Input-Output Approach to Regional Employment

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Abstract

The paper deals with statistical data on regional employment that was constructed on the basis of regional input-output tables. Both regional input-output tables and product linked regional employment were constructed within the research project. This data fits well the purposes of detailed analysis of regional economy since the data is broken down by two-digits level of product classification (CZ-CPA). Employment is presented on the level of the regions (NUTS 2) of the Czech Republic for 2011. The paper briefly describes procedures allowing construction of regional employment by products and the links to data from official statistics. Some of analytical possibilities of data on regional employment are illustrated by simple input-output analysis with three scenarios. The regions are also tested for output and employment sensitivity by estimating multipliers and elasticities. The interpretation of obtained results including hierarchical clustering is provided. The paper also presents discussion about the use of regional input-output tables and regional employment in regional analyses for policy measures.

Keywords

Regional input-output tables, employment, input-output analysis

JEL code

C67, R11

INTRODUCTION

Input-Output Tables (IOTs) are regarded as a suitable tool for sophisticated economic analyses. Besides, they can be used for environmental or social analyses, as well. They allow for a wide range of scientific studies and analytical works conducted by university researchers, analysts or official authorities. IOTs are also used by the OECD for its statistical outcomes such as increasingly important Trade in Value Added (TIVA), see OECD (2016). Traditional input-output tables contain three quadrants with monetary values and some additional indicators, mainly employment and capital stocks. Symmetric Input-Output Tables for national economy are usually officially compiled every five years by official statistical authorities,[2] see Eurostat (2013). In the Czech Republic, the most popular form of IOTs are product by product tables complemented by employment by products. These tables provide a powerful tool for construction of economic models, predictions and analyses.[3]

Input-output models built at the national level can be disaggregated or even differently constructed at the regional level. For the Czech Republic, Regional Input-Output Tables (RIOTs) were constructed

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[2] <http://apl.czso.cz/pll/rocenka/rocenkaout.dod_uziti?mylang=EN>.

[3] This is possible on annual basis only since quarterly input-output tables are not very common, see Marek et al. (2016).

for the year 2011 by the University of Economics,[4] see Sixta and Vltavská (2016). The tables are constructed as symmetrical for 82 product groups at basic prices in line with ESA 1995 methodology. There are only few countries that officially publish RIOTs, e.g. Finland (Piispalla, 1999), United States, Italy (Benvenuti et al., 1995), Spain (INE, 2010) and therefore RIOTs belong mainly to research agenda. The construction of RIOTs and its possibilities were introduced by Kahoun and Sixta (2013).

This paper is particularly aimed at the discussion of employment data on the regional level. Such employment data are linked to products within the boundary of national accounts and should be used as auxiliary indicators to RIOTs. The data originates in academic research and therefore the construction of regional employment is presented at first. Brief description of the methods used for transformation of officially published data into product based data is included, as well. Data on regional employment is broken down by 82 products (adjusted CZ-CPA) and it comes solely from described computations. The most important advantage of this data is that they combine usability for economic modelling and protection of individual data since it is not linked directly to companies. The paper also brings a brief illustration of the possibilities of such data and provides analysis based on the elasticities and multipliers for three scenarios of external shocks. Such sensitivity analysis is used for the presentation of some of the possibilities with the help of the simple static input-output analysis. The first part of the analysis is aimed at the industry with the highest regional output, the second part at the industry of maximum regional employment, the third at construction industry. Finally, the purpose of the paper is also to promote the use of more advanced models based on freely accessible IOTs and RIOTs since they can provide interesting feedback to policymakers.

1 REVIEW OF LITERATURE

Researchers dealing with input-output tables can find plenty of more or less recent scientific literature dealing with regional input-output tables and regional input-output analysis. One of the most relevant information sources offers the publication *Input-output analysis: foundations and extensions* by Miller and Blair (2009). Basic categories and models, mainly inter-regional and multiregional models are deeply described. From the theoretical description to practical compilation issues is a far way. In some countries, regional input-output tables are from time to time available. In Europe, RIOTs are very well described mainly for Finland, Spain and Netherlands. Compilation issues of RIOTs for Finland are described in Louhela and Koutaniemi (2006), Dutch case was introduced in Eding et al. (1999) and Spanish in INE (2010). There were also some scientific works dealing with the case of the Czech Republic, e.g. applying of GRIT method on Czech data, see Semerák et al. (2010). Different approach based on location coefficients is described in Flegg and Tohmo (2013) for the case of Finland.

Input-output researches and fans usually contribute to the journal Economic Systems Research specifically aimed at this area. From this field, recent and closely related paper dealing with regional input-output tables was written by Többen and Konenberg (2015). Besides scientific works dealing with sub-national regional input-output tables, specialised research agenda aimed at the group of regions or countries can be found. There are at least three big databases, EORA (see Lenzen et al., 2012), WIOD[5] or EXIOBASE[6] that are covering specific input-output related information or extensions. Besides regional product flows, distribution effects should not be omitted as well since they can be linked with RIOTs.[7]

[4] <http://kest.vse.cz/veda-a-vyzkum/vysledky-vedecke-cinnosti/regionalizace-odhadu-hrubeho-domaciho-produktu-vydajovou-metodou>.
[5] <http://www.wiod.org/new_site/home.htm>.
[6] <http://www.exiobase.eu/index.php>.
[7] Some basic of linking of product flows with distribution of income can be found in Šimková and Langhamrová (2015).

Regional input-output tables or regional input-output analysis is also tackled for price level measurement since regional structures (Kramulová and Musil, 2013) are often used for these computations, see Čadil et al. (2014). Analytical potential of input-output analysis on both regional and national level is considerable. From this field, discussion about regional economic development and ways of planning can be found in Stimson et al (2006). Regional input-output analysis is also useful for assessing the economic side of organising of cultural events (Raabova, 2010).[8]

In the context of the level of European Union, the case of regional accounts is not dramatically emphasised and regional input-output tables are out of the focus. That is a pity because academic environment can provide methodology or research papers and studies but can hardly provide necessary financial resources. Regular compilation of RIOT done by official statistics is possible but it would have to be supported by European regulation. Otherwise statistical office will not allocate enough resources for this agenda.

2 METHODOLOGY

Data on regional employment expressed in persons, hours worked and full time equivalent areregularly published by the Czech Statistical Office[9] on annual basis. These figures are published on the level of sections of industries (CZ-NACE). Data useful for IO models has to be in the same classification and dimension as regional input-output tables. Estimated regional employment as an additional indicator for input-output analysis is broken down by NUTS 3 level.[10] Therefore, the transition from industries (CZ-NACE) to products (CZ-CPA) has to be done. It is a similar procedure as transformation of use table into symmetric input-output tables. Nevertheless at first, the data has to be prepared. For the purposes of this paper, data on employment in persons was selected. The reason is the simplicity of data and expected higher quality data on regional level. Of course, full time equivalent data offers more appropriate picture of economy (see Fischer and Sixta, 2009) but for the regional comparison such data would be sufficient. Data on hours worked and full time equivalent may be transformed in the same way.

The first step includes the split of published data on regional employment by sections of CZ-NACE into 82 industries in line with national accounts figures. The key assumption is that the gross value added (a) per worker (l) is identical within each section of CZ-NACE across all regions. It means that the first estimate of employment in region r is obtained as:

$$l^r_{i,s} = \frac{a_{i,s}}{l_{i,s}} l^r_s , \tag{1}$$

where:

- s section of CZ-NACE,
- i industry within the section s,
- a gross value added,
- l employment,
- r region.

The next step consists of computation of the difference between the sum of regional employment by sections and the sum of employment by industries (82). The following conditions should be set. The sum of regional figures across all industries must correspond to national totals (2) and the sum of figures by industries within each section of CZ-NACE must correspond to regional figures (3):

[8] More recent research papers can be found at: <http://www.idu.cz/media/document/multiplikacni-efekty-2010.pdf>.
[9] <http://apl.czso.cz/pll/rocenka/rocenka.indexnu_reg>.
[10] The Czech official name for this regional level is "Kraj".

$$l_i = \sum_r l_i^r . \tag{2}$$

$$l_s^r = \sum_s l_{s,i} . \tag{3}$$

Solving formulas (2) a (3) was done by iterative method RAS (see Vavrla and Rojíček, 2006) in two rounds with original RAS method for two constraints (rows and columns of the table). Resulting matrix $\mathbf{L^I}$ where rows correspond to the regions and columns to industries was used as source data for transformation. In each region, product technology was used to transformed industry based data for product based data (method A described in IO Manual, see Eurostat, 2008):

$$l_p^r = l_i^r (V')^{-1} \hat{q} , \tag{4}$$

where:

l vector of employment by products in region r by products (p) of industries (i),
V output matrix (product, industries),
$\hat{q}$ diagonal matrix of output.

Table 1 Regional employment by products, 2011, CZK mil.

Region	Total	Agri-culture	Mining Manu-facturing	Construc-tion	Trade Transport Hotels	Informa-tion activities	Banking Insurance	Real estate	Services for compa-nies	Public adminis-tration Education Health	Other services
	T	A	B+C+D+E	F	G+H+I	J	K	L	M+N	O+P+Q	R+S+T+U
	5 043 438	159 221	1 358 862	508 623	1 275 415	126 966	91 070	32 235	444 488	866 364	180 194
Pha	899 746	3 634	51 853	81 455	284 954	67 047	43 586	23 424	156 794	144 762	42 237
Stc	551 394	25 547	164 943	52 732	157 213	4 829	4 389	637	37 365	87 853	15 886
Jhc	299 676	17 847	85 902	33 265	75 814	2 367	3 822	733	17 749	50 558	11 619
Plz	277 778	12 241	93 446	24 097	62 062	3 680	3 311	518	22 729	46 402	9 292
Kar	141 032	2 810	40 574	13 140	40 612	435	1 334	75	8 461	28 617	4 974
Ust	352 404	8 478	93 774	46 734	83 792	2 402	3 703	904	27 889	71 659	13 069
Lib	193 887	3 614	74 176	17 747	43 660	1 883	2 625	511	10 144	32 763	6 764
Krh	251 777	11 112	81 903	22 178	59 587	2 496	3 169	170	14 288	46 895	9 979
Par	235 667	12 820	85 271	21 676	53 668	2 268	3 503	539	12 877	36 734	6 311
Vys	224 014	18 677	89 013	23 450	39 328	2 029	1 646	598	7 190	36 994	5 089
Jhm	553 654	16 621	139 861	59 796	135 499	21 161	8 766	1 436	53 847	93 554	23 113
Olm	270 893	11 592	93 849	26 191	57 338	3 510	2 876	630	15 653	52 124	7 130
Zln	263 414	6 154	108 128	28 688	57 800	3 023	2 054	638	12 305	39 156	5 468
Mrs	528 102	8 074	156 169	57 474	124 088	9 836	6 286	1 422	47 197	98 293	19 263

Note: Names of CZ-CPA codes were shortened, official names can be found at: <https://www.czso.cz/csu/czso/klasifikace-produkce-cz-cpa>. Full names of regions can be found in the Annex.
Source: Own computation

Employment broken down by product classification is an important part of input-output analysis. The figures correspond to the number of persons needed for production of a particular product. Fourteen resulting vectors obtained by formula (4) are arranged in a matrix $\mathbf{L^p}$ with dimension (14 regions, 82 products). Aggregated figures are described in Table (1). Obtained technical coefficients, defined as number of employed persons divided by output can be downloaded from: <kest.vse.cz>.[11] The elements of matrix **E** (regions x products) were obtained as:

$$e_j^r = l_j^r / x_j^r , \tag{5}$$

where:

- e technical coefficient of employment,
- x output,
- j index pro product.
- r region.

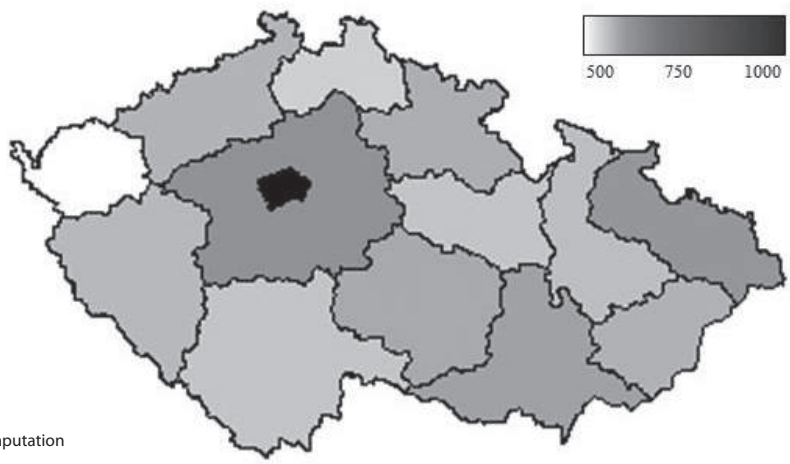
3 ANALYSIS OF REGIONAL EMPLOYMENT

Regional employment corresponds to the size of the region and these figures provide informative value only in connection with production or value added. The following Figure 1 presents regional map of gross value added per worker employed in the region; productivity of employment at current prices (h). For computational purposes, the figures were rescaled (standardized) to be presented in the form of map, see formula (6):

$$h_{st}^r = \left[h^r - \min(h) \right] / \left[\max(h) - \min(h) \right] . \tag{6}$$

The highest productivity is in the capital city of Prague, over CZK 0.9 mil. In three regions (Středočeský, Jihomoravský and Moravskoslezský kraj), the productivity exceeds CZK 640 thousand. In five regions productivity still exceeds CZK 600 thousand and in four regions CZK 560 thousands. The weakest region, Karlovarský kraj, has the productivity of employment on the level of 500 thousands CZK. In comparison with Prague, it is just about a half.

Figure 1 Regional productivity of employment, 2011, thousand CZK per person

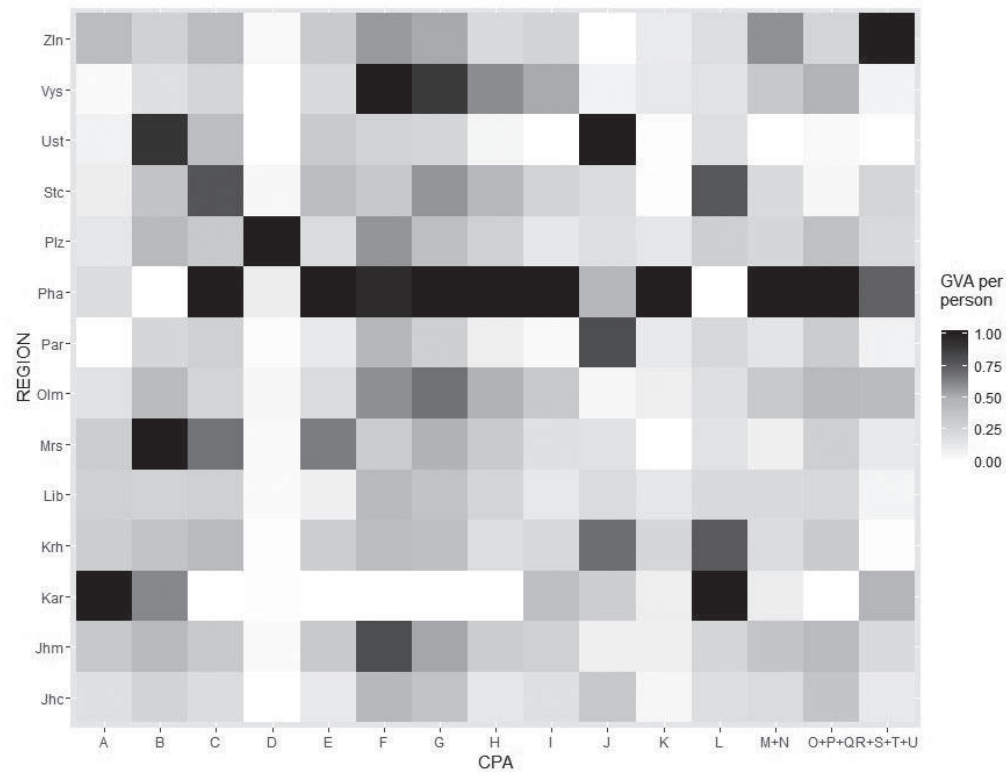


Source: Own computation

[11] The link is active from 1.12.2016.

Regional industrial specifics can be clearly presented on the heat map for emphasizing the differences. Again, heat map was constructed from standardized data (see formula 6). Prague as a capital city has the highest employment productivity for most of products. On the contrary, some regions are very specific. Středočeský kraj is very much linked to manufacturing, trade and real estate products. The region with the lowest employment productivity, Karlovarský kraj, has the highest productivity in agriculture and forestry and real estate products. For all other products, the productivity of this region is very weak. There are two regions without specifically high productivity, Jihočeský and Liberecký kraj. Although Ústecký and Moravskoslezský kraj are connected mainly with mining products, automotive industry in Moravskoslezský kraj creates high value added per worker. Interesting figures can be found also for Zlínský kraj, where other services (recreation, social and other) creates relatively high values of gross value added with relatively low employment and so high productivity of employment (Figure 2).

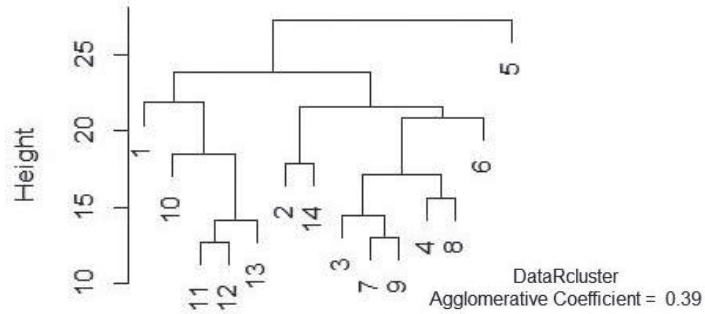
Figure 2 Heat map of regional employment productivity, 2011



Note: The scale for a heat map is based on standardized data, where 0 is given by the minimum and 1 by the maximum value.
Source: Own computation

Similar information is found when using simple cluster analysis based on Euclidean distance. There are some regions that are very different from others, mainly Karovarský kraj and the capital city of Prague. Unsurprisingly, similarity is found between Středočeský and Moravskoslezský kraj (mainly due to automotive industry) and between Jihomoravský and Olomoucký kraj. Close similarity was also identified between Liberecký and Pardubický kraj. Finally, there are found two big clusters and one very distant region, Karlovarský kraj. Clustering of employment productivity was not very successful since agglomeration coefficient is very low (0.39), see Figure 3.

Figure 3 Dendrogram of the clusters of Czech regions, 2011



Note: Regions codes refer the order used in the Table 1 or see the Annex.
Source: Own computation

4 TESTING OF REGIONAL EMPLOYMENT SENSITIVITY

Since regional employment and regional specialization is often discussed, I prepared a simple test related to regional employment. Such discussions take place on both national and regional level, regarding mainly the sensitivity of the Czech Republic on changes in automotive industry and final demand for cars. With respect to the specialization of regions mentioned above, it can be expected that each region has its own sensitivity on external shocks. Regional input-output analysis on preliminary results and selected regions was also provided in Sixta and Fischer (2015).

With respect to the specific output of the region, regional economy would react on external incentives (shocks) differently. From this perspective, it crucially depends on regional employment productivity, the mixture of imported and produced products and regional capacities. Testing regional sensitivity of employment is based on computation of elasticities of employment from simple static input-output analysis with all the limitations and assumptions (e.g. free capacities), see Leontief (1986). Three scenarios were selected to illustrate sensitivity of regional employment. The first scenario consists of external shock in the industry with the highest regional output (SC 1). The second scenario consists of external shock in the industry of maximum regional employment (SC 2). The third scenario represents external shock

Table 2 Selected products for scenarios

Nb.	Region	Scenario 1	Scenario 2	Scenario 3
0	CZ	29	46+47	41_42_43
1	Pha	46+47	46+47	41_42_43
2	Stc	29	46+47	41_42_43
3	Jhc	35	46+47	41_42_43
4	Plz	26	46+47	41_42_43
5	Kar	86	46+47	41_42_43
6	Ust	19	46+47	41_42_43
7	Lib	29	46+47	41_42_43
8	Krh	29	46+47	41_42_43
9	Par	26	46+47	41_42_43
10	Vys	35	01	41_42_43
11	Jhm	46+47	46+47	41_42_43
12	Olm	46+47	46+47	41_42_43
13	Zln	22	22	41_42_43
14	Mrs	29	46+47	41_42_43

Source: Own computation

in construction industry (SC 3). The first two scenarios are specifics for each region. On the contrary, the third scenario was selected to explain sensitivity on the same product. Following Table 2 shows selected products (on the level of two digits CZ-CPA) for all three scenarios in the regions including the Czech Republic.

The external shock is modelled simply in line with traditional statistic input-output analysis, see formula (7). It is used for illustrative purposes only. The change of output vector (x) is derived from the change of vector of final use (y). The final impact on employment is measured by the share of employment in output, see formula (7) and scalar multiplication (8).

$$\Delta x = (I - A)^{-1} \Delta y \,, \tag{7}$$

$$\Delta l = e^{r} \cdot \Delta x \,, \tag{8}$$

where:

l vector of employment by products,
x output matrix (product, industries),
y vector of final use,
e^{r} vector of technical coefficients of employment for region r.

For computation purposes, the change of final use counted 20 CZK bn. or 10 CZK bn. depending on the size of industry in a particular region. The comparison is based on relative figures, simple elasticizes of employment were calculated as:

$$\varepsilon^{r} = \frac{\sum_{i} \Delta l_{i,t}}{\sum_{i} l_{i,t}} \Bigg/ \frac{\sum_{i} \Delta y_{i,t}}{\sum_{i} y_{i,t}} \,. \tag{9}$$

Besides employment elasticities, output elasticities were computed as well. Computed elasticities cover both direct and indirect effects. It means that direct effects can be observed in the affected products (industry) by external shock (e.g. construction in case of the decrease of government investment into public infrastructure). Indirect effects can be identified in transport, trade, construction materials, etc. The overview of all three scenarios is shown in Table 3, data are recalculated for the change of final use by one CZK mil.

Table 3 Impact of the change in final use on output and employment

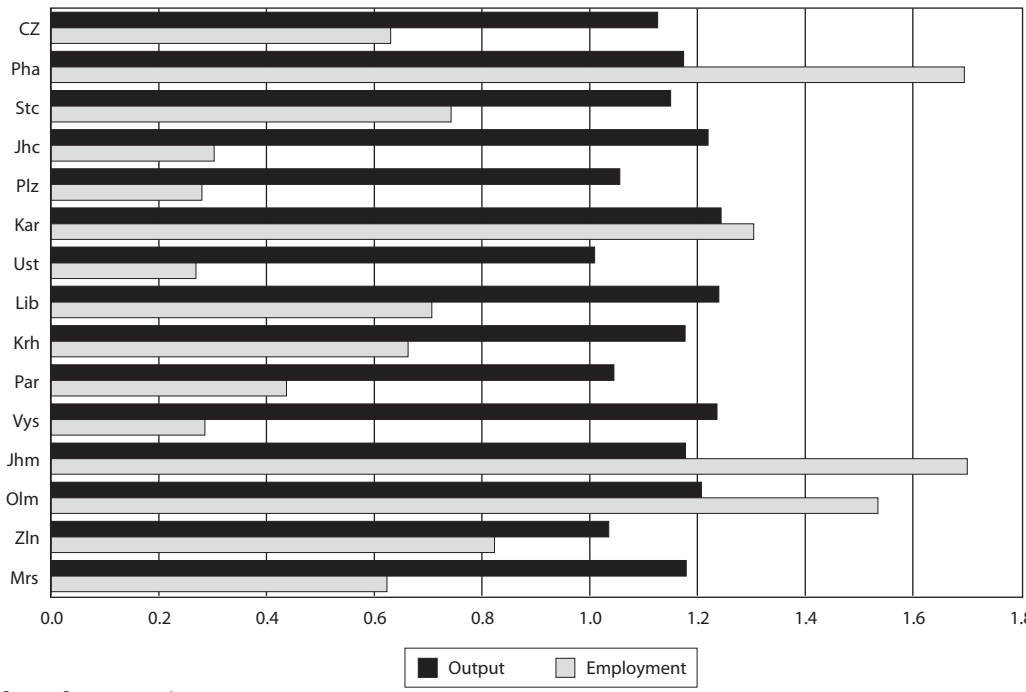
	SC1		SC2		SC3	
	Δx	Δl	Δx	Δl	Δx	Δl
CR	1.51	0.44	1.60	1.25	2.04	1.13
Pha	1.84	1.00	1.84	1.00	2.19	0.77
Stc	1.46	0.43	1.48	1.25	1.93	1.18
Jhc	1.63	0.26	1.47	1.43	1.96	1.31
Plz	1.37	0.22	1.51	1.38	2.02	1.26
Kar	1.32	1.13	1.44	1.58	1.80	1.46
Ust	1.28	0.18	1.48	1.42	1.87	1.39
Lib	1.52	0.56	1.42	1.43	1.99	1.29
Krh	1.51	0.50	1.44	1.40	1.97	1.30
Par	1.29	0.28	1.42	1.43	1.97	1.30
Vys	1.57	0.21	1.59	1.37	1.92	0.98
Jhm	1.64	1.39	1.64	1.39	2.23	1.16
Olm	1.49	1.28	1.49	1.28	2.00	1.27
Zln	1.26	0.59	1.26	059	1.95	1.24

Source: Own computation

Scenario 1

When comparing resulting elasticities for output and employment, very different results are obtained. It is caused by the difference between output in monetary values and number ofworkers necessary for the production, see Figure 4. Only in two regions the difference between output and employment elasticity is low (Karlovarský and Zlínský). On the level of the Czech Republic, the highest output is observed in automotive industry (29) and the elasticity of output is about 1.13 and elasticity of employment only 0.63. It means that the change of final use by one percent leads to the increase of overall output by 1.13% and the increase of employment by 0.63%. In nominal terms it means that additional CZK one million spent in final demand for products of automotive industry leads to CZK 1.5 million of output and 0.4 workers needed, see Table 3. The lowest employment elasticities are observed for regions oriented for energy products, Vysočina, Jihočeský, Ústecký kraj (0.29, 0.3, 0.27) and Plzeňský kraj (0.28) with high share of computers production. The highest employment elasticities are observed for Praha and Jihomoravský kraj, both connected with trade activities (46+47), reaching 1.7.

Figure 4 Elasticities for Scenario 1

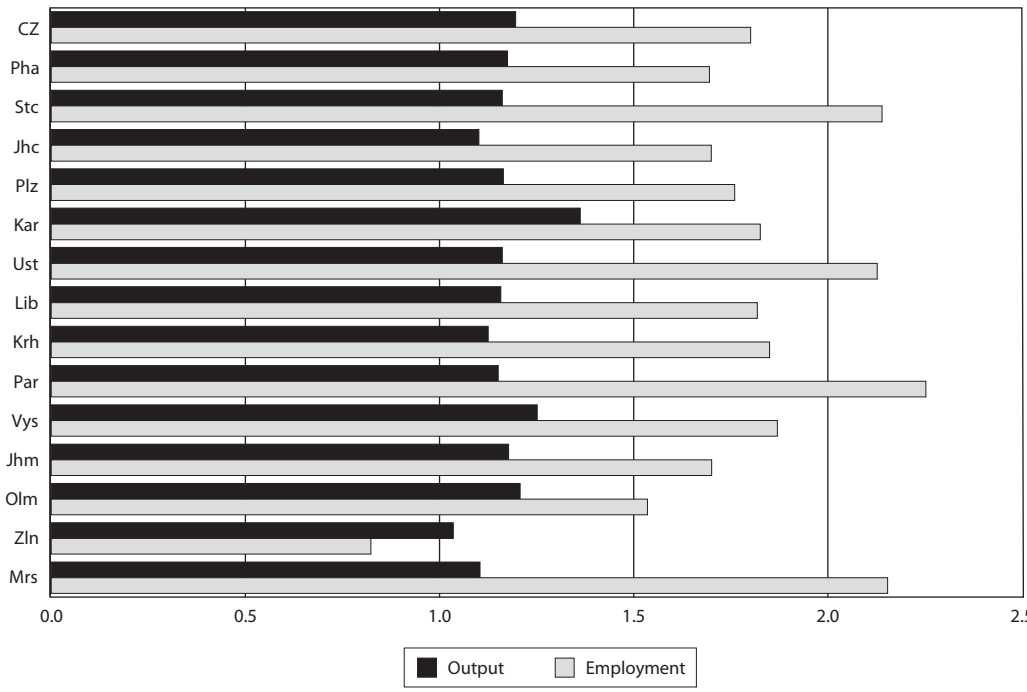


Source: Own computation

Scenario 2

When focusing on products (industries) with the highest employment, stable differences between output and employment elasticities are observed, see Figure 5. Only Zlínský kraj has the lowest employment elasticity, only about 0.823. In nominal terms it means that additional one million CZK creates 0.6 jobs. In all other regions, the elasticity of employment is higher than 1 with maximum about 2.25 in Pardubický kraj. In 12 regions the highest employment is connected with trade products (industries) (46+47), only in Vysočina and Zlínský kraj the most important products (industries) are different. Vysočina is oriented to agriculture and forestry (01) and Zlínský kraj to rubber and plastic products (22).

Figure 5 Elasticities for Scenario 2



Source: Own computation

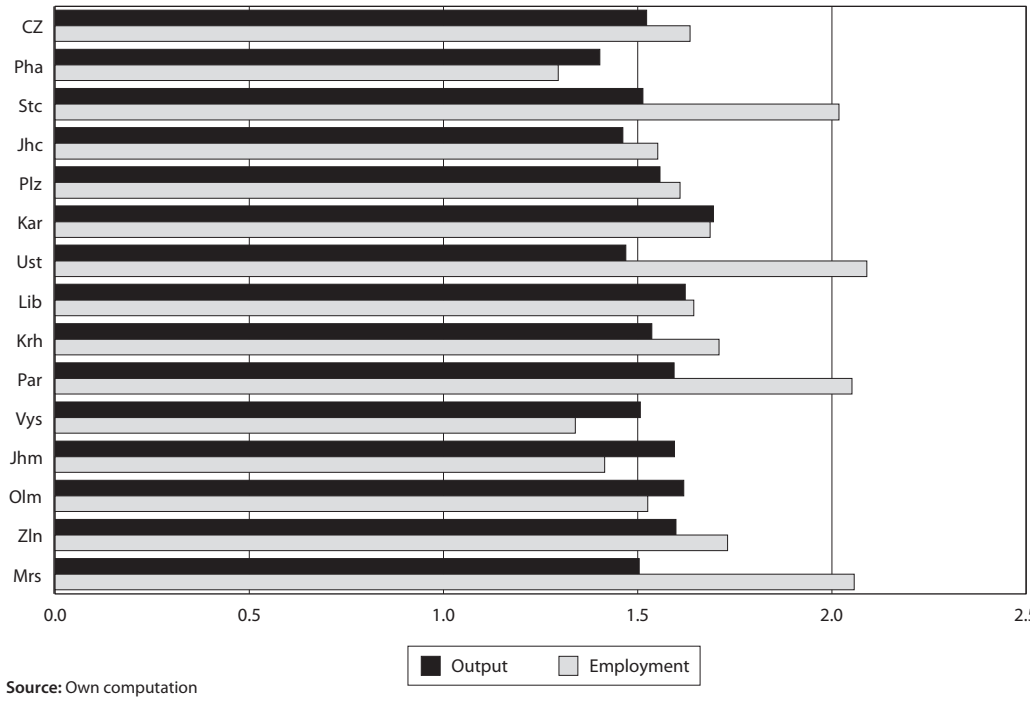
Scenario 3

The third scenario describes the situation when final demand for construction services is increased. This can be reached either by private or public expenditures. It also refers to the frequently discussed role of construction of public infrastructure for the reduction of regional structural unemployment. In this case, the output elasticities do not provide adequate information since construction industry is very interdependent. There are many elements of production chain before completed product (e.g. building or structure) finds its final customer. The analysis of employment elasticities shows that in some regions the possibility of influencing the employment by induced construction works is very limited, see Figure 6. For example, in the capital city of Prague, employment elasticity is very low, additional CZK 1 mil. creates only 0.8 jobs. The elasticity reaches only 1.3 that is the minimum of all regions while the average elasticity for the Czech Republic is 1.63. On the contrary, the same amount invested in Ústecký kraj leads to the increase of jobs by 1.4 with maximum regional elasticity of 2.09. The second lowest values of elasticities are found for Vysočina (1.34) even though the productivity of employment of construction services is relatively high but there is a big share of goods and services imported to construction industry. In all cases it means that incentives aimed at regional employment do not provide adequate response if the regional economy is not equipped by suitable free capacities.

CONCLUSION

The paper provided the information about data on regional employment linked to products within national accounts' framework. The methodology of construction of regional employment data is described including the links to officially published data. Besides, analytical possibilities of this data are presented. Regional data was constructed for 14 regions of the Czech Republic and broken down by product

Figure 6 Elasticities for Scenario 3



Source: Own computation

classification (CZ-CPA) counting 82 categories. Employment by products is an important analytical indicator to be used mainly for input-output based economic models. Such data is not officially published in the Czech Republic and therefore they are based on academic research that follows previous work in this area, see (Sixta and Vltavská, 2016).

Even though presented figures are prepared for the year 2011 and based on ESA 1995 (SNA 1993) methodology, their usage is not significantly affected. The foundations of input-output analysis lie in the structures and relation of costs and production, i.e. output in national accounts methodology. The methodology of construction was developed for the condition of Czech statistics where some principles relating to the breakdown of statistical units in national accounts are not fully implemented. It refers mainly to the definition of local kind of activity unit and widely used principal activity approach and local units. Anyway, the methodology is transferrable to other cases and can be used for other countries.

Analysis of regional employment allows for identifying regional specifics and their links to other regions. Presented heat map shows the significance of employment in different groups of products (homogenous industries). Regions were also compared from the perspective of their distance with simple cluster analysis. The specifics of the capital city of Prague were illustrated. Such information was used for simple static input-output analysis and computation of regional employment elasticities (multipliers) describing the sensitivity of employment. The analysis was presented in three scenarios for selected final demand shocks. It should provide information about the possibility of affecting regional employment.

Regional input-output tables including auxiliary indicators such as employment should serve for regional economic modelling. Optimal regional economic policy should tackle specific regional problems like structural unemployment. Statistical data serve as basis for such analyses and their availability and quality significantly set the limits to their users. Despite high demand for detailed regional data, European official statistics do not provide adequate amount of information for construction of advanced

regional models. Our research data covering regional input-output tables and regional employment can be downloaded from kest.vse.cz/ and they are intended to be exploited in users' analyses.

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ANNEX

List of the regions

Number	Short Name	Name	CZ-NUTS
0	CZ	Česká republika	CZ0
1	Pha	Hlavní město Praha	CZ010
2	Stc	Středočeský kraj	CZ020
3	Jhc	Jihočeský kraj	CZ031
4	Plz	Plzeňský kraj	CZ032
5	Kar	Karlovarský kraj	CZ041
6	Ust	Ústecký kraj	CZ042
7	Lib	Liberecký kraj	CZ051
8	Krh	Královehradecký kraj	CZ052
9	Par	Pardubický kraj	CZ053
10	Vys	Vysočina	CZ063
11	Jhm	Jihomoravský kraj	CZ064
12	Olm	Olomoucký kraj	CZ071
13	Zln	Zlínský kraj	CZ072
14	Mrs	Moravskoslezský kraj	CZ080