Analysis of the labour inputs in the input-output framework[1]

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Abstract. The paper is focused on the change of labour intensity in the Czech economy in the period between 1995 and 2009. The change of labour productivity is analysed in terms of change in labour intensity using input-output framework. The main issue is the construction of symmetric input-output tables expressed in time units. This tool gives the information on time needed for supply and use of goods and services broken down by commodity classification. The analysis is based on the supply and use tables, symmetric input-output tables and hours worked. Hours worked are broken down by industries. Such analysis provides the information of the development of labour intensity in a sufficient detail (products) in time. The advantage of this approach is the elimination of monetary flows and the issue of deflation. Finally, the analysis is compared with volumes derived from input-output tables.

Keywords: Input-Output tables, Labour productivity, Hours worked, Labour intensity

Introduction

Symmetric input-output tables (SIOT) are one of the parts of the system of national accounts. Their compilation allow us to analyze technical and economic relations within the economy and using analyses based on SIOT we can assess the impacts of various changes in the economy[7].

The number of hours worked is one of possible approaches to description of labour inputs to the production process. The objective of this paper is to analyze the labour intensity development connected with production of the products according to commodity classification using the system of input-output tables. The labour intensity is somewhat different approach to the assessment of labour productivity. More about the labour productivity is written in [7] and [10]. With regard to the main goal of this paper, the compilation of the time input-output tables (TIOT) is one of the partial aims. The research in the TIOT area is at the beginning for the Czech economy. For example, spending time on education as a form of investment is not taken into account for compilation of TIOT yet. For more details about time spent on education and about the possibility of using this time as a data entry for compilation of TIOT, see [3]. The matrix expressing number of hours needed for production of products according the commodity classification in each industry is crucial for the established goal.

In the second half of 20th century many analyses based on the input-output models were made and they were focused on use of time in the German economy. These analyses dealt with different goals focusing on the labour market and work area. Extended input-output tables expressed in other units than monetary were used for mentioned analyses. Pischner and Stäglin use the extended symmetric input-output tables expressed in the number of employees involved in production process in their analysis described in [6]. Transformation of classical symmetric input-output tables expressed in monetary units into the form of input-output tables expressed in the number of employees is described by Stäglin [8]. He splits work of employees into two parts. One part is focused on

manufacturing of semi-finished products while the second part is connected with production of final products.

Data

There are two main datasets which can be used for fulfilling the goals of the paper. The supply and use tables are one of them. The output matrix is an object of the interest as it is structured by commodity and industry.

The second source of data is the number of hours worked. The European System of accounts [4] defines the number of hours worked as the total number of hours really worked by employee or self-employed person during the accounting period.

The information on hours worked in the Czech economy, according to CZ-NACE classification, is published by the Czech Statistical Office (CZSO) on its website together with other indicators of the national accounts. The information on hours worked in connection with national account is important particularly for the calculation of the ratio, value added per worker in each industry of the national economy. The length of time work of employees is necessary to be taken into account for this indicator. Hence, the amount of full-time equivalent workers (FTE) is more preferable for the analysis related to the labour input. With regard to usage of this indicator as an analytical tool during the balancing of Gross Domestic Product (GDP), great emphasis on quality of estimates of number of workers in the economy is attributed. More details about balancing the GDP can be found for example in [3] or [5]. The data from statistical surveys [1] as well as the administrative data sources are used for the labour inputs estimates in the last years. Something more about the use of administrative data sources in the Czech Republic is written in [11].

Currently certain difficulties, mainly related to the extraordinary revision of national accounts [2], should be taken into account. It impacts the TIOT for two reasons. The classifications used were changed and also some methodological adjustments connected with the improvement of estimates and model calculations were included to the values of indicators. The first change results into changes in commodity and industry structures, however the second type of changes may also lead to change in the value levels of individual indicators at the level of national economy. Taking into account the intention to assess the labour intensity development in the period 1995–2009, the structure of the year 2009 could be a little different. It is due to the fact that national account indicators were compiled, unlike in the other years, directly in the national mutations of the industry classification (CZ-NACE) and commodity classification (CZ-CPA) respectively.

As it is described below, other data sources for compilation of the TIOT are also used. Mainly it consists of data on average hourly wages broken down by industry and the data on average monthly wages and average monthly fund of working hours.[2] Regarding the early stage of the research in the TIOT area in the Czech economy, some outcomes of the research in the area focused on the German economy are taken [8]. These values can be considered as initial parameters for the future research.[3]

Methodology

For the compilation of symmetric TIOT, the method of transformation of data from the supply and use tables into the symmetric input-output tables (SIOT) form broken down by commodity is used. This method is described for example in [3]. In the Czech Republic the method based on product

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[2] The data on average hourly wages is available only for the years 2005 and 2009. For the years 1995 and 2000, necessary values in the industry breakdown are estimated through the alternative approach using average monthly wages and the fund of working hours.

[3] The results of mentioned research were accepted due to the similar conditions from the geographical point of view and also for the partly similar structure of the national economy. The age of the results does not matter a lot due to the lag of the Czech economy behind the German economy.

transformation assumption (method A) is used for compilation of the SIOT. For the compilation of the TIOT broken down by commodity the same approach is used. According to focus of the article, primarily on the productive part of the fund time, the compilation of the TIOT is limited only on the first quadrant, i. e. matrix of intermediate consumption.

For the use of the mentioned method of compilation of the TIOT, the first step is to compile simplified supply and use tables expressed in hours worked. The simplification is made by the assumption that all worked time allocated in the output matrix on the resource site is whole allocated in the matrix of the intermediate consumption on the use side. The output matrix expresses how many hours of total hours worked in the industry is related to the production of the particular product. The matrix of intermediate consumption presents how many hours are related to the production of particular products which are intermediate in the industry. It is also assumed that the time spent on production of the imported intermediate is the same as the time spent on production of products for the domestic use.

Time spent on the preceding stages of production should be taken into account for the compilation of the TIOT. In accordance to this problem, the hours worked have to be split into the direct labour input and the part which is not the directly part of the output matrix. Due to the early stage research in the TIOT in the area of the Czech economy, the results of Stäglin's work from the [8] are used as the initial distribution of worked time.

For compilation of output matrix expressed in hours worked the published data from the supply and use tables as well as data on average hourly wages broken down by industry are used. The wages of workers in the industry are probably different when one worker is working on production of the particular commodity and the second one is working on another commodity. For this reason, it is supposed that hourly wage for the work on the particular product corresponds to the average hourly wage related to the industry where production of this product is typical. Each value of the output matrix expressed in the hours could be estimated using the equation (1),

$$T_{ij} = \frac{x_{ij}}{w_i} \qquad (1)$$

where T_{ij} is the number of hours worked needed for production of value of output x_{ij} product i in the industry j by the average hourly wage for production of product i.

Due to the fact that the assumption on allocation of average hourly wage in the output matrix is simplistic, the industry sums of the hours worked will be hardly the same as the published data on hours worked broken down by industry. The matrix of the T_{ij} is used for creation of the structure matrix which is used for allocation of the hours worked according to the industry among the specific commodity. The final matrix can be considered as the output matrix expressed in hours worked.

As it is mentioned above in the article, it deals with the allocation of the number of hours worked only in output matrix on the resources side and in the matrix of intermediate consumption on the use side. Therefore the row sums of the output matrix expressed in hours worked can be used for compilation of the matrix of intermediate consumption. For the allocation number of hours worked related to this specific commodity, the structure of row vector of the intermediate consumption from the supply and use tables for the commodity is used. This approach ensures the validity of assumption that the resources are equal to the uses expressed in hours worked. Compiled output matrix and matrix of intermediate consumption in the form product x industry are used for the compilation of the TIOT. The symmetric TIOT in the form product x product are compiled using the above mentioned transformation, described in [3].

The labour intensity can be considered as the time needed for the production of one unit of the specific product. On the level of the national economy is not possible to clearly set the number of produced units of each commodity according to the industry. The development of the labour intensity can be assessed using the compiled TIOT and indices of physical volume of the output broken down by commodity. Indices of physical volume are also taken from the supply and use tables. The development of the labour intensity can be described by the equation (2),

$$i_{LI,i,t} = \frac{i_{T,i,t}}{i_{q,i,t}} \qquad (2)$$

where $i_{LI,i,t}$ is index of labour intensity of production of product i in the year t. Index $i_{T,i,t}$ shows in the numerator the development of the number spent on production of product i in the year t and the index in the denominator $i_{q,i,t}$ is the index of physical volume of production.

Results

The above mentioned method of estimation of the TIOT and the development of the labour intensity was used for four selected years on the data for the Czech economy. The selected years are 1995, 2000, 2005 and 2009. The selection of the years is based on SIOT published for the Czech economy. SIOT and TIOT are compiled on two-digit level of the commodity classification the CZ-CPA. The results in the article are presented in aggregated form on the level of the sections of this classification for sake of clarity. In the result tables, all sections are expressed using placeholders in form of letters.

Table 1 The commodity classification CZ-CPA broken down by the sections.

CZ-CPA	Description
A	Products of agriculture, forestry and fishing
B	Mining and quarrying
C	Manufactured products
D	Electricity, gas, steam and air conditioning
E	Water supply; sewerage, waste management and remediation services
F	Constructions and construction works
G	Wholesale and retail trade services; repair services of motor vehicles and motorcycles
H	Transportation and storage services
I	Accommodation and food services
J	Information and communication services
K	Financial and insurance services
L	Real estate services
M	Professional, scientific and technical services
N	Administrative and support services
O	Public administration and defence services; compulsory social security services
P	Education services
Q	Human health and social work services
R	Arts, entertainment and recreation services
S	Other services
T	Services of households as employers; undifferentiated goods and services produced by households for own use

Source: CZSO

Therefore the table 1 shows the commodity classification (CZ-CPA) in aggregated form, used in next tables. The table 2 presents the number of hours spent on production of products in the selected years broken down by the sections of the CZ-CPA classification.

Table 2 The number of hours spent on production of the products broken down by the sections of the commodity classification the CZ-CPA, in thousands of hours

	1995	2000	2005	2009
Total	**6 207 076**	**5 973 163**	**5 892 940**	**6 028 892**
A	141 624	134 932	108 169	87 612
B	47 619	34 528	25 434	21 307
C	1 195 741	1 120 295	1 084 318	1 022 256
D	43 261	26 550	23 923	25 218
E	32 358	35 053	46 575	49 140
F	994 333	829 770	827 382	841 982
G	790 816	799 658	826 725	785 540
H	239 737	215 147	199 683	208 503
I	239 986	252 357	258 634	273 614
J	119 797	117 754	115 172	126 206
K	75 812	86 568	67 424	78 489
L	195 902	234 296	185 196	250 405
M	260 860	303 808	318 359	354 047
N	141 528	159 272	146 961	195 365
O	404 658	415 557	422 458	404 866
P	429 960	406 692	416 988	426 139
Q	458 149	426 033	419 552	464 862
R	85 424	90 178	89 733	106 301
S+T	309 511	284 715	310 254	307 040

Source: own calculations

The table 2 clearly shows that the products of manufacturing industry, construction and trade (sections C, F and G) are crucial for the Czech economy. It is consistent with reality in the Czech Republic. Table 3 shows clear decrease in the number of hours spent on the production of agricultural goods (section A) as well as on mining (section B). In comparison to the real output development it is obvious that in case of agricultural goods the labour intensity decreased. In case of mining, both labour intensity and output decreased. In manufacturing production industry, labour intensity was decreased quite significantly (from value 65.8 in 2000 to 37.9 in 2009, with the base in 1995). The similar development is also recorded for trade production (section G). In construction, labour intensity drop is evident in all selected years, despite the fact that the output decreased in 2000 too. Nevertheless, decrease in the number of hours worked was larger.

Increase in labour intensity is obvious in case of Accommodation and food services (section I) in 2005 and 2009 when the number of hours worked increased and current increase in output was not recorded. Fluctuation in terms of labour intensity is clear in cases of the Administrative services (section N) and the Human, health and social services (section Q). The other services recorded the increase in labour intensity due to the significant decrease in output. Increased importance of the majority of services for the Czech economy is obvious from the table 3.

Table 3 The development of the number of hours worked, real development of the output and the development of the labour intensity of production of products broken down by the sections of the CZ-CPA classification in the period 1995 – 2009

	Index of hours worked (1995 = 100)			Index of real output (1995 =100)			Index of labour intensity (1995 = 100)		
	2000	**2005**	**2009**	**2000**	**2005**	**2009**	**2000**	**2005**	**2009**
Total	**96.2**	**94.9**	**97.1**	**119.9**	**155.3**	**171.5**	**80.3**	**61.1**	**56.6**
A	95.3	76.4	61.9	100.1	106.7	112.9	95.2	71.6	54.8
B	72.5	53.4	44.7	82.2	76.3	70.9	88.2	70.0	63.1
C	93.7	90.7	85.5	142.4	206.4	225.7	65.8	43.9	37.9
D	61.4	55.3	58.3	106.0	117.0	107.0	57.9	47.3	54.5
E	108.3	143.9	151.9	114.7	150.3	166.8	94.5	95.8	91.1
F	83.4	83.2	84.7	88.5	107.9	124.3	94.2	77.1	68.1
G	101.1	104.5	99.3	131.9	186.4	198.0	76.7	56.1	50.2
H	89.7	83.3	87.0	105.3	133.7	148.4	85.2	62.3	58.6
I	105.2	107.8	114.0	108.0	91.9	101.0	97.3	117.3	112.8
J	98.3	96.1	105.3	153.9	214.9	274.3	63.9	44.7	38.4
K	114.2	88.9	103.5	121.6	136.3	169.6	93.9	65.2	61.1
L	119.6	94.5	127.8	134.8	154.7	187.6	88.7	61.1	68.1
M	116.5	122.0	135.7	113.9	149.8	169.8	102.3	81.5	79.9
N	112.5	103.8	138.0	104.2	118.5	130.8	107.9	87.6	105.5
O	102.7	104.4	100.1	103.7	123.7	124.3	99.1	84.4	80.5
P	94.6	97.0	99.1	100.5	117.9	126.8	94.1	82.3	78.2
Q	93.0	91.6	101.5	82.7	97.6	101.5	112.4	93.9	100.0
R	105.6	105.0	124.4	111.7	130.6	148.2	94.5	80.4	83.9
S+T	92.0	100.2	99.2	90.3	88.1	83.0	101.9	113.7	119.5

Source: own calculations

Conclusion

The analysis of the labour intensity development broken down by commodity based on the input-output framework gives rational results. The result values on the hours worked give quite rational information which is not at first sight inconsistent with the real evolution. Nevertheless, the final values about the labour intensity can be and probably are distorted by the introduction of certain simplifying assumptions.

The use of the ratio of direct labour inputs to output can be considered as weakness because as the initial ratios the values for the German economy were used from the seventies of the 20th century. The second weakness is definitely the absence of time spent on education as one of the inputs to the model of the TIOT. The third weakness of the model is the assumption on the average hourly wage related to the commodities.

All mentioned weaknesses will be the object of our future research. In terms of available data sources, the weakness related to the average hourly wages can be solved using the data on average hourly wages according to the classification of occupations (CZ-ISCO) which should be available for later years for the Czech economy. Solving other mentioned problems will be somewhat more difficult.

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