INFLUENCE OF THE INPUT DATA AGGREGATION LEVEL ON THE QUALITY OF COMPILED TIME INPUT-OUTPUT TABLES[1]

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Abstract

The use of Input-Output models is continually expanding, for various economical analyses in the Czech Republic and in the world as well. The Input-Output tables are always the base for construction of such models. The paper deals with Input-Output tables expressed in time units broken down by commodity classification. The aim of this paper is to analyse the influence of the level of aggregation of input data on the quality of compiled Time Input-Output tables. In the analysis there are compared two Time Input-Output tables, which should express the same on the level of sections of commodity classification. The difference lies in the way of compilation. One approach uses the input data aggregated on the level of sections before the compilation starts. The second approach uses the input data for the compilation at more detailed level, namely at the level of product groups. The resulted Time Input-Output tables are aggregated after the compilation on the level of sections of commodity classification, in this case. Time Input-Output tables use data from published Supply and Use tables, data on hours worked and data on wages and salaries as input data.

Key words: Time Input-Output tables, hours worked, Input-Output framework, Supply and Use tables, national accounts

JEL Code: C82, J22, O11

Introduction

Input-Output tables are one of the possible tools for the description of the national economy as it is written in (Zbranek, 2013b). While monetary Input-Output tables are expressed in monetary units, Time Input-Output tables show allocation of the number of hours worked in the production of products. The Time Input-Output tables could be seen as an extension of the monetary Input-Output tables. Such tables could be used as one of tools for verification of

[1] This paper has been prepared under the support of the project of the University of Economics, Prague – Internal Grant Agency, project No. 18/2013 „The Use of DSGE Models in the National Accounts."

deflation. More about deflation is written in (Eurostat, 2008). Moreover, as it is written in (Eurostat, 2008) or in (Ewenhart, 1999) it is an old dream of economic science to describe economical activities using non-monetary units. Time is one of such metrics. Of course, it is assuming the Time Input-Output tables are well compiled. Time represents a significant link between final output and living standard of the population. The time spent with labour is an input into the final production. The final production is intended to meet the demand. Time spent for leisure activities is one of the factors for measuring living standard. This paper is especially focused on the method of compilation of the Time Input-Output tables and following kind of sensitivity analysis.

Compilation of the symmetric Time Input-Output tables consists of several steps. Compilation of the time supply and use tables is the first step. We can use time supply and use tables for some analysis connected with allocation working time fund among production of products in each industry. In comparison to monetary supply and use tables, the time supply and use tables are compiled in the simplified form and describe allocation of the number of hours worked among commodities in each industry. Simplified supply and use tables (expressed in hours worked) are used for the compilation of symmetric Time Input-Output tables. These tables serve as a base for derivation of Input-Output models connected with working time during the process of production.

The compiled Time Input-Output tables allow the evaluation of the labour time needed for the production of specific amounts of products. Beside this possibility, these tables show also the labour time needed for the production of the intermediates.

The compilation of the Time Input-Output tables is based on several assumptions. Some factors can negatively influence the validity of the results. Therefore the main aim of the paper is evaluation of the impact of one of these factors. The level of aggregation of the source data represents one of these factors for the compilation of the Time Input-Output tables. This approach of evaluation is done on the data for the Czech Republic in 2010.

1 The principle of influence of the level of aggregation of the source data for the compilation of the Time Input-Output tables

The chosen approach represents some kind of sensitivity analysis. There are always more possibilities to compile Input-Output tables. This paper focuses especially on Time Input-Output tables (TIOT) in product-by-product breakdown. One possibility is to choose an easier way and compile TIOT on the sections level of the CZ-CPA classification. The second

approach is to compile TIOT on the more detailed level of the CZ-CPA classification. This second possibility is more complicated but it should provide better results in terms of higher quality of compiled TIOT. It is clear that the best approach would be the compilation of TIOT on the most detailed level of the commodity classification for following analysis. Of course, there are some limitations. At first it is the level of aggregation of the published source data. The second kind of limit represents the information technology for difficult calculations. The goal is to find optimal level of aggregation of the source data, which provides good quality results with minimum of requirements. The data from the Czech National accounts database is used for the compilation of TIOT. More about the possibilities of the use of National accounts data writes (Fischer, 2011).

Regardless of the chosen approach to the compilation of the TIOT, this is based on the methodology written in (Eurostat, 2008; Stahmer, 1998 and Ewenhart 1990). The foundations for use of the Input-Output tables focusing on human labour are put probably by Stäglin for example in (Stäglin, 1973); instead of hours worked number of employees was used. It should be noted that his aims were different because he focused on the analysis of the situation of individual professions on the labour market. As it is pointed out in the mentioned resources, it should be taken into account that also the compiled TIOT for the Czech economy could be and probably are partly distorted due to human capital. For example the same output can be done for different time by different people according to different level of education or length of practice. Number of hours worked does not reflect the quality of work.

The number of hours worked is one of possible approaches to description of labour inputs to the production process. The compiled TIOT can be used for the evaluation of labour intensity that is a bit different approach to the assessment of labour productivity. More about the labour productivity in the Czech Republic is written in (Sixta, 2011) or in (Rojíček, 2007).

2 Methodology

The methodology connected with the aim of this paper can be split into two parts. The first part shows the method of compilation of the TIOT. The second part provides the methodology of the sensitivity analysis based on comparison of the two approaches to the compilation of TIOT.

2.1 Compilation of the Time Input-Output tables

The Methodology for compilation of the TIOT describes (Zbranek, 2013a). It can be rewritten in a shortened form that compilation of the symmetric time input-output tables consists of

several steps. Compilation of the time supply and use tables is the first step. We can use time supply and use tables for some analysis connected with allocation working time fund among production of products in each industry. In comparison to monetary supply and use tables, the time supply and use tables are compiled in the simplified form and describe allocation of the number of hours worked among commodities in each industry. Simplified supply and use tables (expressed in hours worked) are used for the compilation of symmetric time input-output tables. It should be noted that specific role is played by the consumption of fixed capital. This indicator is used for the estimates of the depreciation rate, which serve to estimation of the appropriate part of the gross fixed capital formation connected with the current year. More about consumption of fixed capital on the national level is written in (Krejčí, 2010). The symmetry of the final TIOT is reached using the Almon method. This method is described in (Almon, 2000). These tables serve as a base for derivation of input-output models connected with working time during the process of production. All data for the compilation of TIOT are taken over from the published Czech national accounts database.

2.2 Evaluation of the impact of level of aggregation of the source data for the compilation of the Time Input-Output tables

The comparison of the two approaches for compilation of TIOT is used for this kind of sensitivity analysis. The resulting data from the compiled TIOT can be compared in the way of absolute differences and on the other hand using measure of relative changes. It is practical to start with the evaluation of the absolute differences. This method is simple and in case of insignificant absolute differences it can be said that the level of aggregation of the source data has no impact on the compiled TIOT.

There are three parts of the TIOT called quadrants. The vector of output in time units is the subject of the interest in the third quadrant. For the purpose of the evaluation of the influence on each element of the output vector it can be used the formula (1)

$$\Delta t_j = {}^{agr.}t_j - t_j, \qquad (1)$$

where ${}^{agr.}t_j$ means the elements of the output vector in time units in case of compiled TIOT based on aggregate source data. The t_j represents the elements of the output vector in time units when TIOT are compiled on the detailed level of aggregation and are aggregated additionally to the sections level of the CZ-CPA classification.

Probably more important part of the TIOT is the second quadrant, which consists of intermediates transformed into the time units. In general, the matrix of intermediate

consumption shows the input structure in the production process. In case of TIOT the matrix of intermediate consumption shows the allocation of the labour time needed for production of intermediates. For the evaluation of the influence on each element of the matrix of intermediate consumption it can be used the formula (2)

$$\Delta c_{ij}^{(t)} = {}^{agr.}c_{ij}^{(t)} - c_{ij}^{(t)}, \qquad (2)$$

where ${}^{agr.}c_{ij}^{(t)}$ represents the elements of the matrix of intermediate consumption in time units in case of compiled TIOT based on aggregate source data. The $c_{ij}^{(t)}$ are the elements of the matrix of intermediate consumption in time units when TIOT are compiled on the detailed level of aggregation and are aggregated additionally to the sections level of the CZ-CPA classification.

The remaining part for the evaluation is the vector of final use transformed into the time units. This vector of figures shows the allocation of the labour time needed for production of products intended for final use. For this purpose can be used formula (3)

$$\Delta y_i^{(t)} = {}^{agr.}y_i^{(t)} - y_i^{(t)}, \qquad (3)$$

where ${}^{agr.}y_i^{(t)}$ represents the elements of the vector of final use in time units in case of compiled TIOT based on aggregate source data. The $y_i^{(t)}$ are the elements of the vector of final use in time units when TIOT are compiled on the detailed level of aggregation and are aggregated additionally to the sections level of the CZ-CPA classification.

When the absolute differences based on the formulas (1)-(3) are not insignificant the differences should be evaluated also in relative way. For this purpose formulas (4)-(6) are intended. The formula (4)

$$\delta_{t_j} = 100 \times \left(\frac{{}^{agr.}t_j}{t_j} - 1 \right) \qquad (4)$$

represents the relative growth rate of each element of the output vector in time units. Analogously the formula (5)

$$\delta_{c_{ij}^{(t)}} = 100 \times \left(\frac{{}^{agr.}c_{ij}^{(t)}}{c_{ij}^{(t)}} - 1 \right) \qquad (5)$$

shows the relative growth rate of the elements of the matrix of intermediate consumption in time units. Finally the formula (6)

$$\delta_{y_{ij}^{(t)}} = 100 \times \left(\frac{^{agr.}y_{ij}^{(t)}}{y_{ij}^{(t)}} - 1 \right) \qquad (6)$$

means the relative growth rate of the elements of the vector of final use in time units. All elements used on the right side of the formulas (4)-(6) are the same as the ones in the formulas (1)-(3).

3 Results

The described approach to sensitivity analysis was applied on TIOTs based on the source data for 2010. The Tab. 1 shows the TIOT compiled on the detailed level of aggregation. In this table can be seen the allocation of the hours worked among the produced and used products.

Tab. 1: Time Input-Output tables for the Czech Republic – additional aggregation, 2010, hours worked

CZ-CPA	Name of section	Products according to the CZ-CPA sections							TOTAL	Final use, total	Used resources, total
		A	B	C	D	E	F	G - S			
A	Products of agriculture	31 229	342	152 609	642	804	382	23 888	209 896	107 555	317 451
B	Mining and quarrying	716	3 269	17 420	18 290	363	4 679	672	45 409	4 023	49 432
C	Manufactured products	40 000	13 776	1 015 825	17 775	6 757	96 411	377 403	1 567 947	568 742	2 136 689
D	Electricity, gas, steam	416	616	8 959	13 745	136	366	11 224	35 462	19 823	55 285
E	Water supply, sewerage	1 059	450	20 314	1 885	30 527	353	15 231	69 819	27 297	97 116
F	Constructions	15 750	4 637	45 022	4 814	4 507	338 879	523 397	937 006	43 918	980 924
G - S	Services	47 162	28 743	575 821	35 631	63 126	170 925	2 944 516	3 865 924	1 656 167	5 522 091
$C_i^{(t)}$	**Intermediate consumption**	**136 332**	**51 833**	**1 835 970**	**92 782**	**106 220**	**611 995**	**3 896 331**	**6 731 463**	**2 427 525**	**9 158 988**
$t_i^{(t)}$	**Output**	**317 451**	**49 432**	**2 136 689**	**55 285**	**97 116**	**980 924**	**5 522 091**	**9 158 988**		

Source: Own calculations

The Tab. 2 shows resulted absolute differences between all elements of the compiled TIOT based on aggregate source data and elements of the TIOT compiled on the detailed level of aggregation. It means after the application of the formulas (1)-(3).

Tab. 2: Time Input-Output tables for the Czech Republic – absolute differences, 2010, hours worked

CZ-CPA	Name of section	Products according to the CZ-CPA sections							TOTAL	Final use, total	Used resources, total
		A	B	C	D	E	F	G - S			
A	Products of agriculture	5 815	174	5 098	-180	-461	-382	-2 459	7 605	-9 179	-1 574
B	Mining and quarrying	-290	-685	880	-6	-154	1 789	-392	1 142	-1 178	-36
C	Manufactured products	14 990	240	29 943	-1 583	2 237	-1 315	31 813	76 325	-62 791	13 534
D	Electricity, gas, steam	0	15	-125	-45	71	-366	627	177	99	276
E	Water supply, sewerage	163	17	-573	545	-4 664	-353	927	-3 938	1 090	-2 848
F	Constructions	-2 251	-848	-14 998	-333	3 210	-10 338	-94 771	-120 329	114 779	-5 550
G - S	Services	4 772	-357	-42 065	-3 160	4 721	18 174	-4 268	-22 183	18 381	-3 802
$C_i^{(t)}$	**Intermediate consumption**	**23 199**	**-1 444**	**-21 840**	**-4 762**	**4 960**	**7 209**	**-68 523**	**-61 201**	**61 201**	**0**
$t_i^{(t)}$	**Output**	**-1 574**	**-36**	**13 534**	**276**	**-2 848**	**-5 550**	**-3 802**	**0**		

Source: Own calculations

The results in the Tab. 2 inform that the level of aggregation of the compiled TIOT is significant for the structure of allocation of the labour time. For complete information about the range of influence of level of aggregation the Tab. 3 is showed. The Tab. 3 consists of relative growth rates between each element the two TIOTs compiled according to described approaches. The results in the Tab. 3 confirm also in relative terms quite significant differences in the matrix of intermediate consumption and in the vector of final use. On the other hand, the differences connected with the output vector in time units are insignificant. The negative values in the Tab. 2 or in the Tab. 3 mean the situation when there is a lower value in the cell in case of the compiled TIOT based on aggregate source data.

Tab. 2: Time Input-Output tables for the Czech Republic – relative growth rates, 2010, in %

CZ-CPA	Name of section	Products according to the CZ-CPA sections							TOTAL	Final use, total	Used resources, total
		A	B	C	D	E	F	G - S			
A	Products of agriculture	18,62	50,88	3,34	-28,04	-57,34	-100,00	-10,29	3,62	-8,53	-0,50
B	Mining and quarrying	-40,50	-20,95	5,05	-0,03	-42,42	38,23	-58,33	2,51	-29,28	-0,07
C	Manufactured products	37,48	1,74	2,95	-8,91	33,11	-1,36	8,43	4,87	-11,04	0,63
D	Electricity, gas, steam	0,00	2,44	-1,40	-0,33	52,21	-100,00	5,59	0,50	0,50	0,50
E	Water supply, sewerage	15,39	3,78	-2,82	28,91	-15,28	-100,00	6,09	-5,64	3,99	-2,93
F	Constructions	-14,29	-18,29	-33,31	-6,92	71,22	-3,05	-18,11	-12,84	261,35	-0,57
G - S	Services	10,12	-1,24	-7,31	-8,87	7,48	10,63	-0,14	-0,57	1,11	-0,07
$C_i^{(t)}$	**Intermediate consumption**	**17,02**	**-2,79**	**-1,19**	**-5,13**	**4,67**	**1,18**	**-1,76**	**-0,91**	**2,52**	**0,00**
$t_i^{(t)}$	**Output**	**-0,50**	**-0,07**	**0,63**	**0,50**	**-2,93**	**-0,57**	**-0,07**	**0,00**		

Source: Own calculations

Especially in connection with constructions there is absolutely different input structure comparing the two applied approaches. It can be seen in case of products of agriculture (A), Electricity, gas and steam (D) and water supply and sewerage (E) as intermediates for the production of constructions. In case of the compiled TIOT based on aggregate data sources it seems that these products are not the intermediates for the production of constructions.

Conclusion

The applied sensitivity analysis showed that the choice of the level of aggregation plays a quite significant role for the quality of the final estimates of the TIOT. The conclusion is obvious. It should be preferred the compilation of the TIOT in the way of more detailed commodity classification. Such compiled TIOT better respects the structure of the matrix of intermediate consumption. Moreover they allow the following analysis in the more detailed level, what is mostly positively assessed.

On the other hand the figures of the compiled TIOT based on the aggregate source data do not represent absolutely nonsense results. In this case it means the results are accompanied by a certain higher degree of inaccuracy. In some situations, it could be applied

also the less accurate approach for the compilation of TIOT based on more aggregate source data, especially in the situations without sufficient computing technology.

In general the choice of the level of aggregation for the compilation of this kind of tables is based especially on the user needs and on the source data availability and on its quality. Therefore the common practice is to compile Input-Output tables on the more detailed level of aggregation to satisfy user needs. The compilation of the TIOT has specific limitations from the point of view the level of source data aggregation. The choice of the level of aggregation for the compilation of the TIOT is influenced by the level of aggregation of the input data sources especially supply and use tables. The results of the sensitivity analysis showed, that it is more suitable disaggregate the indicator of the average hourly wage and to compile the TIOT on the same level of aggregation as the published supply and use tables. Despite there isn't any similar another author's work for comparison of the results, these are useful for the approach to the compilation of the TIOT.

This paper aimed to evaluate the influence of the level of aggregation of the commodity classification on the compilation of the TIOT. This goal was achieved and the assumption was confirmed.

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