to estimate category-, country- and use(r)-specific transformation coefficient/share matrices to disaggregate the elements of the domestic and import ESTAT IO tables and, subsequently, convert them into GTAP IO tables came from available Supply, Use and IO tables, the GTAP9 database, Harmonized System (HS) foreign trade statistics, the Structural Business Survey and the Agricultural Economic Accounts, among others.

In particular, we also used the following datasets in the data processing:

a) Final Report of the APRAISE project (correspondence between NACE Rev.2 and GTAP classification).However, the correspondence turned out to be not one-to-one with the GTAP classification, mainly because the APRAISE's correspondence matrix (calibrated for the 2007 GTAP8 output values for the EU countries) mapped 64 NACE Rev.2 sectors into 26 GTAP sectors only and not the required 57 GTAP sectors. As a result, we could not use the APPRAISE's correspondence matrix to split, for instance, the values of agriculture and energy utilities into the requested 12 agriculture and 8 food-industry sectors and into the electricity, supply and gas distribution sectors, respectively.
b) The 4 and 6 digit-level HS foreign trade statistics (COMEXT) for the EU countries (downloadable from the Eurostat homepage) and the Eurostat's RAMON correspondence tables between the HS 4/6 digits product classification and NACE Rev.2 classification at 4 digit level.

c) The PRODCOM database (downloadable from the Eurostat Statistical Database), which contains the value of outputs, exports and imports of about 3700 industrial products by NACE Rev.2 classification at 8 digit level.
d) The ESTAT Structural Business Survey's data on outputs, value added and main cost categories of about 400 industrial sectors.
e) The US Geological Survey Yearbook (USGSY), used mainly to split the IOdata on mining.
f) The energy balances of the International Energy Agency.
g) The Agricultural Economic Accounts (downloadable from the Eurostat Statistical Database, containing output mix and main costs of the agricultural sector of the EU countries).
h) The CAPRI[2] database.
i) The GTAP9 dataset (used mainly as initialshares of domestic and import flows by user).
j) The report of the Matrix Insight Ltd (2013) and other reports to separate out the tobacco industry and the food and beverage industry.
k) Other specific sectorial reports: for rice processing industries (Global Rice Science Partnership, 2013) and sugar manufacturing activities (European Commission, 2012).

For future updates of the EU-GTAP IO tables, we would highly recommend using in addition detailed Supply, Use and IO tables from the National statistical Offices, whenever available. We have not used them extensively in the estimating process this time provided that we have put most of our efforts in designing a conversion method that can hopefully be used in forthcoming updates of the EU-GTAP IO tables. Now that this method exists, more time could be envisaged to search for more detailed IO tables (e.g. Germany, Hungary, the Czech Republic and the United Kingdom); however, resource constraints and timelines will certainly determine the extent to which they will be used.

Consistency with ESTAT IO tables is of utmost importance in this Project provided the high quality standards followed by official statistics. The estimated GTAP IO tables are therefore consistent (i.e. 'block-wise' add-up consistency) with the ESTAT IO tables. In addition, other official statistics also provide value added, gross output and total imports by GTAP sectors (more detailed) or information to fairly estimate them (although such estimates required very careful considerations and efforts, including the reconciliation of at least seemingly and occasionally inconsistent data). Accordingly, the conversion method from ESTAT IO tables into GTAP IO tables has indeed used official statistics as much as possible to build up the so called matrices of transformation coefficients and to benchmark the resulting GTAP IO tables to the ESTAT IO tables. The estimations are done separately for domestic and import IO tables as well as the consistency benchmarks.

[2] http://www.capri-model.org/dokuwiki/doku.php?id=start

The lack of proper official data made us sometimes endogenously estimate **gross outputs by GTAP sectors** (mainly in services). In all those cases, all candidate data sources proved to be incomplete. For example, for many EU countrieseither the data for the tobacco industry are confidential or simply missing. Besides, although the PRODCOM data were sufficiently detailed to work out the correspondence between NACE Rev.2 and GTAP sectors for certain products, they generally proved to be not sufficiently representative to make out reliable estimates of gross outputs (i.e. the iron and steel products in Hungary).

The same can be said about the data coming from the Structural Business Survey (SBS), which reported gross outputs by industry instead of by product - this was particularly problematic in the mining sector. The SBS data submission of the EU countries proved to be very heterogeneous, which prevented us to use them in our general process of transformation. However, the SBS data still were quite useful for some sectors and countries.

We managed to retrieve some missing data from other official sources and also sometimes reasonably estimate them by using other related sources as proxies (e.g. detailed employment or energy balance sheet data). In other cases, we have dealt with data country specific features. A similar story can be told about the agricultural satellite accounts.

The US Geological Survey Yearbook was very useful for finding out the physical amounts of the outputs produced by the mining sector. However, we had to estimate the corresponding sales prices from external sources like the OECD energy price statistics (although not available by country and user). Sometimes, it was not even clear enough whether the produced quantities were conveyed to the market or even taken into account (imputed) in the IO tables at all.

In relation to the **Taxes less Subsidies on Products** (TLS), we adopted a simplified approach awaiting for the second part of the Project where we will obtain more precise estimations of TLS by GTAP sectors. For the moment being, we made simple allocations proportionally to the above estimated gross outputs by GTAP sector.

Sometimes, we also had to estimate endogenously the **value added by GTAP sectors** in the absence of comprehensive and reliable data from official statistics. Given the endogenous gross output estimated as described above, we computed the value added residually, as a difference between the gross output and the total estimated (domestic and imported) intermediate uses. According to Huff et al (2000), value added has to be split up into three components: labour compensation (lab), other net taxes on production (ontp) and capital compensation (cap). We used SBS data to estimate the labour compensation components by GTAP sectors (shares) and the estimated gross outputs by GTAP sectors to allocate the other net taxes on production (shares). Eventually, capital compensation was estimated residually as the difference between gross output and total intermediate uses (domestic and imported), TLS, labour compensation and other net taxes on production. However, there were exceptions whenever the capital values turned out to be negative and

therefore, we estimated instead the labour cost as residual.

Regarding **exports/imports**, we used HS foreign trade statistics from COMEXT and the Eurostat's RAMON correspondence tables between the HS 4/6 digits product classification and the NACE Rev.2 (4 digits) classification. Then, by using the APRAISE's correspondence tables between NACE Rev.2 and GTAP sectors we allocated each NACE Rev.2 code to the appropriate GTAP sector code. In the (unlikely) case that we found not sufficiently detailed information about the correct correspondence to a single GTAP sector, we opted for choosing the dominant one to match it to its correspondent NACE Rev.2 code. In doing this, we should also avoid causing new "many-to-many" cases, which are mainly caused by NACE Rev.2 codes (e.g. salt recycling activities) that formerly corresponded to the main related GTAP sector (e.g. food industry) but now it corresponds to a very different one (e.g. mineral products).Presumably, many of these cases are due to the fact that the GTAP classification was designed in accordance with NACE Rev.1.1 and with NACE Rev.2 there are some activities (notably the recycling and repairing services) that were separated out. This is indeed one more reason to recommend an urgent update of the GTAP classification to make it consistent with NACE Rev.2 (or ISIC Rev.4).As for services exports we have also used the APRAISE's correspondence tables. In the future, as long as the ESTAT's services foreign trade data become more available, it would be advisable to use them.

Most of the work in the conversion process of ESTAT IO tables is concentrated on the estimation of GTAP IO tables that are fully consistent with ESTAT IO values (block-wise add-up consistency) and have product-wise balanced supply and demand. However, these (prior) tables do not necessarily match the target values of gross output, value added and imports by GTAP sector/product provided by official statistics. Hence, it is absolutely necessary to set up an **entropy model** to get the final GTAP IO tables, subject to:

a) full consistency with ESTAT IO tables (block-wise add-up consistency)
b) balanced supply and demand
c) (estimated/exogenous) gross outputs by GTAP sectors
d) (estimated/exogenous) value added by GTAP sectors
e) (estimated/exogenous) imports by GTAP sectors
f) and other constraints on negatives and upper/lower bounds in changes in inventories and export/output ratios that turned out to be necessary.

Concerning the objective function, the entropy model finds – separately for each country –GTAP domestic and import IO tables minimizing their distance to their initial values (priors). We set up the objective function as the sum of the squared relative differences of their corresponding elements (Friedlander, 1961).Note that the numerical results of an entropy model are difficult to explain one by one, since each resulting element may depend on both equations and constraints of the model and it is impossible (or at least cumbersome and difficult) to 'decompose' precisely the total effect on the role/contribution of the individual conditions.

For this reason, it is of utmost importance to estimate good prior tables so that the entropy model can easily find a solution without distorting too much the initial values. If that would be the case, then the final estimates could be almost fully explained by the conversion method and even the contribution of the different steps easily computed. Otherwise, adjustments might be large in certain elements of the resulting GTAP IO tables. Nonetheless, those large differences can be further used for identifying ad-hoc data/model correction mechanisms to eventually end up with more plausible GTAP IO tables. Evidently, there is no perfect solution but still we think the EU GTAP conversion method provides quite satisfactory results for all EU countries.

From a simple comparison of our preliminary results (mostly concentrated on the agricultural and food industry sectors) with previous versions of the GTAP IO tables (GTAP9), we have drawn some general reasons for the most remarkable differences. They are the following:

a) Some input coefficients from the ESTAT IO tables or from other official statistics can be considered to be unclear or difficult to explain. This would need further communication/exploration with the affected National Statistical Offices in order to clarify the related figures. In this Project, we have left such values unchanged and only in some exceptions we have approached the national statistical offices.

b) Some odd values can be determined by the data adjustments (e.g. block-wise add-up consistency) made to rows and columns derived from the conversion method. This was particularly relevant in the estimation of the labour and capital components of the value added. Although, capital is generally estimated residually, sometimes we left labour as a residual in order to avoid (resulting) negative capital values.

c) We found odd values in estimates based on export and imports statistics; indeed, foreign trade statistics generally differ from National Accounts and Balance of Payments statistics and the mapping made between HS codes, NACE Rev.2 and GTAP sectors may have also played an important role. We have identified the so called crowding-out and crowding-in effects when exports and imports turned out to be too high or too low. In other words, if exports are overestimated then, there is a crowding-out effect for the domestic output (underestimated) given a fixed gross output total.

d) Some odd coefficients might be inherited from the GTAP9 values, which were used to compute the initial matrices and therefore, the preliminary GTAP IO tables (priors). For instance, in some cases the average user distribution of input flows across the rows of the IO table was not consistent with our knowledge about the nature of the technology of the given sector (intermediate user).It should be noted here that the comparison was made against the published GTAP9 IO tables, which are not necessarily the ones submitted by GTAP contributors. Ideally, we should have made

the comparison against them.

e) New technologies can appear. For instance, from 2008 onwards (white) sugar was mainly produced in the EU from isoglucose (allocated to other cereals - "gro" - in the GTAP classification) rather than from sugar beet -"c_b" (Zimmer, 2013). This led to lower sugar beet input coefficients in the sugar industry and higher input coefficients from the other cereals. Note, however, that the entropy model would have allocated significant amounts to the own-consumption of the sugar industry even without doing such adjustment but realizing that the total supply (use) of sugar beet had indeed decreased. In some sense, there is some rationality in this result as long as sugar that is not (directly) processed from raw-materials it is instead processed from semi-finished/semi-processed sugar, which is the main product of the sugar industry ("sgr").

f) Sometimes, the odd values come from the limitations of distance minimizing objective functions; whenever the constraints are tight enough the entropy model tends to find extreme solutions with few extremely high coefficients and others very close to zero. This is generally resolved by using exogenous information.

g) We should also be aware that the IO tables are in current prices and therefore, input coefficients may change from one year to another just due to price changes. When comparing GTAP9 IO tables with our estimates, some of the differences might also be due to the different price valuation. This is particularly relevant for the energy sector, where the world oil and gas prices were fluctuating extremely from 2008 to 2015.

h) The entropy model does not consider import-domestic substitution. Therefore, changes in domestic coefficients are not compensated by analogous changes in the import coefficients.

In sum, despite the above problems and uncertainties, we ran successfully the entropy model for each of the EU countries and the results obtained were not only consistent with the ESTAT IO tables but, in many aspects, quite good and of better quality than the current GTAP9 figures (e.g. energy sector).

The next section describes the so called EU-GTAP conversion method and provides a detailed stepwise description of the process.

4. The EU-GTAP conversion method

The present methodological description serves not only to make the existing process and results more understandable for the reader but also serves as a basis for future further developments of the method. The EU-GTAP conversion method consists of seven steps, which are comprehensively described in a numerical example provided in MS Excel (*EU-GTAP_NumExample_FlowChart.xls*). The steps are the following:

1) **GTAP-Profile cleaning** process (IMC) for the domestic and import flows of the IO tables, both for final and intermediate uses;

2) **Block-wise adjustment** of the base year GTAP9 IO tables (block-wise add-up consistency) to the ESTAT IO data;

3) **Estimation of total imports, gross outputs and value added** by GTAP commodities/sectors;

4) **Adjustment of intermediate and final uses** to gross outputs by sector and by commodity;

5) **Recalculation of conversion coefficients** matrices:

6) **Estimation of the preliminary GTAP IO tables** prior to its final balancing process;

7) **Estimation of the final GTAP IO tables** via an ad-hoc entropy model fulfilling all required constraints.

As regard data requirements for applying the EU-GTAP conversion method (*sheet Data*), the following input data is required:

- **GTAP Input-Output tables** of a base year (old version) distinguishing between domestic and import flows (e.g. GTAP9 version). In the numerical example, there are seven GTAP sectors (3 sectors for agriculture activities; refineries; other manufactured products; construction; and services); three final demand components (consumption, investment and exports); taxes less subsidies on products; and three value added categories (labour compensation, other net taxes on production and capital compensation).

- **ESTAT Input-Output Tables** at basic prices of the reference year (2010) distinguishing between domestic and import flows in NACE Rev.2. In the numerical example, there are six NACE sectors (agriculture; refineries; other manufactured products; construction, and 2 services sectors); taxes less subsidies on products; and the same final demand and value added components as in the GTAP IO tables of the base year. However, we consider that some activities of the NACE sector "refineries" should be re-allocated to the NACE sector producing "other manufactured products" provided that the GTAP sector of "other manufactured products" actually include these activities by definition. Besides, we have assumed that the same applies the other way round, i.e.: part of the activities of the "other manufactured products" should be re-allocated to "refineries". Both assumptions also apply for domestic and import flows separately.

- **Transformation matrices** (for domestic and import flows separately) from NACE Rev.2 into the GTAP-Profile cleaned (IMC) classification, which is actually a modified NACE Rev.2 version to account for changes in the classification system of sectors (from NACE Rev.1 to NACE Rev.2). The rows correspond to IMC sectors and the columns to NACE Rev.2 sectors, being the sum of each column equal to one in all cases. In the numerical example, we have considered that 20% (25% for imports) of the NACE sector "refineries" should be re-allocated to the NACE sector "other manufactured products" and that 10% of the NACE sector "other manufactured products" (15% for imports) should be re-allocated to the NACE sector "refineries".

- **Foreign trade statistics** (exports/imports) by GTAP sector in the reference year (2010) using the most disaggregated data as possible (COMEXT). In the numerical example, we only need to disaggregate the agricultural sector into three different GTAP sectors, thus we assumed fictitious distribution (shares) of exports and imports across the three different GTAP sectors, supposedly coming from official statistics. We assumed 97% of the exports of NACE/IMC agricultural products correspond to GTAP sector 3, while 2% to GTAP sector 2 and 1% to GTAP sector 1. For imports, the shares were 45%, 30% and 25%, respectively. All other cases had either one-to-one correspondences or many-to-one correspondences (e.g. services).

- **Gross outputs and value added** by GTAP sector (i.e. shares) using as much official statistics as possible (SBS, Agricultural Accounts, PRODCOM, etc.). In the numerical example, we assumed that 60% of the output of the NACE/IMC agricultural sector came from the GTAP sector 3, 12% from the GTAP sector 2 and 28% from the GTAP sector 1. For value added, the shares were 55%, 20% and 25%, respectively. All other cases had either one-to-one correspondences or many-to-one correspondences (e.g. services).

Table 1 shows the description of the sectors in the different classification systems: GTAP, IMC and NACE Rev.2.

Table 1 Correspondence of classifications

Description	NACE Rev.2	IMC	GTAP
Agriculture	nace1	imc1	gtap1+gtap2+gtap3
Refineries	nace2*	imc2	gtap4
Other manufactured products	nace3*	imc3	gtap5
Construction	nace4	imc4	gtap6
Services	nace5 + nace6	imc5 + imc6	gtap7

* Part of nace2 should be re-allocated to other manufactured products and part of nace3 should be re-allocated to refineries

4.1. Step 1: GTAP-Profile cleaning process

The first step of the process consists in making proper re-allocations across NACE sectors to remove the "many-to-many" cases. In the numerical example, it is basically the conversion from NACE Rev.2 into IMC classification by using the appropriate transformation matrices. We used the domestic transformation matrix to make the conversion of the rows and columns of the domestic IO tables while we used the import transformation matrix to convert the rows of the import IO tables. Instead, the columns of the import IO tables were converted using the domestic transformation matrix provided that imported inputs are still related to domestic production.

This is done in sheet *S1Prof*. The reader can check there that the re-allocations did not change the main totals (gross output, imports and value added) of the ESTAT IO tables. The outcomes of Step 1 are the ESTAT IO tables transformed from NACE Rev.2 into the IMC classification.

4.2. Step 2: Block-wise adjustment to the ESTAT IO tables

As a second step, we used the GTAP9 IO tables and re-scaled them to match the ESTAT IO data by blocks: agriculture, refineries, other manufactured products, construction and services (see Table 1). This is done in sheet *S2Bloc*. There are two main aspects to consider here:

a) Re-exports are originally set to zero in the GTAP IO tables while there is some information in the ESTAT IO tables; hence, we used import shares by GTAP sectors to fill the gaps. They were estimated from HS foreign trade statistics.

b) The eventual comparison between the ESTAT IO tables and the final GTAP IO tables will have to be done on the basis of IMC and GTAP sectors and, particularly, on the basis of the common sectorial aggregation shown in Table 1.

The outcomes of Step 2 are the GTAP9 IO tables benchmarked with ESTAT IO data.

4.3. Step 3: Estimation of total imports, gross outputs and value added by GTAP sectors

As a third step, we estimate the missing total values for imports, gross output and value added by GTAP sectors. Some others are taken from more detailed statistical sources as described in Section 3.

a) For *imports*; we use shares provided by foreign trade statistics, which are then applied to the total imports of the corresponding IMC sector (from Step 2). In the numerical example, this is done for agricultural activities (imc1), which are decomposed into three GTAP sectors (gtap1, gtap2 and gtap3). This estimation is done in sheet *S3a-Impt*. The resulting values are the import totals by GTAP sector to be considered as target values in the final GTAP IO tables.

b) For *gross output*; the rows of the ESTAT IO tables (in IMC classification – from Step 1) are split up into GTAP sectors using the shares obtained in Step 2, which in turn come from benchmarked GTAP9 IO tables and (HS) foreign trade statistics. As a result, the sum of each row will correspond to the endogenously estimated gross output by GTAP sector. These resulting gross outputs would have to be replaced whenever superior exogenous data will become available. In the numerical example, we used existing exogenous shares of gross output to decompose the agricultural activities (imc1) into the corresponding three GTAP sectors (gtap1, gtap2 and gtap3). Hence, we have not used any endogenous estimation, although they are provided for the sake of completeness. This estimation is done in sheet *S3b-Out*. The resulting values are the gross output totals by GTAP sector to be considered as target values in the final GTAP IO tables.

c) For *value added*; in the numerical example, the value added of the three GTAP agricultural sectors have been obtained by applying shares of GTAP9 (adjusted) value added coefficients[3] to the value added of the agricultural sector (imc1) of the ESTAT IO tables. The adjustment of the GTAP9 value added coefficients is made by multiplying them by the ratio: *(targeted) gross output by GTAP sector from Step 3b / gross output by GTAP sector from Step 2*. This estimation is done in sheet *S3c-Va*. The resulting values are the value added totals by GTAP sector to be considered as target values in the final GTAP IO tables. However, analogously to gross output, we have not used any endogenous estimation, although they are provided for the sake of completeness. We have assumed instead that there are official statistics on value added by GTAP sectors (i.e. gtap1, gtap2 and gtap3).

The main outcomes of the Step3 are the provision of target values for imports, gross output and value added by GTAP sectors, either endogenous or exogenously determined.

4.4. Step 4: Adjustment of intermediate and final uses to gross outputs

Fourthly, the domestic and import intermediate flows of the GTAP IO tables obtained from Step 2 are re-scaled column-wise by the ratio: *(targeted) gross output by GTAP sector from Step 3b / gross output from GTAP9 data*. This is done in sheet *S4a-Interm*.

Next, the resulting GTAP IO table (from *S4a-Interm*) is again re-scaled but row-wise in order to get the targeted gross output and import totals by GTAP sector. The ratio applied to domestic uses is: *(targeted) gross output by GTAP sector from Step 3b / gross output from S4a-Interm*; while for imports: *(targeted) imports by GTAP sector from Step 3a / import totals from S4a-Interm*. This is done in sheet *S4b-Domr*.

[3] Value added divided by gross output.

4.5. Step 5: Recalculation of conversion coefficients

In the fifth step, the rows of the ESTAT IO tables (in IMC classification – from Step 1) are split up into GTAP sectors using the (updated) shares or recalculated conversion coefficients calculated from the value of the GTAP IO tables from Step 4. The same applies to final demand components both for domestic and import uses. This is done in sheet *S5RecTrf*.

4.6. Step 6: Estimation of the preliminary IO tables (priors)

The starting point of Step 6 is the semi-transformed GTAP IO table (GTAP x IMC) obtained from Step 5. In Step 6, their columns are converted from IMC sectors to GTAP sectors using the same conversion coefficients as in Step 5. However, now the shares are computed row-wise instead. Final demand components should remain unchanged.

For value added, given the endogenous (or available) gross output estimated as described above, we computed capital compensation residually, as a difference between the gross output and the total estimated (domestic and imported) intermediate uses, TLS, labour compensation and other net taxes on production. We used SBS data to estimate the labour compensation components by GTAP sectors (shares) and the estimated/available gross outputs by GTAP sectors to allocate the other net taxes on production (shares) and TLS (shares). However, there were exceptions whenever the capital values turned out to be negative and therefore, we estimated instead the labour cost as residual.

The main outcomes of Step 6 are the so called "prior" GTAP IO tables. These GTAP IO tables are block-wise benchmarked with ESTAT IO data and balanced from the perspectives of supply and demand. However, they do not necessarily comply with: (see blue cells) targeted output, imports and value added. This is shown in sheet *S6Priors*.

4.7. Step 7: Estimation of the final GTAP IO tables

The previous step provided GTAP IO tables that did not match the targeted values for totals of imports, gross outputs and value added by GTAP sector. Hence, we defined an entropy model based on an objective function that minimizes the squared relative differences between the estimated and the prior GTAP IO tables subject to certain restrictions (Friedlander, 1961). The use of entropy models is justified in the sense that we want to deviate the least from the prior GTAP IO tables in order to meet the targeted totals. Besides, it provides a flexible framework for adding ad-hoc constraints on specific data (particular to one country), exemptions to non-negativity constraints and upper/lower bounds for inventories and export/output ratios, if needed.

The full conversion process, including the entropy model, has been coded in GAMS. In the numerical example, the sheet *S7Entropy* just describes the main features of the model while the sheet *Final* provides the final GTAP IO table. The final GTAP IO tables eventually match:

- ESTAT IO data
- Supply and use totals by sector
- Gross output, imports and value added by sector

5. Concluding remarks and recommendations

This paper presents a summary of the work carried out by the European Commission to produce a set of Input-Output Tables for the 28 Member States for the reference year 2010 under the new European System of Accounts methodology (ESA2010, complying with UN SNA2008) and in compliance with GTAP submission requirements. The so called EU-GTAP conversion method consists of several steps and converts the ESTAT IO tables (NACE Rev.2) into GTAP IO tables (GTAP classification). The resulting EU GTAP IO tables fully comply with Eurostat aggregates and subtotals at a certain common level of aggregation as well as with other official statistics.

The development of the EU-GTAP conversion method turned out to be highly time and resource consuming, mainly due to the fact that the GTAP classification has a clear correspondence to the NACE Rev.1.1/ISIC Rev.3 Classification but not to the new NACE Rev.2/ISIC Rev.4 Classification. In addition, the search for more detailed official statistics became cumbersome as well because of the lack of detailed homogenous information on gross output, value added and foreign statistics by GTAP sector, let alone more detailed IO tables.

Hence, it is very urgent for future GTAP database releases (or updates) to revise the GTAP classification and re-arrange it in line with newer classification systems. Countries are progressively moving into NACE Rev.2/ISIC Rev.4 and it will be very difficult to update future GTAP IO tables still based on old versions of previous systems of classifications.

Besides, we would highly recommend using detailed Supply, Use and IO tables from the National statistical Offices, whenever available (e.g. Germany, Hungary, the Czech Republic and the United Kingdom) for future updates of the EU-GTAP IO tables,; however, resource constraints and timelines will certainly determine the extent to which they will/can be used.

Disclaimer

The views expressed herein are those of the authors and do not necessarily reflect an official position of the European Commission.

References

European Commission (2012) EU SUGAR BALANCE SHEETS: Final production 2009/10, Final production 2010/11, Forecast 2011/12, Balance sheet 2009/10 to 2011/12 - Directorate General for Agriculture and Rural Development, Unit C5, Version: 22 January 2012.

Eurostat (2008) *European Manual of Supply, Use and Input–Output Tables.Methodologies and Working Papers*. Luxembourg, Office for Official Publications of the European Communities.

EPU-NTUA (2013) Assessment of Policy Impacts on Sustainability in Europe - Baseline and exploratory scenarios, parameters and validation, Deliverable no.: D 4.1, Grant Agreement no.: 283121, Project Acronym: APRAISE, Theme: ENV.2011.4.2.1-1: Efficiency Assessment of Environmental Policy Tools Related to Sustainability.

Friedlander, D. (1961) A technique for estimating contingency tables, given marginal totals and some supplemental data, Journal of the Royal Statistical Society, Series A, 124, pp. 412–420.

Global Rice Science Partnership (2013)"Rice almanac", 4th edition, International Rice Research Institute.Los Baños (Philippines).

Huff, K., McDougall, R. and Walmsley, T. (2000) "Contributing Input-Output Tables to the GTAP Data Base", GTAP Technical Paper, No.1. Release 4.2

Matrix Insight Ltd (2013)"Economic analysis of the EU market of tobacco, nicotine and relatedproducts" - *Revised Final Report for the Executive Agency for Health and Consumers*(Specific Request EAHC/2011/Health/11 for under EAHC/2010/Health/01 Lot 2).

Narayanan G., B.; Dimaranan, B.V. and McDougall, R.A. (2009) *Guide to the GTAP Data Base*Chapter 2. Centre for Global Trade Analysis, Purdue University.

Rueda-Cantuche, J. M., Beutel, J., Remond-Tiedrez, I. and Amores, A. F. (2013) "Good practice guidelines in the estimation of use tables at basic prices and valuation matrices for multiregional input-output analysis", *Report to the European Commission's Joint Research Centre under the Contract Project: "European and Euro Area Time Series of Supply, Use and Input-Output Tables in NACE Rev.2, current and previous year prices (2000-2009)".*

Rueda-Cantuche, J. M., Saveyn, B., Ferrari, E., Amores, A. F., Revesz, T., Mainar, A., Montinari, L. and Mraz, M. (2015) "Improving the EU Input-Output Database for Global Trade Analysis: the EU-GTAP Project", *Report from the European Commission's Joint Research Centre.*

Zimmer, Y. (2013) "Isoglucose – How significant is the threat to the EU sugar industry?" - *Sugar Industry* 138 (12) p.770–777.

Appendix:

1. Correspondence of the NACE Rev.2, IMC and GTAP sectors

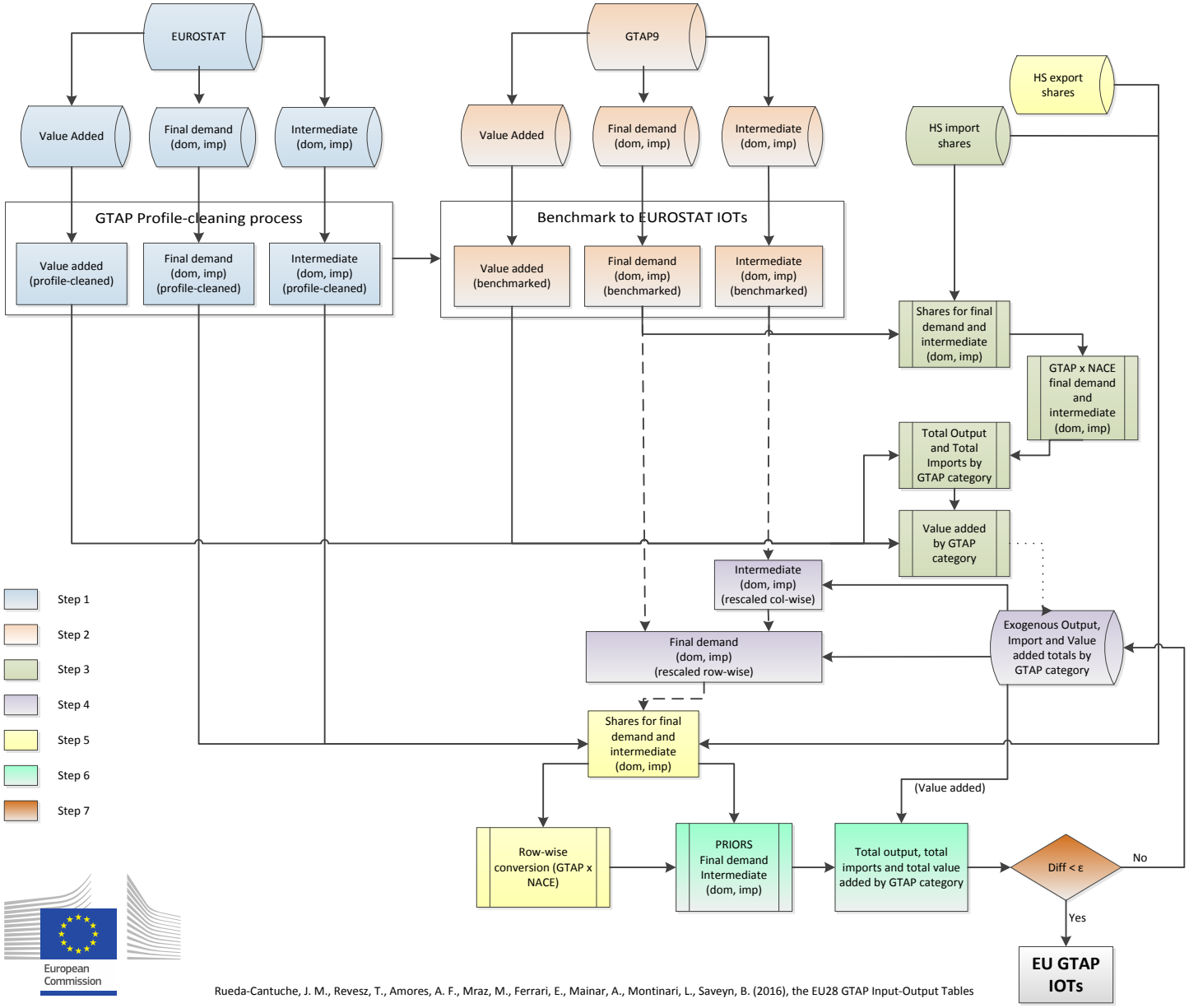
IMC (GTAP Profiled-cleaned)	NACE Rev.2 Codes	GTAP Code	Description of GTAP sectors
A01	01	1. pdr	Paddy rice
		2. wht	Wheat
		3. gro	Cereal grains nec
		4. v_f	Vegetables fruit nuts
		5. osd	Oil seeds
		6. c_b	Sugar cane sugar beet
		7. pfb	Plant-based fibers
		8. ocr	Crops nec
		9. ctl	Bovine cattle sheep and goats horses
		10. oap	Animal products nec
		11. rmk	Raw milk
		12. wol	Wool silk-worm cocoons
A02	02	13. frs	Forestry
A03	03	14. fsh	Fishing
B05	05,06,07,08,09	15. coa	Coal
		16. oil	Oil
		17. gas	Natural gas
		18. omn	Minerals nec
C10	10,11,12	19. cmt	Bovine meat products
		20. omt	Meat products nec
		21. vol	Vegetable oils and fats
		22. mil	Dairy products
		23. pcr	Processed rice
		24. sgr	Sugar
		25. ofd	Food products nec
		26. b_t	Beverages and tobacco products
C13	13,14,15	27. tex	Textiles
		28. wap	Wearing apparel
		29. lea	Leather products
C16	16	30. lum	Wood products
C17,C18,J58,J59	17,18,58, part of 59	31. ppp	Paper products publishing
C19	19	32. p_c	Petroleum coal products
C20,C21,C22	20,21,22	33. crp	Chemical rubber plastic products
C23	23	34. nmm	Mineral products nec
C24	24	35. i_s	Ferrous metals
		36. nfm	Metals nec
C25	25	37. fmp	Metal products
C29	29	38. mvh	Motor vehicles and parts

C30	30	39. otn	Transport equipment nec
C26	26	40. ele	Electronic equipment
C27,C28,C33	27,28,33	41. ome	Machinery and equipment nec
C31	31,32	42. omf	Manufactures nec
D35	35	43. ely	Electricity
		44. gdt	Gas manufacture distribution
E36	36	45. wtr	Water
F41	41,42,43	46. cns	Construction
G,I55,S95	45,46,47,55,95	47. trd	Trade
H49,H52,N79	49,52,79	48. otp	Transport nec
H50	50	49. wtp	Water transport
H51	51	50. atp	Air transport
H53,J61	53,61	51. cmn	Communication
K64,K66	64,66	52. ofi	Financial services nec
K65	65	53. isr	Insurance
J62,L68,M,N\79	62,part of 68,69,70,71,72,73,74	54. obs	Business services nec
R,S96,T97,J59	90,91,92,93,96,97, part of 59	55. ros	Recreational and other services
E37,O,P,Q,S94	37,38,39,75,84,85,86,87,88,94	56. osg	Public Administration Defense Education Health
LIR	part of 68 (imputed rent)	57. dwe	Dwellings

Legend of the codes in the first column (based on NACE Rev.2 codes, see second column):

C10 = C10+C11+C12
C13 = C13+C14+C15
C31 = C31+C32
E37 = E37+E38+E39
F41 = F41+F42+F43
G = G45+G46+G47
M = M69+M70+M71+M72+M73+M74+M75
N79 = N76+N77+N78+N80+N81+N82
O = O84
P=P85
Q = Q86+Q87+Q88
R = R90+R91+R92+R93

2. Flow chart of the EUGTAP conversion method



Rueda-Cantuche, J. M., Revesz, T., Amores, A. F., Mraz, M., Ferrari, E., Mainar, A., Montinari, L., Saveyn, B. (2016), the EU28 GTAP Input-Output Tables