Estimating balanced detailed SUT using benchmark SUT

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Abstract

Given an aggregate set of balanced supply and use tables (SUT) and a set of more detailed SUT, e.g. for a different time period where more detailed data is available, that could be used to breakdown the aggregated SUT into more detailed ones, the outcome would be unbalanced detailed SUT. This paper proposes a balancing procedure to breakdown balanced aggregated SUT into balanced detailed ones, which was specifically developed to convert US SUT in NAICS to (CPA/NACE), making them comparable with EU tables. However, the method can be applied to any case where aggregated tables are to be broken-down to more detailed ones using as a reference detailed tables from a different time period or different economic area. The procedure follows a GRAS-type of approach, having an inner loop, which makes at each that at every k steps the estimated detailed SUT, and an outer loop, making the procedure flexible regarding SUT margins constraints, i.e. total supply / total use and output derived from supply table / output derived from use table. The results of this method applied to the US SUT tables will be presented.

Introduction

The motivation to develop the balancing procedure that will be presented in this paper was to be able to compare supply and use tables (SUT) for United States published by (BEA, 2017), which follows the NAICS classification, with supply and use tables for EU countries, which follows the CPA / NACE classification (ESA Supply, Use and Input-Output Tables, 2017).

BEA publishes supply and use tables at a level of detail for which the conversion between NAICS to CPA/NACE becomes a many to many exercise. The approach that we found more suited was to estimate detailed table for US, fully consistent with published tables, for which the conversion would be a simple aggregation of sub-products and sub-industries.

Fortunately, BEA have provided us very detailed SUT for 2007, with near 400 products and industries, so for 2007 the conversion of US SUT to CPA/NACE is a trivial exercise. For other time periods, it was possible to expand each cell of the published SUT into a $(n \times m)$ area at the detailed level. Necessarily, the estimated detailed SUT are not balanced any more, therefore the need to have a procedure that, simultaneously, balance the detailed SUT and are fully consistent with the published tables.

The balance procedure that will be presented in the next sections is based on the GRAS method but ensures that at each iteration of GRAS the underlying solution is fully consistent with the more aggregated and published table. In addition, consistency between the supply and use tables must be also guaranteed. Detailed assumptions and descriptions about both NAICS, CPA and NACE classifications as well as assumptions made during the conversion of US SUT to CPA / NACE is the content of another paper. This one will focus mainly on the

balancing procedure which can be in principle applied on other cases than converting classifications, e.g. whenever there is an aggregated set of tables and a suitable benchmark detailed tables.

Problem statement

Let's assume that for a specific time period balanced supply and use tables are available, which will be denominated 'reference tables'. Let's assume as well that there is a different pair of supply and use tables with a bigger number of products and industries, e.g. for a previous time period, which will be denominated 'benchmark tables'. The problem at hand is how to estimate 'detailed tables' for the reference year based on the available benchmark tables. The first thing to be noted is that for each cell of the reference tables corresponds a set of cells of the 'detailed tables', as represented in
Figure 1.

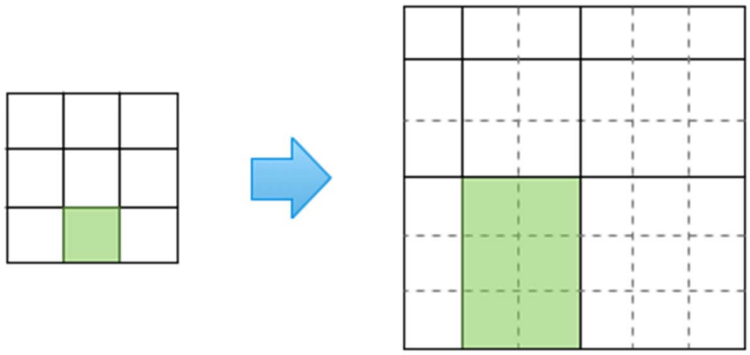

Figure 1: Relationship between reference and detailed tables

As a starting point one could produce detailed tables by proportionally allocate each cell of the reference tables to corresponding set of cells of the benchmark tables. The problem is that by doing so the detailed supply table will not be consistent with the detailed use table. Furthermore, using the usual balancing procedures like the ones described in (Eurostat, 2008) will make detailed SUT consistent with on another but at the cost of breaking the consistency between reference tables and detailed tables. Therefore, the need to develop a procedure that accomplishes simultaneously both type of consistencies required.

Methodology

This paper proposes a simple method to estimate detailed supply and use tables satisfying the following constraints:

1. Detailed supply and detailed use internally consistent, i.e. sum of rows and columns are equal to totals by row and by column;
2. Detailed tables are fully consistent with the reference tables, i.e. each cell of the reference table is equal to the sum of the corresponding set of cells of the detailed tables;
3. Detailed supply and use table are consistent with one another, i.e. total supply by product should be equal to total use by product and total output by industry in supply and use tables should be the same.

The propose method uses the GRAS method formulated according to (Lenzen, 2007) but with the following modification: the method stops at the very first iteration. Obviously, after the first iteration tables are not internally consistent with their totals yet but they are one step closer. At this point, that preliminary solution is forced to be consistent with the respective reference table by forcing each block of cells of that preliminary solution to equal the respective cell of the reference table by proportionally allocation, i.e. the preliminary solution is benchmarked to the reference table. After this, another GRAS iteration is made, followed by another benchmark, and the process can be repeated until convergence is achieved.

The way to make supply and use tables consistent is to use the use table margins when balancing and benchmarking the supply table for a couple of iterations and then to use the supply table margins for balancing and benchmarking the use table.

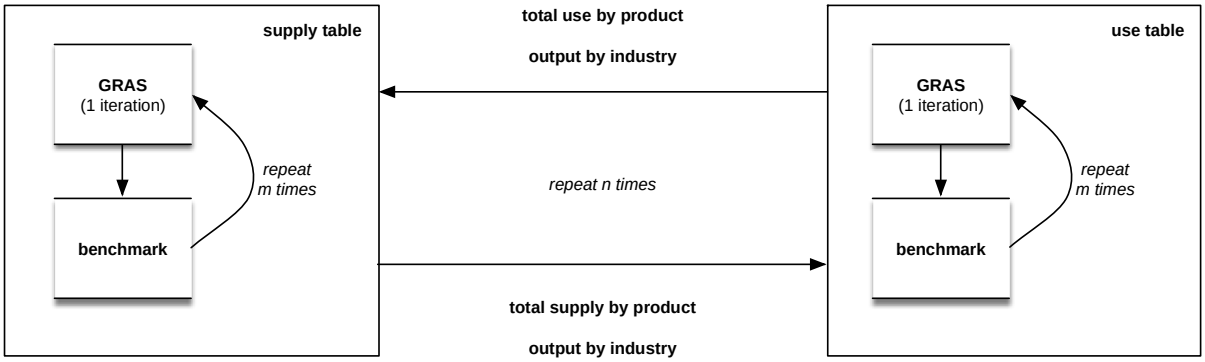

Figure 2: Balancing algorithm

The proposed method can be represented by

Figure 2. There is an 'inner loop' that tries to make the supply table consistent with the use table margins which is repeated m times. Then, the margins of the supply table, i.e. total supply by product and output by industry, is used for balancing the use table, which will have its inner loop as well, after which total use by product and output by industry will be used again for balancing the supply table. This is makes the 'outer loop' of the balancing procedure

Testing the methodology

This method was tested using real supply and use tables available at (ESA Supply, Use and Input-Output Tables, 2017). Supply and domestic use tables at basic prices with 64 products and industries for 2010 were used as benchmark tables. Tables for 2011 onwards were aggregated to 38 products and industries, according to the correspondence presented as Annex. Then the method described above was used to estimate detailed (64x64) tables so a comparison with real tables was possible.

Data was available for the following countries / time periods:

Table 1: Available SUT by time period and country

Time period	Countries
2010-2015	CZ
2010-2014	FI, NL
2010-2013	AT, DE, EE, FR, IT, SK, DK, HU, RO

Fixed benchmark vs rolling benchmark

When one tries to use as benchmark tables from 2 or more years before the reference period there are two approaches that can be followed:

- **Fixed benchmark**: the same reference tables are use independently of how far in time reference tables are;
- **Rolling benchmark**: for the time period (n+1) the benchmark is the detailed table estimated in time period (n), e.g. 2011 uses the true benchmark table of 2010 but 2012 uses the estimated detailed tables for 2011.

Both methods provided in general similar results in terms of accuracy as measured by the Weighted Average Percentage Error (WAPE). However, using a rolling benchmark made the balancing procedure converge faster than the fixed benchmark and therefore was the preferred approach to be used when converting US tables to CPA/NACE classifications.
Table 2 presents as an example the results for Czech Republic, the country with the longest time series of supply and use tables. Year 2010 was used as a benchmark.

Table 2: Weighted Average Percentage Error (%) between the estimated and real tables

		2011	2012	2013	2014	2015
supply	fixed	2.2	4.6	5.4	6.1	7.1
	rolling	2.2	4.0	5.3	6.0	6.8
use	fixed	2.2	3.5	4.6	5.5	5.2
	rolling	2.2	3.1	4.6	5.7	5.4

The farther away from the reference year the lower is the accuracy between the estimated and real tables. However, errors between 5-7% cannot be considered too bad.
Finally, the symmetric input-output tables were derived from the true supply and use tables and from the estimated supply and use tables for 2015, using the rolling benchmark approach, for Czech Republic. Then the output multipliers were compared in order to asses if the balancing method proposed in this paper had a significant impact.

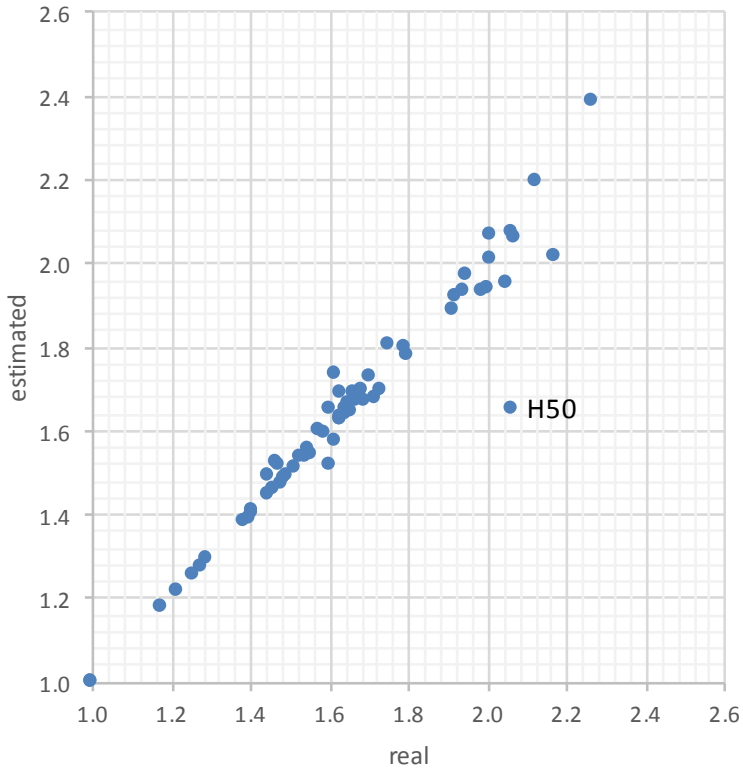

Figure 3: Output multipliers derived from the estimated and real supply and used tables

With the exception of "H50 – Water transport", the output multipliers derived from the estimated supply and use table are quite consistent with the true output multipliers.
In general, the results for Czech Republic were in line with all other countries which corroborates our assumption that the estimated supply and use tables are quite acceptable even in the case that the available benchmark table is 5 years apart from the reference tables.
As a final remark the method presented in this paper was developed with the specific purpose of estimating balanced detailed tables which, basically, were aggregated back again but now to a different set of sub-products and not to conduct any type of detailed analysis. As such, the method was considered valid for which it was developed.

Future research

The detailed tables were instrumental to be able to make a more accurate correspondence between the NAICS classification and the CPA/NACE classifications, making the conversion a simple aggregation of sub-products after supply and use tables are balanced.
However, this method could probably be applied to a more general case, e.g. when more aggregate supply and use tables are available as well as more detailed tables for a different economy but which is believe to be similar to the reference economy. Some very preliminary results are encouraging, however further research needs to be made to be able to draw more concrete conclusions.

References

ESA Supply, Use and Input-Output Tables. (2017). Retrieved from http://ec.europa.eu/eurostat/web/esa-supply-use-input-tables/overview

Eurostat. (2008). *Eurostat Manual of Supply, Use and Input-Output Tables.* Eurostat.

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Annex: Correspondence between

A38	A64	Description
01-03	01	Crop and animal production, hunting and related service activities
	02	Forestry and logging
	03	Fishing and aquaculture
05-09	05-09	Mining and quarrying
10-12	10-12	Manufacture of food products, beverages and tobacco products
13-15	13-15	Manufacture of textiles, wearing apparel and leather products
16-18	16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
	17	Manufacture of paper and paper products
	18	Printing and reproduction of recorded media
19	19	Manufacture of coke and refined petroleum products
20	20	Manufacture of chemicals and chemical products
21	21	Manufacture of basic pharmaceutical products and pharmaceutical preparations
22-23	22	Manufacture of rubber and plastics products
	23	Manufacture of other non-metallic mineral products
24-25	24	Manufacture of basic metals
	25	Manufacture of fabricated metal products, except machinery and equipment
26	26	Manufacture of computer, electronic and optical products
27	27	Manufacture of electrical equipment
28	28	Manufacture of machinery and equipment n.e.c.
29-30	29	Manufacture of motor vehicles, trailers and semi-trailers
	30	Manufacture of other transport equipment
31-33	31-32	Manufacture of furniture; other manufacturing
	33	Repair and installation of machinery and equipment
35	35	Electricity, gas, steam and air conditioning supply
36-39	36	Water collection, treatment and supply
	37-39	Sewerage; waste collection, treatment and disposal activities; materials recovery; remediation activities and other waste management services
41-43	41-43	Construction
45-47	45	Wholesale and retail trade and repair of motor vehicles and motorcycles
	46	Wholesale trade, except of motor vehicles and motorcycles
	47	Retail trade, except of motor vehicles and motorcycles
49-53	49	Land transport and transport via pipelines
	50	Water transport
	51	Air transport
	52	Warehousing and support activities for transportation
	53	Postal and courier activities
55-56	55-56	Accommodation; food and beverage service activities
58-60	58	Publishing activities
	59-60	Motion picture, video and television programme production, sound recording and music publishing activities; programming and broadcasting activities
61	61	Telecommunications
62-63	62-63	Computer programming, consultancy and related activities; information service activities
64-66	64	Financial service activities, except insurance and pension funding
	65	Insurance, reinsurance and pension funding, except compulsory social security
	66	Activities auxiliary to nancial services and insurance activities
68	68	Real estate activities
69-71	69-70	Legal and accounting activities; activities of head o ces; management consultancy activities
	71	Architecture and engineering activities; technical testing and analysis
72	72	Scienti c research and development
73-75	73	Advertising and market research
	74-75	Other professional, scienti c and technical activities; veterinary activities
77-82	77	Rental and leasing activities
	78	Employment activities
	79	Travel agency, tour operator reservation service and related activities
	80-82	Security and investigation activities; services to buildings and landscape activities; o ce administrative, o ce support and other business support
84	84	Public administration and defence; compulsory social security
85	85	Education
86	86	Human health activities
87-88	87-88	Social work activities
90-93	90-92	Creative, arts and entertainment activities; libraries, archives, museums and other cultural activities; gambling and betting activities
	93	Sports activities and amusement and recreation activities
94-96	94	Activities of membership organisations
	95	Repair of computers and personal and household goods
	96	Other personal service activities
97-98	97-98	Activities of households as employers of domestic personnel and undi erentiated goods and services production of households for own use
99	99	Activities of extraterritorial organisations and bodies