European Union

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1. Introduction

This update of the European Union GTAP (EU-GTAP) Input-Output Tables has been carried out by the European Commission to produce a set of Input-Output Tables (IOTs) and Taxes less Subsidies on Products matrices for the 28 Member States for the reference year 2010 under the new European System of Accounts methodology (ESA10, complying with UN SNA08) and in compliance with GTAP submission requirements (Huff, McDougall and Walmsley, 2000).

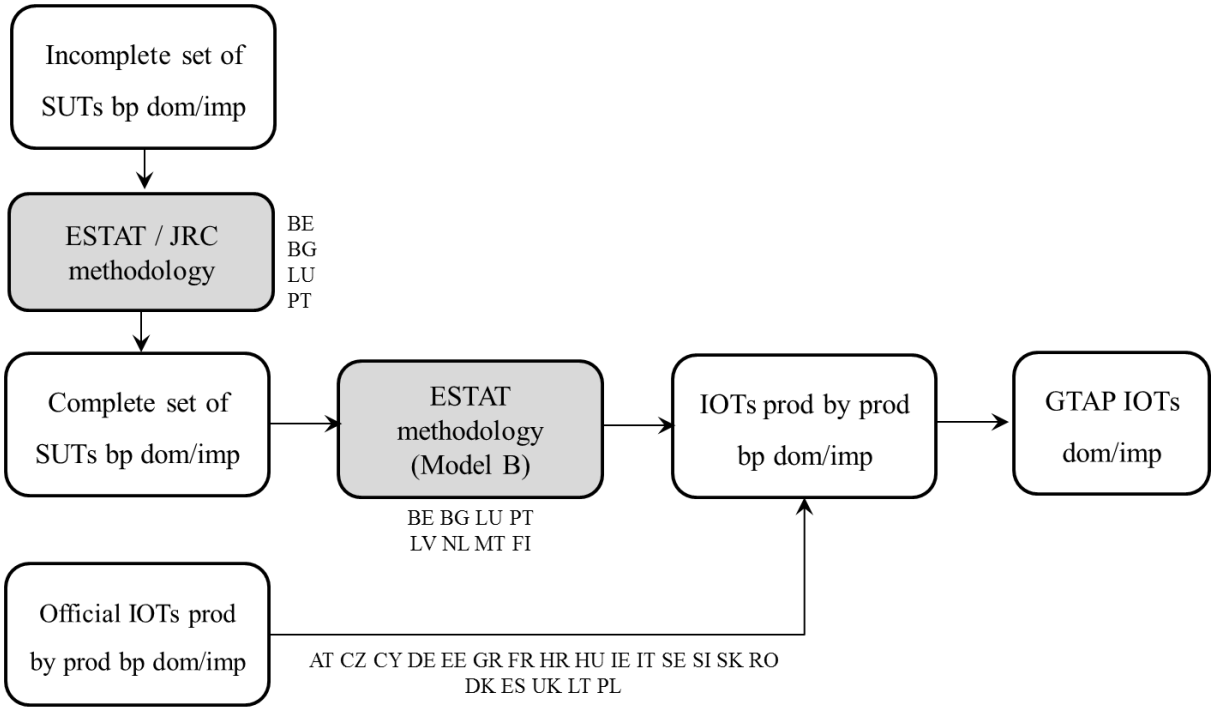
The new EU-GTAP conversion method allows the transformation of the Eurostat's Input-Output Tables and Taxes less Subsidies on Products (TLS) tables from NACE Rev.2/ISIC Rev.4 into the GTAP sectorial classification by means of several steps. The resulting tables fully comply with Eurostat aggregates and subtotals at a certain common level of aggregation as well as with other official statistics on gross output, value added and foreign trade statistics. Complementarily, this work also developed a decomposition process of the TLS matrices into: value added tax, excises, other taxes on products (excluding import tariffs and excises), import tariffs and subsidies on products, in GTAP format.

2. Data sources

As of July 31, 2016 (see Figure 1) Eurostat provided 20 official IOTs (Germany, the Czech Republic, Cyprus, 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 IOTs using the so called industry technology assumption (Model B, in Eurostat (2008)). With respect to the remaining four countries, we projected the SUTs at basic prices from 2011 backwards to 2010 for Bulgaria by using the EURO method (Eurostat, 2008). Subsequently, we used the industry technology assumption to estimate their IOTs. We eventually estimated Supply and Use Tables at basic prices for Luxembourg, Belgium and Portugal by using the same set of Eurostat's good practice guidelines (Rueda-Cantuche et al, 2013). These tables were further used for the estimation of their corresponding IOTs. For Luxembourg and Belgium, the row structures of their use tables at purchaser's prices were used for the estimation of the valuation matrices, then the use table of totals at basic prices and eventually the disaggregation between domestic and imported uses. Portugal only

needed the split between domestic and imported uses. All Supply, Use and IOTs (SUIOTs) have been used in their national currency.

Figure 1 Data sources: SUIOTs



NOTE: *bp = basic prices; prod = product; dom = domestic; imp = imports*

Regarding TLS tables and their decomposition, as of July 31, 2016 Eurostat provided 26 official TLS tables (all 28 EU Member States, excluding Spain and Belgium), of which 12 countries submitted a full decomposition (i.e.: Austria, Czech Republic, Germany, Croatia, Lithuania, Malta, Netherlands, Poland, Portugal, Romania, Sweden and Slovakia) with:

a) Taxes less subsidies on Products, excluding VAT (Table 1631)
b) Value added tax (Table 1632)
c) Taxes on Products (Table 1633)
d) Subsidies on Products (Table 1634)

Other 3 countries (Estonia, France and United Kingdom) provided only Tables 1631 and 1632 while the remaining 11 countries provided only the aggregated TLS table (Table 1630). These countries were: Bulgaria, Cyprus, Denmark, Greece, Finland, Hungary, Ireland, Italy, Luxembourg, Latvia and Slovenia.

Concerning the treatment of confidentiality values of the SUIOTs (and TLS tables) of Ireland, Lithuania, Poland and Sweden, we have estimated their missing values by applying the column/row structures of the EU consolidated IOTs published by Eurostat. The adjustments were absorbed by the highest value of the final demand category in each case and by the gross operating surplus in order to keep the balance of total supply and demand unchanged. However, the GDP of the affected countries

were slightly modified as a result of these adjustments (Ireland: 0.006%; Lithuania: 0.014%; Poland: 0.0004%; Sweden: 0.007%).

The new EU-GTAP IOTs and TLS tables counted with the support of Eurostat on the quality of the European Statistics used. Eurostat provided the most recent IOTs and TLS tables available at the time of compilation. Moreover, not only we used the most recent Eurostat data but we followed the Eurostat's good practice guidelines for the estimation of missing IOTs. Eurostat has been consulted throughout the different stages of the elaboration of the tables.

3. Conversion of IOTs into GTAP format (EU-GTAP conversion method)

3.1 General overview

The conversion of the Eurostat's IOTs into GTAP IOTs implies (dis)aggregations of four different types:

a) **One-to-one** cases; where one single Eurostat 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 Eurostat.

b) **Many-to-one** cases; where many Eurostat 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 Eurostat 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.

d) **Many-to-many** cases; where many Eurostat 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 Eurostat 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.

Evidently, the first two cases do not entail a great difficulty and does not deserve additional comments. The third case requires knowing certain allocation shares that one way or the other has to be searched through more detailed statistics. However, the solution given to the fourth type of case 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 were no "many-to-many" cases any more.

For instance, "man-made fibres" (C20.6) are considered chemical products (C20) in the Eurostat IOTs but they are considered instead textile products (tex) in the GTAP classification. This implies that a part of the Eurostat sector C20 (i.e. C20.6) has to be reallocated to the Eurostat sector C13 (Textiles) because the GTAP sector (tex) includes "man-made fibres". As a result, the adjusted (or modified) new Eurostat 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 Eurostat 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 IOTs still based on old versions of previous systems of classifications.

The appendix provides the eventual *GTAP-Profile cleaned (IMC)* Eurostat 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 Eurostat'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 Eurostat IOTs and, subsequently, convert them into GTAP IOTs came from available Supply, Use and IOTs, the GTAP9 database, Harmonized System (HS) foreign trade statistics, the Structural Business Survey and the Agricultural Economic Accounts, among others.

For future updates of the EU-GTAP IOTs, we would highly recommend using in addition detailed Supply, Use and IOTs 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 could hopefully be used in forthcoming updates of the EU-GTAP IOTs. Now that this method exists, more time could be envisaged to search for more detailed IOTs (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.

3.2 Numerical example

This brief methodological description serves not only to make the existing process and results more understandable for the reader but also serves as the basis for future further developments of the method (see also Figure 2, later on). 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*) for the interested reader. The steps are the following:

1) **GTAP-Profile cleaning** process (IMC) for the domestic and import flows of the IOTs, both for final and intermediate uses;
2) **Block-wise adjustment** of the base year GTAP9 IOTs (block-wise add-up consistency) to the Eurostat 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 IOTs** prior to its final balancing process;
7) **Estimation of the final GTAP IOTs** 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).

- **Eurostat 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 IOTs 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 around, 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).

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

- **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).

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 IOTs while we used the import transformation matrix to convert the rows of the import IOTs. Instead, the columns of the import IOTs were converted using the domestic transformation matrix provided that imported inputs are still related to domestic production.

This was 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 Eurostat IOTs. The outcomes of Step 1 are the Eurostat IOTs transformed from NACE Rev.2 into the IMC classification.

Step 2: Block-wise adjustment to the Eurostat IOTs

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

a) Re-exports were originally set to zero in the GTAP IOTs while there was some information in

the Eurostat IOTs; 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 Eurostat IOTs and the final GTAP IOTs 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 IOTs benchmarked with Eurostat IO data.

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

As a third step, we estimated the missing total values for imports, gross output and value added by GTAP sectors. The others were taken from more detailed statistical sources.

a) For *imports*; we used shares provided by foreign trade statistics, which were then applied to the total imports of the corresponding IMC sector (from Step 2). In the numerical example, this was done for agricultural activities (imc1), which were decomposed into three GTAP sectors (gtap1, gtap2 and gtap3). This estimation was 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 IOTs.

b) For *gross output*; the rows of the Eurostat IOTs (in IMC classification – from Step 1) were split up into GTAP sectors using the shares obtained in Step 2, which in turn come from benchmarked GTAP9 IOTs and (HS) foreign trade statistics. As a result, the sum of each row corresponded to the endogenously estimated gross output by GTAP sector. These resulting gross outputs were replaced whenever superior exogenous data became 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 was 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 IOTs.

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[1] to the value added of the agricultural sector (imc1) of the Eurostat IOTs. The adjustment of the GTAP9 value added coefficients was 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 was done in sheet *S3c-Va*. The resulting values were the value added totals by GTAP sector to be considered as target values in the final GTAP IOTs. However, analogously to gross output, we have not used any endogenous estimation, although they were provided for the sake of completeness. We have assumed instead that there were 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.

[1] Value added divided by gross output.

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

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

Next, the resulting GTAP IO table (from *S4a-Interm*) was 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 was: *(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 was done in sheet *S4b-Domr*.

Step 5: Recalculation of conversion coefficients

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

Step 6: Estimation of the preliminary IOTs (priors)

The starting point of Step 6 was the semi-transformed GTAP IO table (GTAP x IMC) obtained from Step 5. In Step 6, their columns were converted from IMC sectors to GTAP sectors using the same conversion coefficients as in Step 5. However, now the shares were computed row-wise instead. Final demand components must 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, value added or labour costs by GTAP sectors to allocate the other net taxes on production (shares). As mentioned earlier, the TLS values were estimated using an ad-hoc procedure, which is reported separately. However, there were exceptions whenever the capital values turned out to be negative and therefore, we estimated instead the labour cost as residual. Still, the problem may persist and therefore, we also provide normal (positive) capital shares using official data coming from National Accounts and SBS surveys.

The main outcomes of Step 6 were the so called “prior” GTAP IOTs. These GTAP IOTs are block-wise benchmarked with Eurostat 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*.

Step 7: Estimation of the final GTAP IOTs

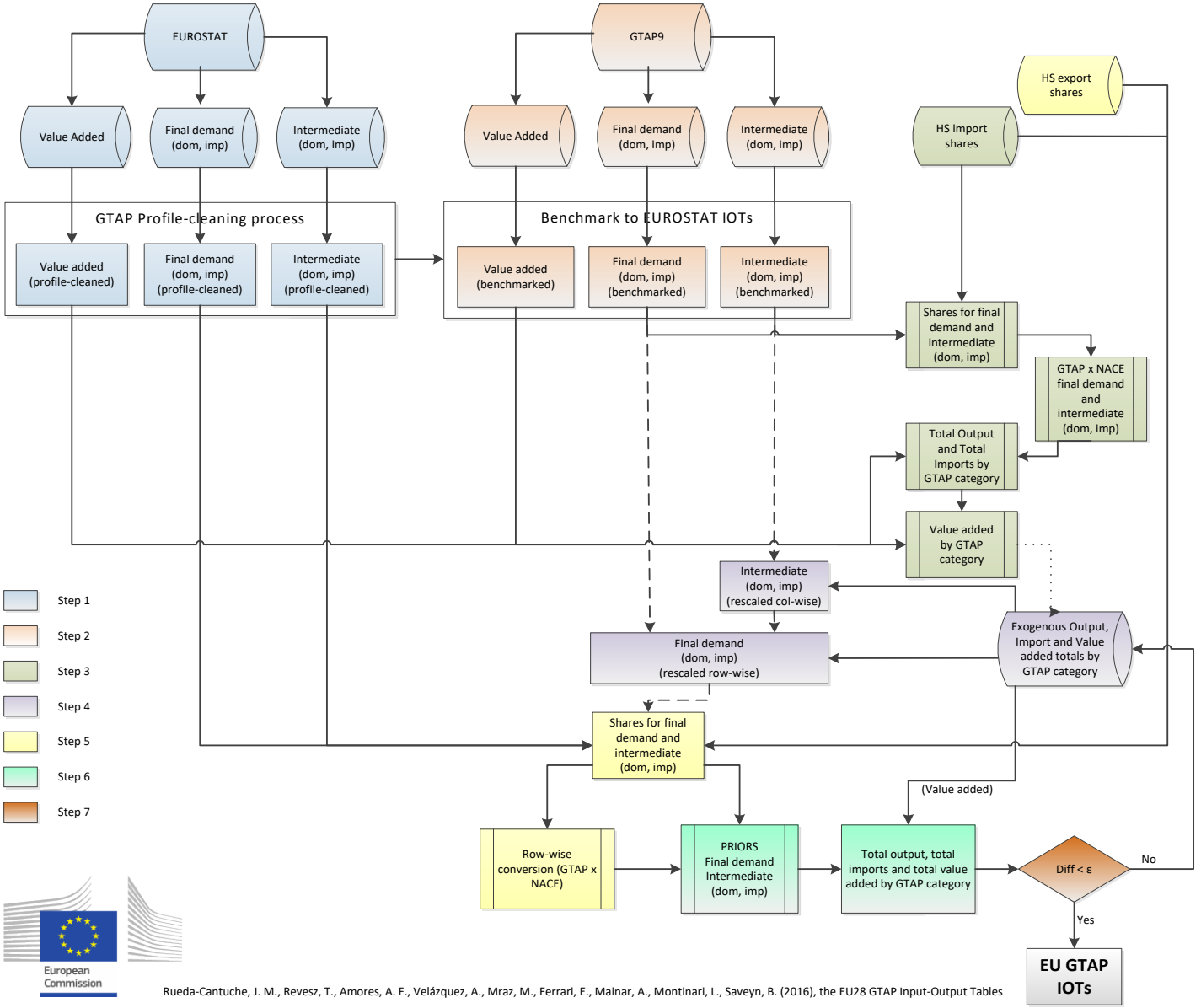
The previous step provided GTAP IOTs that did not match the targeted values for totals of imports, gross outputs and value added by GTAP sector. Hence, we defined an entropy model based on an objective function that minimizes the squared relative differences between the estimated and the prior GTAP IOTs 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 IOTs 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 (see Figure 2), 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 IOT. The final GTAP IOTs eventually match:

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

Figure 2 Flow chart of the EUGTAP conversion method



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Appendix: 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	1	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	2	13. frs	Forestry
A03	3	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

IMC (GTAP Profiled-cleaned)	NACE Rev.2 Codes	GTAP Code	Description of GTAP sectors
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