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Input-Output Tables for Regions of the Czech Republic

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Abstract

Regional Input-Output Tables represent a powerful statistical tool for deep economic analysis. They belong to a group of detailed statistical indicators linked to the information contained in national accounts and they are widely demanded by skilled users. Unfortunately, Regional Input-Output Tables are rarely officially compiled since they are strongly dependent on demand extensive statistical surveys. With respect to users' needs, we constructed symmetric regional tables for 14 regions (NUTS 3 level) of the Czech Republic for 2011. These tables are compiled at basic prices and broken down by 82 products. They arise from officially published data covering mainly Supply and Use Tables, Symmetric Input-Output Tables and regional accounts. The key approach lies in the decomposition of the output vector into the regions and applying national technological relations. The paper brings both a brief description of the methodology of our freely available tables and a basic description of possibilities of Regional Input-Output Tables for economic analysis.

Keywords	***JEL code***
Input-output analysis, national accounts, regional accounts	*C67, R15*

INTRODUCTION

Regional Input-Output Tables (RIOTs) have represented an object of long economic research since the introduction of Symmetric Input-Output Tables (SIOT) (Leontief, 1966). Efficient regional policy requires detailed description of regional economy and therefore lots of researchers look for RIOTs to use them in their analyses. In many cases this effort fails. Compiling RIOTs is expensive since official statistical agencies employ their own standard procedures to compile statistical indicators. They typically arise from direct data surveys ensuring required quality of data. Obtaining data on regional cost structures for both intermediates and primary inputs proves very difficult for both statistical agencies and respondents. It causes that only few statistical offices publish RIOTs or RIOT based multipliers, e.g. these tables were constructed for Spain (INE, 2010), Finland (Piispalla, 1999) and Italy (Benvenuti et al., 1995). On the contrary, even though academic approach consists in many simplifying assumptions that may not meet the requirements applied to official statistics, the results should suffice for researchers.

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The issue of the construction of RIOTs is theoretically very well described. Miller and Blair (2009) offer a comprehensive introduction, foundations and classification of the types of RIOTs. Louhela and Koutaniemi (2006) describe practical experience with constructing regional tables.[3] One can find lots of available scientific literature dealing with Regional Input-Output Tables but practical manual is unavailable. It is partly due to specifics of each country's statistical system. The estimation of regional output vector represents the most important issue connected with the definition of statistical units, mainly local kind-of-activity units.

Our paper briefly illustrates the methodology of pure RIOTs compilation on the case of the Czech Republic. We constructed regional tables for all 14 regions (NUTS 3 level) at basic prices for 2011. These tables are derived from officially published national and regional accounts according to our specific approach. RIOTs are symmetric, product-by-product type and based on European System of Accounts ESA 1995 (Eurostat, 1996) and System of National Accounts SNA 1993 (United Nations, 1993) methodology. Even though ESA 2010 (Eurostat, 2013) is currently in effect the difference for input-output analysis are irrelevant. The tables reflect the specifics of the Czech national accounts mainly the concepts of kind-of-activity units.

Besides the methodological points dealing with the construction of RIOTs, we present differences in using input-output analysis based on national and regional data. Regional Input-Output Analysis (RIOA) provides a powerful tool for studying regional specifics.

1 METHODOLOGY OF CONSTRUCTION

Regional input-output tables can be constructed by various methods. The most comprehensive and demanding methods arise from detailed regional surveys aimed at regional cost structure, regional production, final consumption, employment, etc. These approaches are usually very costly and allow a direct calculation of supply and use tables or symmetric input-output tables. On the contrary, a similar way remains far from researchers' possibilities, including ours. We focused on the compilation of RIOT from available (published) data sources with minimum additional (qualitative) information.

From the perspective of researchers, studying regional economy through RIOTs provides lots of interesting data with interconnections. RIOTs provide detailed description of regional economy and the data can be easily extended to multiregional models. The following description of methodology was used to compile fourteen individual regional input-output tables for the Czech Republic, product-by-product type.[4]

RIOTs compilation is based on several assumptions. For our purposes, we adopted the following ones:

a) The level of independence in decision making of local units is irrelevant, all the data originate in individual companies' accounting and no inter-company sales are recorded.
b) The Czech Statistical Office does not follow the definition of local kind-of-activity and therefore simplification is necessary. It refers to the industrial structure of the data.[5] The headquarters of a company and all subsidiaries are classified according to the principal activity of the whole company. This simplification influences the interpretation of data and transformation from industry-based data to product-based data.

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[3] Detailed literature review can be found in Sixta (2017).

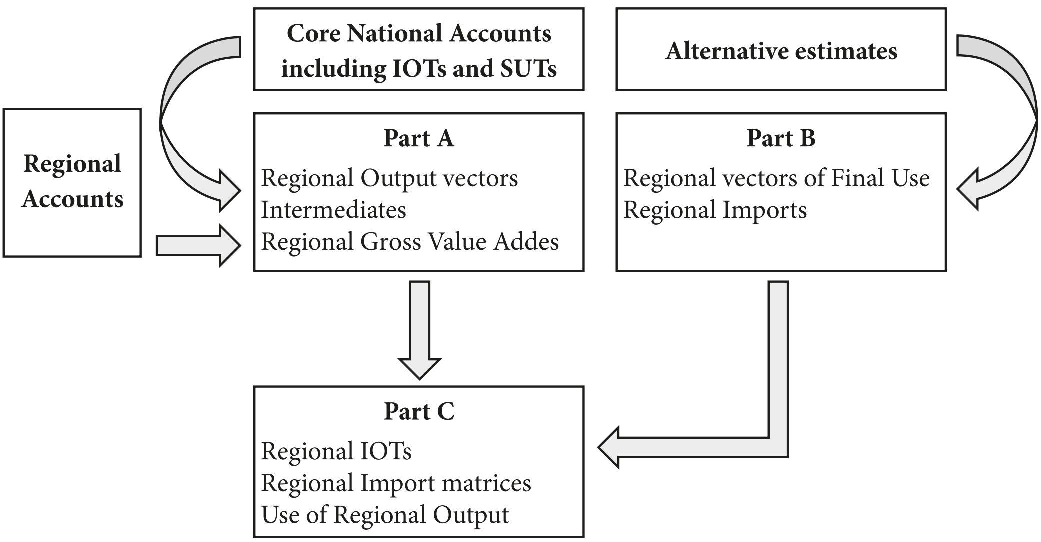
[4] The issue of combining our RIOTs into multiregional input-output tables is a subject of research of collaborating researcher Karel Šafr. The first estimate should be published during 2017.

[5] The case of electricity represents an illustrative case. The headquarters of a company providing electricity is located in Prague. Even though the power plants are situated elsewhere, the amount of wages paid to management, accounting, legal and similar services reach significant proportion. The output of the headquarters is interpreted as a service invoiced to the customer originated in Prague.

c) The key frame is set by the estimation of the output vector. Its estimation arises from a combination of regional and national accounts.
d) National technology given by existing SIOT for the Czech Republic is applied on a detailed level (82 products).

In some aspects, our approach is similar to the GRIT method[6] where national input-output tables undergo redistribution into regions. The substance of the process lies in constructing regional output vectors (x^R) and applying national technology to the estimates of intermediates and primary inputs. Figure 1 describes these steps.

Figure 1 Process of estimation



Source: Authors' elaboration

The difference between our approach and approaches recommended in contemporary literature lies in statistical matter. We do not focus primarily on regional relations, the links between regional and national multipliers.[7] We strictly focus on compilation issues; the compilation of RIOTs should follow the procedure of compiling SIOTs as much as possible.

The link between officially published regional gross value added for particular region and the result obtained as the difference between estimated regional output and regional intermediate consumption represent the principal issue. With respect to users' needs, we fitted regional gross value added to official figures. Intermediates are increased proportionally. The following formula explains the transformation of gross value added from industry based figures to product based ones:

$$v^{R,P} = v^{R,I}(X')^{-1}(\hat{x}), \tag{1}$$

6 Generation of regional input-output tables, see Miller and Blair (2009).
7 See Deng et al. (2014).

where:
$v^{R,P}$ estimated regional gross value added by products,
$v^{R,I}$ published regional gross value added by industries,
X output matrix,
$(\hat{x})$ diagonal output matrix.

Output vectors were estimated using allocation keys for each industry in all fourteen regions. These allocation keys arise from the decomposition of output within institutional sectors. For example, the output of public infrastructure influences the output of ancillary activities in transport industry (NACE code 52) significantly. It means that the value of products of roads and railways within the government sector is allocated according to their length in individual regions. Therefore, it is necessary to take into account the sector composition of output. Final estimates of regional output vectors broken down by industries (CZ-NACE) undergo transformation into a product-by-output matrix obtained from annually published supply and use tables, for details see Sixta and Vltavská (2016). Estimates of output, intermediate consumption and independent estimation of gross value added have to be put together, checked and balanced. It is useful to discuss these results with experts on regional economy since on the level of all products (i) following condition applies:

$$x_j^R - \sum_i c_{i,j}^R = v_j^R \,, \tag{2}$$

where:
x_j^R output of product j in the region R,
$c_{i,j}^R$ intermediate consumption of i for j,
v_j^R gross value added by product j in the region R.

Initial estimates of intermediate consumption result from applying national technology coefficients (input coefficients) to output. Applying national technology means that we multiplied coefficients of intermediates ($a_{i,j}$) and primary inputs (w_j) by output vectors for all regions. Since the breakdown goes into considerable detail (two-digit level, 82 product groups), results are reasonable even for the first estimate. Finally, another condition applied to intermediates is:

$$c_{i,j} = \sum_R c_{i,j}^R \,. \tag{3}$$

A well-known method, called RAS method[8] allows to keep the condition given by Formulas (2) and (3). Usually several rounds of iterative procedures are necessary.

We did not deal with the third quadrant (primary inputs, structure of value added) in detail. Hence, we obtain the total value added from Formula (2). A different approach is used for the estimation of final use. Some economists do not focus on final use (see Nosková, 2016) since they primarily need regional Leontief matrices (see Eurostat, 2008). However, we consider it necessary, at least for the consistency of the tables. Two approaches are available. One consists in applying output coefficients on output and other comprises an effort to tackle final use separately and combine with the first and third quadrant. We adopted the latter and with the help of our collaborating researches Musil and Kramulová, (Kramulová and Musil, 2013)[9] we received initial estimates of regionalised final use. Independent estimates were checked and adjusted to fit the condition (2) where instead of intermediate consumption (c), matrix (arranged vectors) of final use (Y) is used.

8 Trinh and Phong (2013) describe the RAS method in detail.
9 A thorough description of regionalisation of final use would make up a subject of an entire paper.

The next stage tackles exports and imports. The key assumption says that both exports and imports split between international and inter-regional trade. International exports are allocated into the region according to the regional output, proportionally, product-by-product. International imports are allocated according to domestic use, i.e. total use less exports. Inter-regional trade (exports or imports) arises from the balancing difference on the regional level. Insufficient resources (uses exceed resources) for a particular product represent imports needed. On the contrary, if regional resources (output plus imports) exceed regional use, the surplus of product is exported. Of course, it represents a simplification since a product is only exported or imported between regions and no re-exporting of products (or exporting and importing of the same type of products) is assumed. The sum of inter-regional exports equals the sum of inter-regional imports, see Formula (4):

$$\sum_{R=1}^{14} e\,i^R = \sum_{R=1}^{14} m\,i^R , \tag{4}$$

where:
ei^R inter-regional regional exports,
mi^R inter-regional regional imports.

Finally, all the figures were checked, combined and balanced. Balancing input-output tables is not a very common procedure since they arise from balanced supply and use tables but the principle remains the same (Kahoun and Sixta, 2013). Such statistical exercise aims mainly at providing analytical material for economists. Therefore, we hope that all the assumptions and simplification mentioned above do not distort these economists' analyses.

2 RESULTING REGIONAL INPUT-OUTPUT TABLES

RIOTs incorporate several pieces of important information used in describing regional economy as well as in regional modelling. As RIOTs represent a considerable data source, we chose only several results

Table 1 Production approach, regional structure, 2011, mil CZK

Region	Output	Intermediate consumption	Net taxes on products	GDP
CZ	9 784 432	6 339 967	378 936	3 823 401
Pha	2 383 174	1 526 468	65 926	922 632
Stc	1 202 298	828 636	46 971	420 633
Jhc	475 328	299 696	20 759	196 391
Plz	458 501	290 171	19 424	187 754
Kar	172 979	102 086	9 144	80 037
Ust	672 570	456 204	28 207	244 573
Lib	301 634	191 221	13 843	124 256
Krh	424 476	267 094	18 215	175 597
Par	458 280	319 796	18 346	156 830
Vys	388 428	246 977	16 777	158 228
Jhm	945 857	589 141	39 874	396 590
Olm	403 541	241 954	19 653	181 240
Zln	447 197	283 746	19 241	182 692
Mrs	1 050 169	696 777	42 556	395 948

Note: CZ – the Czech Republic, Pha – Prague, Stc – Central Bohemia Region, Jhc – South Bohemia Region, Plz – The Plzen region, Kar – the Karlovy Vary Region, Ust – the Usti Region, Lib – the Liberec Region, Krh – the Hradec Kralove Region, Par – the Pardubice Region, Vys – the Vysocina Region, Jhm – the South Moravian Region, Olm – the Olomouc Region, Zln – the Zlin Region, Mrs – the Moravian-Silesian Region.
Source: Authors' calculations

for an illustration of their possibilities. Complete sets of RIOTs including technical coefficients for 82 products[10] are available at the website of the Department of Economic Statistics.[11]

Tables 1 and 2 represent two main approaches to gross domestic product (GDP) estimation. The production approach indicates that Prague reaches the highest regional output, with 24% of the national output. Central Bohemia Region that surrounds Prague and the Moravian-Silesian Region represent other comparatively powerful regions (based on the value of the output) with the share of regional output about 12% and 11% respectively.

Similar to other countries, Czech capital stands out in terms of all indicators (see Table 2). The expenditure approach to GDP indicates that Prague records the highest final consumption expenditures. It is caused mostly by a high share of final consumption expenditures by government (see Figure 2) with 39% unlike other regions. Final consumption expenditures also constitute an important part of regional GDP in the South Moravian Region (77% of regional GDP).

Gross fixed capital formation (GFCF) shows the value of investment in the particular region. GFCF is allocated notably in Prague and Central Bohemia Region. Export and import in the perspective of RIOTs cover both international and interregional trade. This proves the dominancy of Prague with 845 bn. CZK for export and 643 bn. CZK for import. These results were expected as Prague comprises the centre for Central Bohemia Region whose inhabitants commute to Prague for work, shopping and entertainment. Central Bohemia Region and the Moravian-Silesian Region reach significant values of import and export as well.

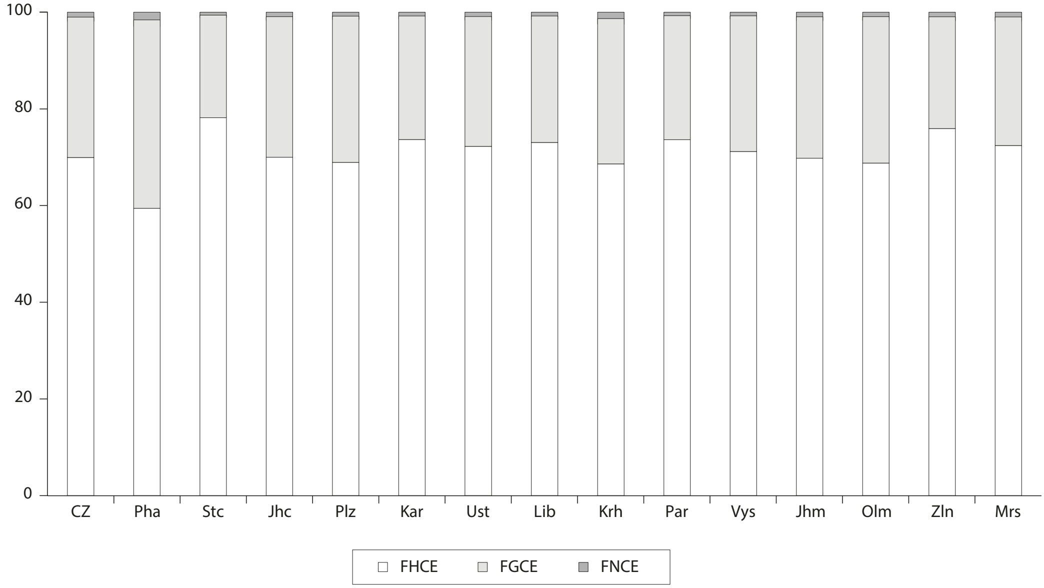
Table 2 Expenditure approach, regional structure, 2011, mil CZK

Region	FCE	GFCF incl. valuables	Changes in inventories	Export*	Import*	GDP
CZ	2 727 725	926 270	10 824	3 899 905	3 741 323	3 823 401
Pha	488 163	232 805	–1 156	845 565	642 745	922 632
Stc	303 567	113 613	3 542	556 880	556 969	420 633
Jhc	154 132	45 199	1 156	170 394	174 490	196 391
Plz	141 697	41 075	1 033	184 569	180 620	187 754
Kar	69 309	24 123	112	77 096	90 603	80 037
Ust	195 977	73 294	833	279 971	305 502	244 573
Lib	102 986	27 961	311	125 629	132 631	124 256
Krh	136 841	31 660	827	175 983	169 714	175 597
Par	120 288	34 633	1 132	228 007	227 230	156 830
Vys	123 368	35 253	510	158 796	159 699	158 228
Jhm	307 196	97 515	760	301 872	310 753	396 590
Olm	157 218	40 624	247	143 163	160 012	181 240
Zln	133 292	36 635	115	210 723	198 073	182 692
Mrs	293 691	91 880	1 402	441 257	432 282	395 948

Note: FCE – final consumption expenditures, GFCF – gross fixed capital formation, * the total value for the Czech Republic is different since the trade between regions is included.
Source: Authors' calculations

[10] We use the standard European classification of products, CPA (CZ-CPA).
[11] <http://kest.vse.cz/veda-a-vyzkum/vysledky-vedecke-cinnosti/regionalizace-odhadu-hrubeho-domaciho-produktu-vydajovou-metodou>.

Figure 2 Structure of final consumption expenditures, regions, 2011 (in %)



Note: FHCE – final consumption expenditures of households, FGCE – final consumption expenditures of government, FNCE – final consumption expenditures of non-profit institutions serving households.
Source: Authors' calculations

Table 3 Structure of regional export and import, 2011 (in %)

Region	Export		Import	
	International	Interregional	International	Interregional
CZ	72.3	27.7	71.1	28.9
Pha	43.4	56.6	65.2	34.8
Stc	82.3	17.7	70.1	29.9
Jhc	72.0	28.0	71.4	28.6
Plz	81.1	18.9	74.6	25.4
Kar	74.6	25.4	50.5	49.5
Ust	71.4	28.6	73.9	26.1
Lib	86.3	13.7	68.1	31.9
Krh	85.3	14.7	73.9	26.1
Par	87.3	12.7	76.1	23.9
Vys	74.0	26.0	68.2	31.8
Jhm	79.9	20.1	79.3	20.7
Olm	81.1	18.9	70.1	29.9
Zln	73.3	26.7	70.5	29.5
Mrs	85.5	14.5	75.1	24.9

Source: Authors' calculations

Table 3 describes the structure of regional import and export. Clearly, only Prague reaches a higher share on interregional export (56.6%) than on international export (43.4%). Central Bohemia Region achieves a high share of international export (82.3% of total export, i.e. 147 bn. CZK). The main commodities belong to the category of Manufacturing since automobile industry dominates this region as well as the Moravian-Silesian Region. In the Usti Region, mainly the export of coke and refined petroleum products push the share on interregional export up to 28.6%.

International import into Prague comprises services of Wholesale and retail trade and Crude petroleum and natural gas products. A significant share of Central Bohemia international import belongs to the category of Manufacturing. The South Moravia Region imports mainly ICT products. The Moravian-Silesian Region interregional import consists mainly of Wholesale and retail trade services.

3 INPUT-OUTPUT ANALYSIS BASED ON REGIONAL DATA

RIOTs represent an important tool for modelling economic impact in individual regions based on different inputs into the regional economy. The wide range of analytical possibilities covers mainly assessments of regional impacts of different events or policies. The easiest example consists in modelling of the changes in final use (e.g. investments shocks), changes in regional wages, regional tax and price incentives, etc. The most demanding models are based on the organisation of regional matrices in a big single matrix that illustrates flows of products between the regions. Such inter-regional models can be constructed on the basis of regional input-output tables where the inter-regional flows are estimated by different methods, see Šafr (2016).

For the purpose of this paper, we prepared an illustration based on a simple static input-output model (Eurostat, 2008). The effect is demonstrated on the influence of the investment of households into dwellings amounting to 10 bn. CZK (Buildings and building construction works, CPA 41). The analysis is presented separately on national input-output tables for the Czech Republic (i.e. country average) and 3 regional tables. This division reveals the differences of the impact using national IOTs and RIOTs for individual regions.

Table 4 presents the overall impact of an investment on the economy. The results show that even if an investment is made in the same amount in all regions and the Czech Republic as a whole, the impact differs significantly. South Bohemia Region (4.6%), the smallest region in our selection (according to the portion of the regional output on national output), records the highest increase of output. The lowest increase of output is achieved when using data for the Czech Republic as a whole. South Bohemia Region along with the Moravian-Silesian Region scored the highest increase of gross fixed capital

Table 4 The total impact of the investment into Buildings and building construction works, 2011 (in %)

		CZ	Mrs	Stc	Jhc
P.1	Output (basic prices)	0.2	1.9	1.6	4.6
D.21-D.31	Net taxes on products	0.0	0.3	0.3	0.5
P.7	Import	0.1	0.8	0.9	2.4
	Resources	0.2	1.6	1.4	3.9
P.2	Intermediate consumption	0.2	2.0	1.8	5.3
P.3	Final consumption expenditures	0.0	0.0	0.0	0.0
P.5	Gross capital formation	1.1	10.7	8.5	21.6
	of which GFCF incl. valuables	1.1	10.9	8.8	22.1
P.6	Export	0.0	0.0	0.0	0.0
	Total uses	0.2	1.6	1.4	3.9

Source: Authors' calculations

formation, with 22.1% and 10.9% respectively. This implies that the smaller area of region the higher the impact achieved.

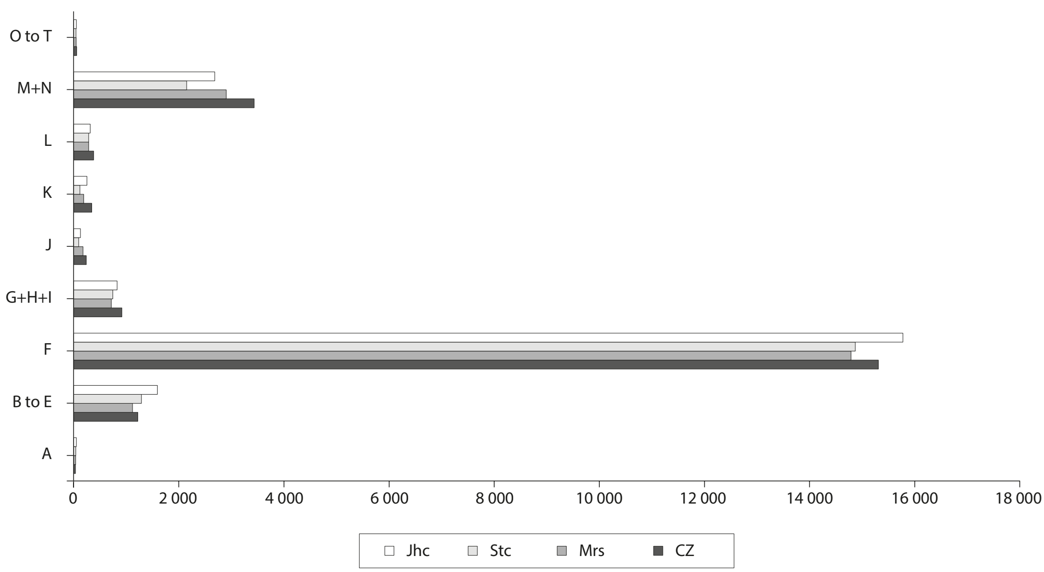
When analysing the increase of the investment into the Buildings and building construction works (Table 5), the Moravian-Silesian Region achieved the highest increase of gross value added (6 466 mil CZK). Gross value added increased less in Central Bohemia Region (4 939 mil CZK) and South Bohemia Region (5 763 mil CZK) compared to the average of the Czech Republic (6 251 mil CZK).

Table 5 The total impact of the investment into Buildings and building construction and works on gross value added, mil CZK

	CZ	Mrs	Stc	Jhc
A	15	10	18	26
B to E	363	309	375	467
F	3 779	4 307	3 120	3 336
G+H+I	395	335	352	401
J	125	95	37	59
K	195	116	59	146
L	183	135	191	175
M+N	1 163	1 128	761	1 120
O+P+Q	21	18	15	18
R to T	12	13	11	14
Total	6 251	6 466	4 939	5 763

Source: Authors' calculations

Figure 3 Total change of output, mil CZK



Source: Authors' calculations

Beside the structure of gross value added, the structure of output differs among regions as well (Figure 3). The Moravian-Silesian Region and South Bohemia Region represent regions closest to the average of the Czech Republic while Central Bohemia Region deviates the furthest from it. The most visible impact is observable within the Construction industry (F) with more than 14 bn. CZK in each region.

All results of IOA show that using only national IOTs does not capture what happens to the economy in individual regions. IOTs disregard the impact of a single investment. Employing RIOTs and investigating the impact of the same investment in individual regions allows us to describe the changes in regional economy more precisely.

SUMMARY AND CONCLUSION

Regional Input-Output Tables are used for many kinds of economic analysis, ranging from simple description of regional economy to sophisticated modes containing links among regions. Unfortunately for researchers, these tables are rarely compiled. The fact that RIOTs are occasionally available for some countries allows testing some theoretically described methods and models. However, a complete data set used for e.g. European regional economic policy remains out of reach. When analysing regional policy impacts on value added and employment, it represents the most suitable tool.[12]

Our paper brought a brief description of the construction of regional input-output tables based on the model approach combining official data and technological assumptions. Experts on regional economy verified the results several times and we updated them according their comments. Basic data come from officially published Supply and Use Tables and Regional Accounts. RIOTs for the Czech Republic were constructed at basic prices for the year 2011. The dimension of 82 × 82 products allows sufficient detail for most economic studies. The tables follow the ESA 1995 methodology but its differences from the recently used ESA 2010 would provide negligible effects on their use. However, we will prepare RIOTs for the Czech Republic using the presented methodology according to ESA 2010 for the year 2013 as officially published national IOTs by the Czech Statistical Office have been made only up to this date.

The presented simple static input-output analysis on the case of regional investments was selected for illustration purposes. It clearly shows that one can hardly study detailed regional effects using only tables for the whole economy. Regional tables are especially suitable for modelling of the impact of regional investments, investment incentives or holding important events (e.g. Olympic Games).

The Czech Statistical Office belongs to the most developed statistical agencies in the compilation of input-output tables since it publishes both product-by-product and industry-by-industry tables more frequently than it is required by the EU regulations. As the construction of Regional Input-Output Tables represents a task that lies somewhere between official statistics and academic research, the Czech Statistical Office considers this issue rather as scientific then the task for official statistics. The academic approach allows lots of simplification and a model oriented attitude. Official statistics usually rely on hard, i.e. surveyed, data. With respect to that, possibilities of regional surveys aimed at the structure of costs of local units (intermediates) are very limited. An optimal mix of procedures used in official statistics and models (verified by experts) can become a breakpoint for a future upturn in this area.

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[12] A detailed regional structure of uses as defined in national accounts also allows the computation of specific purchasing power parities, e.g. Čadil et al. (2014).

References

BENVENUTI, S. C., MARTELLATO, D., RAFFAELLI, C. INTEREG: A Twenty-Region Input-Output Model for Italy. *Economic Systems Research*, 1995, 7, pp. 101–116.

ČADIL, J., MAZOUCH. P., MUSIL. P., KRAMULOVÁ, J. True regional purchasing power: evidence from the Czech Republic. *Post-Communist Economies*, 2014, 26, pp.241–256.

DENG, X., WAMG, Y., WU, F., ZHANG, T., LI, Z. *Practical Guideline for the IO Table Compilation and CGE Modeling.* Springer, 2014.

EUROSTAT. *European System of Accounts – ESA 1995.* Luxembourg: Office for Official Publications of the European Communities, 1996.

EUROSTAT. *Eurostat Manual of Supply. Use and Input-Output Tables.* Luxembourg: Office for Official Publications of the European Communities, 2008.

EUROSTAT. *European System of Accounts – ESA 2010.* Luxembourg: Office for Official Publications of the European Communities, 2013.

INE. *Spanish Regional Accounts. Base 2010.* Madrid: Instituto Nacional de Estadística, 2010.

KAHOUN, J. AND SIXTA, J. Regional GDP Compilation: Production. Income and Expenditure Approach [online]. *Statistika: Statistics and Economy Journal*, 2013, 4, pp. 24–36.

KRAMULOVÁ, J. AND MUSIL, P. Experimentální odhad výdajové metody regionálního HDP. *Politická ekonomie*, 2013, 61, pp. 814–833.

LEONTIEF, W. *Input-Output Economics.* Oxford University Press, 1966.

LOUHELA, T. AND KOUTANIEMI, M. Construction of regional input-output tables in Finland 2002 [online]. In: *46th Congress of the European Regional Science Association (ERSA)*, Greece, 30.8.–3.9.2006. [cit. 20.12.2016]. <http://www-sre.wu-wien.ac.at/ersa/ersaconfs/ersa06/papers/110.pdf>.

MILLER, R. E. AND BLAIR, P. D. *Input-output analysis: foundations and extensions.* Cambridge University Press, 2009.

NOSKOVÁ, M. Regional Economic Effects of the European Capital of Culture Project: The Use of Input-Output Analysis. *E+M. Ekonomie a Management*, 2016, 19, pp. 57–74.

PIISPALA, J. *Constructing Regional Supply and Use Tables in Finland.* Presented at the European Regional Science Association (ERSA), 39th European Congress in Dublin, Ireland, 23.–27.8.1999.

SIXTA, J. Input-Output Approach to Regional Employment [online]. *Statistika: Statistics and Economy Journal*, 2017, 1, pp. 5–17.

SIXTA, J. AND VLTAVSKÁ, K. Regional Input-output Tables: Practical Aspects of its Compilation for the Regions of the Czech Republic. *Ekonomický časopis*, 2016, 64, pp. 56–69.

ŠAFR, K. Allocation of commodity flows in regional Input-Output tables for the Czech Republic [online]. In: *AMSE 2016 (Applications of Mathematics and Statistics in Economics)*, 2016, pp. 328–340. <http://amse.umb.sk/proceedings/Safr.pdf>.

TRINH, B. AND PHONG, N. V. A Short Note on RAS Method. *Advances in Management & Applied Economics,* 2013, 3, pp. 133–137.

UNITED NATIONS. *System of National Accounts 1993 – SNA 1993.* New York: United Nations, 1993.

Impact of Consumption Unit's Scale on Credibility of the Income Indicators in the Czech Republic

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Abstract

The comparison of income of a person has to consider the household composition. Additional persons realize economies of scale especially for expenditures related to housing. Therefore, so-called consumption units have been introduced. International scales have been produced by the OECD and Eurostat. The definition of consumption units has an impact on indicators of poverty as consumption units are used when equalized income is estimated. International scales should ensure comparability of results among countries, but they may not be appropriate for conditions in different countries.

The aim of the paper is to prepare methodological background for computation and then to estimate consumption units for the Czech Republic. Results are compared with international scales. In addition, the impact on indicators of poverty is assessed. Income and poverty indicators based on estimated consumption units should assure more accurate results for household's living in the Czech Republic.

Keywords

Consumption units, equivalence scale, economies of scale, household disposable income, poverty threshold

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INTRODUCTION

One of the important social and statistical issues is to analyze the well-being of households. The main attention is paid to households with low income that may suffer from the lack of food or other basic needs. These households are considered to be in poverty. This term 'poverty' is quite a multifaceted concept and it is associated with the lack of income or with failure to attain capabilities (Sabates, 2008). Problems of poverty are often associated with joblessness. However, some people are at-risk-of poverty even though they work (Šustová and Zelený, 2013).

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Poverty lines are set in two ways: absolute and relative. Absolute poverty lines are based on costs of basic needs (Coudel et al., 2002). This kind of measurement is usually applied for developing countries and the World Bank uses several thresholds[3] (e.g. 1.9 USD in PPP). Relative poverty thresholds are defined in relation to the overall distribution of income or consumption in a country. This approach is common in developed countries. In European countries, the at-risk-of poverty threshold is set at 60% of the national median equivalized disposable income (after social transfer).[4]

Statistical issue is how to define and estimate the median of equivalized disposable income. As the indicator should contain all incomes including social transfers, the only data source is the EU-SILC survey. The average earnings information system and wage statistics cover just wages and salaries. National accounts provide data on total net disposable income, however, no information on probability distribution is available.[5] In addition, the term 'equivalized' is supposed to be defined. Motivation may be seen in including composition of household into account. Some expenditures are directly linked to persons, such as expenditures on food, restaurants. However, other expenditures do not depend on the number of persons in household. They are rather connected to the dwelling itself, e.g. expenditures on rent, energy, maintenance. Households consist of two or more members realize economies of scale. The fact should be taken into account by applying scales of consumption units.

Consumption units can be defined as follows: 'A weighting system assigning a coefficient to each member of the household and used to compare standards of living between households of different sizes and compositions. With this weighting, the number of people is converted into a number of consumption units (CU)'.[6] It means that the first household member (usually an adult) is always considered as a base of this scale with the weight (or consumption unit) equal to one. Consumption units for the next members is may be found in range <0;1>. Currently, two main scales produced by international organizations are applies, see the following table:

Consumption units	OECD	Modified OECD
The first adult in the household	1.0	1.0
Other adults in the household	0.7	0.5
Children in the household	0.5	0.3

Source: Lapáček (2013)

International scales ostensibly ensure comparison of results among countries. However, it has not been proved yet that economies of scales are the same or very similar in all countries. It can be argued that the structure of consumption expenditures, which probably determines economies of scales, differs. The aim of the paper is to estimate consumption units in the Czech Republic. Subsequently, estimated results are compared with international scales and the impact on indicator of poverty is expressed.

1 MAIN PUBLICATION IN THE FIELD

Besides the above mentioned scales (OECD scale, modified OECD scale) other research has been carried out. Many consumption unit's scales were prepared, especially for the purpose of international comparison. Some of them are published by Chanfreau and Burchardt (2008). The most important are

[3] <http://povertydata.worldbank.org/poverty/home>.

[4] <http://ec.europa.eu/eurostat/statistics-explained/index.php/Glossary:At-risk-of-poverty_rate>.

[5] National accountants are grateful users of data from social statistics and data about domestic households are very often used as a benchmark for non-residents, see Šimková and Langhamrová (2015).

[6] <https://www.insee.fr/en/metadonnees/definition/c1802>.

the Square root designed by Luxemburg Income Study (LIS), and the Oxford scale originally recommended by OECD. The second one already considered the different needs among household members in relation to demographic characteristics of people. In this time, the most common scale is the modified OECD scale prepared by Hagenaars, De Vos and Zaidi (1994), which is derived from the Oxford scale and primarily used by Eurostat. These scales were designed by experts of European or other international institutions in order to apply the common approach in all countries. It may ensure comparability of data on the standard of living among countries.

Next to these approaches, other methods taking into account the country specific needs could be used on national level. Buhmann et al. (1988) presented the general approach based on survey data on consumption expenditures. The recommendation for preparing the scales by regression analysis of survey data is to specify the power relation between the household size and total expenditures. The larger is the equivalence elasticity e, which varies between 0 and 1, the smaller are the economies of scale assumed by the equivalence scale. The relation between needs and size could be expressed by the equation (Buhmann et al., 1988).

The other variables, than the household size, should be considered within the equation of household expenditures. The most important equations are presented in the following chapter and considered in this analysis. According to Van der Gaag and Smolensky (1982), it is necessary to distinguish between household with and without children. The impacts on families with children by considering the economies of scales should be higher than on household of adults. The equivalence scale should reflect both economies of scale and differences in household characteristics. Given the household size, elasticity will decrease with the number of children (Schwarze, 2003). According to Dudel (2015) the estimates of nonparametric bounds on equivalence scales for couples with one child and childless couples as reference are between (1.16, 1.46), so the consumption unit for the child should range from 0.16 to 0.46. The affected indicators taking into account equivalence scale are all income indicators based on personal income level, all income inequality indicators and, finally, also poverty rates indicators (Förster, 1994).

The consumption unit's scale is the important factor affecting the indicators comparing the living conditions of households. The assessment of consumption units impacts primarily the income indicators. Considering the consumption units instead of members in household increases the average personal income, the income per consumption unit (equivalised income) will be higher than income per capita. The equivalence scale changes distribution of income and thereby the income inequality and all of indicators dependent on income, especially the poverty threshold and at-risk-of-poverty rate. According to De Vos and Zaidi (1997) the poverty threshold is very sensitive on equivalence scale, because it depends on number of consumption units which dispose with the total household income.

The aim of the paper is to estimate the equivalence scale of consumption units, appropriate for the conditions of households in the Czech Republic. Estimates are based on expenditures of Czech households and they have not been calculated yet. The reason is that current equivalence scales used by Eurostat or OECD may not be appropriate for Czech households. Developed methodology and estimates equivalence scale of consumption units are presented in the article. Finally, the impact on poverty indicators is discussed.

2 DATA AND METHODOLOGY

The estimation of economies of scale by each household is prepared on data from the Household Budget Survey (HBS), which collects information about household expenditures (CZSO_HBS, 2014). The impact of choice of consumption unit's scale on income indicators is provided. The data of income are taken from national version of Survey on Income and Living conditions (EU-SILC) conducted by the Czech Statistical Office (CZSO_SILC, 2014).

2.1 Assessment of household expenditure

This HBS is conducted by the Czech Statistical Office every year with the sample size of around 3 000 households. It provides data on expenditures and consumption structure of private households. The aim of the survey is to produce statistics on consumption, expenditures and income of all members of household, data on household composition, furnishings and other economic characteristics of household. Data are collected monthly, however, the results are published annually. The most important household characteristics should be defined for estimation of equation of household expenditures. They can be found in OECD guidelines.

Buhmann et al. (1988) defined crucial household characteristics that mostly influence their consumption and structure of expenditures. The number of household members taking into account the number of children is the main factor. The explanatory variables in regression analysis are the number of adults and the number of children meaning up to 14 years. This age limit was chosen according to recommendation of the OECD experts preparing the consumption unit's scales (Chanfreau and Burchardt, 2008). Household budget survey in the Czech Republic provides data enabling to estimate the consumption unit based on expenditure of households and their characteristics.

According to Van der Gaag and Smolensky (1982) the expenditure of households should be modeled by some equation. The simplified version of equation of expenditure is as follows:

$$q = a_o + a_i, \tag{1}$$

where q is total expenditure amount, a_0 is the expenditure of one person's household (base), a_i are the specific differences of expenditure for household type i (households with specific demographic structure i) in relation to one-person's household. The next step is to quantify the system of weights for each specific household type i by using the parameter d_i, which could be derived from Formula (1) as follows:

$$d_i = a_i/a_o. \tag{2}$$

Thereafter, it is possible to assign to each specific household i the number of consumption units m according to the following formula (Van der Gaag and Smolensky, 1982):

$$m = 1 + d_i. \tag{3}$$

The first equation could be estimated using regression analysis. The type of regression function should correspond with real shape of function of total expenditures that could be estimated by data exploring. In household budget survey, there is a variable 'household size' that is considered as continuous because the number of months spent in specific household is taken into account. Due to the above, the method of linear regression could be used including significant input variables, as it is treated for example in analysis by Bishop (2015). The regression coefficients mean the expenditures increase by addition of further household member.

2.2 Assessment of income indicators

The EU–SILC is conducted by the Czech Statistical Office as the national version of international harmonised survey. It provides data about income, material and living conditions of households. One of the most important indicators based on the EU–SILC survey is at-risk-of-poverty-rate. It expresses the share of people under poverty threshold computed as the 60% of median national equivalised disposable income. The threshold is affected by choice of equivalence scale of consumption units, which determines the economies of scale realised by household with respect to household size and composition.

It is because this threshold is dependent on whole distribution of equivalised income, which is computed by using chosen equivalence scale. Therefore, not only the number but also the structure of people at-risk-of-poverty depends on used type of scale. This is the reason, why the equivalence scale should be precisely determined.

3 RESULTS

3.1 Regression coefficients of the equation of household expenditure

The household expenditure can be described by Formula (1), which takes into account the type of household. Brázdilová and Musil (2016) proved that expenditures depend on the number of adults and number of children in household, see the following formula:

$$q = b_0 + b_1{*}\ adults + b_2{*}\ adults^2 + b_3{*}\ children, \tag{4}$$

where q stands for expenditure, adult for number of adult members and children for number of children in household. Regression coefficients represent the specific amount of expenditures added for each variable. Parameters of the model are given in the Table 1.

Table 1 Parameter estimates of regression analysis

Variable	Parameter Estimate	Standard Error	t Value	Pr > |t|	Standardized Estimate	Variance Inflation
Intercept	–272.6	1 680.3	–0.16	0.8711	0	0
Adult	16 771.0	1 614.1	10.39	<.0001	0.706	16.347
Adult^2	–1 898.4	341.6	–5.56	<.0001	–0.375	16.141
Children	5 029.7	4 814	10.45	<.0001	0.182	1.075

Source: Authors

This whole regression model has Adjusted R-square value equal to 0.184, it can explore just 18.4% of total variability of expenditures. Nevertheless, this is not the aim of this paper. The estimates are given in CZK per month.

The result equation of household expenditure from the regression analysis based on survey data from year 2014 is as follows:

$$q = -273 + 16\,771\ adults - 1\,898\ adults^2 + 5\,030\ children, \tag{5}$$

where q stands for expenditure, *adults* for number adult members and children for number of children in household.

In this case the base of the equivalence scale of consumption units, precisely the one-person's household, could be expressed as follows:

$$a_0 = b_0 + b_1 + b_2. \tag{6}$$

The parameter d_i that allows to find the system of weights of additional household members for each specific household type i could be derived from the Formula (7):

$$d_i = ((b_0 + b_1{*}\ adults + b_2{*}\ adults^2 + b_3{*}\ children) - (b_0 + b_1 + b_2))\ /\ (b_0 + b_1 + b_2). \tag{7}$$

3.2 Estimate of consumption unit's scale

The parameters of result equation allow us to estimate total expenditures for each specific type of household taking into account the household composition. In the Table 2 there is the total number of consumption units in each specific household type. Estimates of consumption units, which belong to further additional member of household based on an increase of expenditure that he or she brings relative to one-person's household, are in the last column. The second adult in household causes the increase of total expenditure in year 2014 by about 76%, for third and following adult it is much less. The first child leads to an increase in total expenditures just about of 34%. Children's demand is not so large as it is for adults. The total expenditure of multi-household with children shows higher economies of scale than multi-households of adults.

Table 2 Estimates of total expenditure (in CZK per month) and system of consumption units by household structure in the year 2014

Household structure	Total expenditure	Number of CU	CU of additional member
1 adult	14 600	1.00	-
2 adults	25 676	1.76	0.76
1 adult with child	19 630	1.34	0.34

Note: CU stands for consumption unit.
Source: Authors

These results should be proved by analysis based on data from the previous five years. Such a regression analysis was carried out with similar values of estimated parameters and similar result equations. There are estimates of means of total expenditures by particular type of household and the weights of the second additional member of household by taking into account the difference between adults and children. The weights for adults seem to be the same for each year, namely 0.76. On the other hand, the weights for children vary between 0.21 and 0.42, the average of previous five year is 0.31. Analysis provides the evidence that the consumption units are stable over the time and the average results should be considered as appropriate consumption units for a household living in the Czech Republic. For additional adults in household, it means weight of 0.75 and for additional child up to 14 years it results on level of 0.3. These units represent the combination of two most frequent used scales, the OECD scale (1; 0.7; 0.5) and the modified OECD scale (1; 0.5; 0.3), which is used by Eurostat for income indicators measurement in each EU country (OECD_project). Based on results of our research, an appropriate consumption unit's scale is (1; 0.75; 0.3) for the Czech Republic. The further adult in household realizes lower economies of scale than it is expected by international scales in the Czech Republic. Otherwise the consumption level of child (up to 14 years old) is just 0.3 of total consumption of one-person's household. The economies of scale are higher for the household with children than for household (with the same household size) of adults.

3.3 Impact of consumption units on income indicators

Considering the consumption units instead of members in a household it increases the average personal income, so the income per consumption unit (equivalised income) is higher than the income per capita. The impact of applying consumption units instead of the number of members in household on income distribution is discussed by Malá (2015). The equivalence scale changes the distribution of income and thereby the income inequality and all of indicators dependent on income, especially the poverty threshold and at-risk-of-poverty rate. According to (De Vos and Zaidi, 1997) the poverty threshold is very sensitive to equivalence scale, which determines the number of consumption units in each household type.

The at-risk-of-poverty rate for year 2014 would be 12.3% by consideration of income per capita, while this indicator based on equivalised incomes is always lower. The results of this income indicator by using different consumption unit's scales are presented in the Table 3.

Table 3 Total impact of each of consumption unit scales on at risk of poverty rate in 2014

CU scale	Poverty threshold	Number of people below poverty threshold	At-risk-of-poverty rate
Per capita	80 459	1 269 987	12.31%
Modified OECD	118 817	1 002 252	9.72%
OECD	100 080	995 986	9.66%
Estimated CU	101 056	933 583	9.05%

Source: Authors

The consumption unit scales considering higher range economies of scale indicate higher personal equivalised income, thereby higher poverty threshold and more people below this threshold that increases the at-risk-of-poverty rate. The indicator based on modified OECD scale is 9.72%, while for the OECD scale is slightly lower. Consumption units resulting from our research would decrease the at-risk-of-poverty rate on 9.05% as shown in the table. This equivalence scale compared with modified OECD scale decreases the equivalised income for household with more adults because it takes into account smaller economies of scale. This distribution of equivalised income may be probably more equal and the income inequality indicators would be likely lower.

3.4 Impact of consumption units on structure of people below poverty threshold

The choice of equivalence scale affects not only values of indicators, but also their variability. With the change of at–risk-of-poverty rate, the structure of people below poverty threshold is also different. The various groups of people are influenced by consumption unit's scale in different ways. Considering the economic status of people, the most significant changes are observed on one hand for children and, on the other hand, for pensioners because the children live more often in households with more members while the pensioners live often alone. The household size is the most important factor which causes the significance of the impact of equivalence scales. The income situation of multi-households is affected by a determination of equivalence scale at the most, but the change is observed also for one person household. The reason is the movement of the overall income distribution, which causes the relative change ranking all households by their income.

In the Table 4, the comparison of commonly used modified consumption unit's scale and the estimated scale is presented. According to at-risk-of-poverty rate indicator published by Eurostat just 8.6% of people below poverty threshold are children, while pensioners constitute 20%. Using the estimated scale the decrease of number of people the below poverty threshold is observed and their structure by economic status is slightly different. Among them 11.2% are children and only 12.6% pensioners. Children usually live in multi-households, which realise smaller economies of scale according to the estimated scale. Therefore, their income situation is worse in comparison with other household types. More children fall into poverty despite lower threshold. The income situation of pensioners usually living alone remains unchanged. However, they more probably drop out of at-risk-of-poverty. The overlap of person who is below the threshold by both criteria is also observed. In spite of lower number of such people the structure is similar. It varies between both criteria, only for unemployed people and other inactive people is higher than in each other threshold.

Table 4 Structure of people below poverty threshold per different criterion by their economic status in 2014

	Structure of population		Structure of people below poverty threshold (%)		
	Absolute	Relative (%)	Threshold per modified OECD	Threshold per estimated CU	Threshold per both criteria
Children	700 768	6.8	8.6	11.2	10.1
Employee with lower education	1 513 168	14.7	7.2	8.1	7.3
Self-employed	814 990	7.9	5.9	6.5	6.2
Employee with higher education	2 276 663	22.1	4.0	5.1	4.2
Pensioners	2 473 028	24.0	19.9	12.6	13.0
Unemployed	550 009	5.3	24.6	26.7	27.7
Others	1 986 945	19.3	29.7	29.8	31.6
Total	10 315 571	100.0	100.0	100.0	100.0

Source: Authors

Income indicators for various groups of people by their economic status are also dependent on equivalence scale. In the table 5 the value of at-risk-of-poverty rate for each of groups is shown. They differ by applied equivalence scale. Overall rate based on Eurostat's approach for the whole population is slightly higher than the rate resulting from our research. It is caused by considerably higher rate for pensioners, who represent 24% of population. At-risk-of-poverty rate for pensioners is 8.1%, while using the estimated scale it accounts for 4.8%. It is not offset by higher rate for children, which rises from 12.3% to 15%. Other groups of people by their economic status are not significantly affected. It is possible to set the number of people below both thresholds (based on Eurostat scale and on estimated scale). This share of people is slightly lower because of stricter conditions. Overall rate is the same (8.2%) in both approaches. The change in structure of the at-risk-of-poverty people may have an important impact on political decisions in social and family policies.

Table 5 At risk of poverty rate per different criterion of poverty threshold by their economic status in 2014 (in %)

	Rate by threshold per modified OECD	Rate by threshold per estimated CU	Rate by threshold per both criteria
Children	12.3	15.0	12.2
Employee with lower education	4.8	5.0	4.1
Self-employed	7.2	7.4	6.4
Employee with higher education	1.8	2.1	1.6
Pensioners	8.1	4.8	4.5
Unemployed	44.8	45.3	42.7
Others	15.0	14.0	13.5
Total	9.72	9.05	8.22

Source: Authors

CONCLUSION

The determination of consumption unit's scale has a huge impact on evaluation of economic and social conditions of households. Currently, international equivalence scales are applied. There is the advantage that common methodology and equivalence scale is used and results should be comparable. People may also believe that equivalence scale does not differ significantly as societies are similar even in Europe. However, it has been proved that equivalence scale in the Czech Republic is not same to equivalence scale used by Eurostat or OECD.

The OECD scale with weights (1; 0.7; 0.5) is used by OECD for international comparison of countries across the world. The modified OECD scale with stricter weights (1; 0.5.; 0.3) is commonly used by Eurostat for comparisons among European countries. Nevertheless, analysis of households within specific country should respect local conditions.

The estimated consumption unit's scale for the Czech Republic is the following: (1; 0.75; 0.3) based on our research. For additional adult in household should be used the weight 0.75 because his or her value of consumption is on 75% level of the first household member. The economies of scale are just 25% for the household of two members. The consumption level of child in household represents just 30% of value of first adults in a household, so the weight of the child is 0.3. The range of economies of scale for children is similar to that considered in the modified OECD scale.

Using the estimated equivalence scale for Czech households allows us to assess their economic and income conditions more precisely. This consumption unit's scale compared to modified OECD scale decreases the equivalised income for household with more adults because it assumes smaller economies of scale. Total household income is thus distributed between more consumption units. It leads to a change in the income distribution. Subsequently, the at-risk-of-poverty rate falls to 9.1%. Equivalized income distribution based on estimated consumption unit scale is more equal. Consequently, income inequality is lower.

It was proved that households realize not so large economies of scales in the Czech Republic as it is considered in international scales. The consumption level of Czech household depends on household characteristics such as household composition, namely the size and number of children. However, other characteristics were not taken into account. Currently, limited characteristics of households are available in household budget survey. The survey is now being redesigned and it will be merged with EU-SILC. More information about particular household will be available in the future. The challenge for further research subsists in design of more complex model.

Using this estimated equivalence scale for Czech households specifies more precisely assessment of their economic and income conditions. This consumption unit scale compared to modified OECD scale decreases the equivalised income for household with more adults because it takes into account the smaller economies of scale, so the total household income is then distributed between higher value of consumption units.

The choice of equivalence scale affects not only the level of total income indicators, but also the individual indicators for groups of people by their economic status. At-risk-of-poverty rate is lower for pensioners and higher for children based on our research. The consumption unit's scale has also the impact on the structure of people below the poverty threshold. The proper identification of this structure of people at-risk-of-poverty is important for policy makers.

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References

BISHOP, J. A. et al. Subjective Poverty Equivalence Scales For Euro Zone Countries. *Journal Of Economic Inequality*, 2014, Vol. 12, Iss. 2, pp. 265–278. DOI: 10.1007/S10888-013-9254-7.

BRÁZDILOVÁ, M. AND MUSIL, P. Estimate of Scale of Consumption Units in the Czech Republic Based on Expenditures of Czech Households. In: *Applications of Mathematics and Statistics in Economics – AMSE* [CD ROM], Banská Stiavnica, 2016.

BUHMANN, B. et al. Equivalence Scales, Well-Being, Inequality, And Poverty – Sensitivity Estimates Across 10 Countries Using The Luxembourg Income Study (Lis) Database [online]. *Review Of Income And Wealth*, 1988, Iss. 2, pp. 115–142. <http://www.roiw.org/1988/115.pdf>.

CHANFREAU, J. AND BURCHARDT, T. *Equivalence Scales: Rationales, Uses And Assumptions* [online]. 2008. <http://www.gov.scot/Resource/Doc/933/0079961.pdf>.

COUDOUEL, A., HENTSCHEL, J. S., WODON, Q. T. Poverty measurement and analysis. *A Sourcebook for poverty reduction strategies*, 2002, Vol. 1, pp. 27–74.

CZSO_HBS [online]. 2014. <https:// www.czso.cz/csu/czso/statistika-rodinnych-uctu-metodika>.

CZSO_SILC [online]. 2014. <https://www.czso.cz/csu/czso/prijmy-a-zivotni-podminky-domacnosti>.

DE VOS, K. AND ZAIDI, M. A. Equivalence Scale Sensitivity Of Poverty Statistics For The Member States Of The European Community [online]. *Review Of Income And Wealth*, 1997, Iss. 3, pp. 319–333. <http://www.roiw.org/1997/319.pdf>.

DUDEL, C . Nonparametric Bounds On Equivalence Scales. *Economics Bulletin*, 2015, Vol. 35, Iss. 4, pp. 2161–2165.

FÖRSTER, M. F. Measurement Of Low Incomes And Poverty In A Perspective Of International Comparisons [online]. In: *Labour Market And Social Policy*, OECD, Directorate For Education, Employment, Labour And Social Affairs, 1994, No. 14. <http://www.oecd-Ilibrary.org/Docserver/Download/5lgsjhvj7v5g.Pdf?Expires=1460379899&Id=Id&Accname =Guest&Checksum=8D171B0609737C927D1CEF2570D19C18>.

HAGENAARS, A., DE VOS, K., ZAIDI, M. Poverty Statistics. In: *The Late 1980s: Research Based On Micro-Data*, Office For Official Publications Of The European Communities, OECD: Luxembourg, 1994.

LAPÁČEK, M. *Ekvivalenční stupnice a příjmová nerovnost* [online]. Prague, 2013. [cit. 30.3.2016]. <http://nf.vse.cz/Download/Veda/Workshops/Inequality.pdf>.

MALÁ I. Vliv definice spotřebních jednotek na ekvivalizované příjmy domácností v České republice (The Impact of Definition of Consumption Units on Equivalised Household Income in the Czech Republic). *Acta Oeconomica Pragensia,* 2015, Vol. 12, Iss. 3, pp. 53–67. DOI 10.18267/j.aop.536.

OECD_PROJECT. *Adjusting Household Incomes: Equivalence Scales* [online]. <http://www.oecd.org/Eco/Growth/OECD-Note-Equivalencescales.pdf>.

SABATES, R. The Impact of Lifelong Learning on Poverty Reduction [online]. *IFLL Public Value Paper,* 2008,1. <http://www.learningandwork.org.uk/lifelonglearninginquiry/docs/Public-value-paper-1.pdf>.

SCHWARZE, J. Using Panel Data On Income Satisfaction To Estimate Equivalence Scale Elasticity. *Review Of Income And Wealth*, 2003, Iss. 3, pp. 359–372.

ŠIMKOVÁ, M. AND LANGHAMROVÁ, J. Remittances and their Impact for the Czech Economy. *Prague economic papers*, 2015, Vol. 24, Iss. 5, pp. 562–580. DOI: 10.18267/j.pep.548.

ŠUSTOVÁ, Š. AND ZELENÝ, M. At Work…, and Poor? A Look at the Czech Working Population in the Living Condition Survey (EU-SILC) [online]. *Statistika: Statistics and Economy Journal*, 2013, Vol 93, Iss 1, pp. 56–70.

VAN DER GAAG, J. AND SMOLENSKY, E. *True Household Equivalence Scales And Characteristics Of The Poor In The United Satets* [online]. 1982. <http://www.roiw.org/1982/17.pdf>.

The Public Sector´s Structure of Production and Its Changes: the Czech Case

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Abstract

The public sector in its role as a producer has been expanding beyond the provision of public goods only. Currently, public producers are engaged in almost all activities as they are classified in the NACE classification. However, due to political or economic reasons, the structure of production has been changing over time. The aim of this paper is to investigate trends in the evolution of the public sector in the Czech Republic in individual areas. In addition, the paper examines the share of public units in the value added production of individual industries of the Czech economy. Moreover, the analysis reveals the current distribution of production between the public and the private sphere of the economy and its changes during last 15 years.

Keywords	***JEL code***
Public sector, industries, structure of production	*H40, H54, L38*

INTRODUCTION

Particularly since the Great depression in the 1920s, the states as central authorities have become growingly involved in an ever-broader spectrum of activities ranging from the fiscal and monetary management to water supply or provision of public transport services. However, not all of these activities are undertaken by the state itself. For this purpose, central or local authorities have set up a great deal of specialized institutions putting general public policies into practice. The formation of such establishments is usually done for the sake of addressing market deficits, promoting of economic performance or a reduction in mass employment (OECD, 2005). Thereafter, a production of these public producers embodies a deliberate social and economic policy of central or local government authorities, practically substituting a market solution by the political management.

Obviously, the same holds true for the Czech Republic or the former Czechoslovakia. After the Velvet revolution in 1989, the Czech economy went through the transformation process aiming to redirect the economy from the centrally-planned system to a more market oriented environment. This process made the politicians to consider carefully an optimal distribution of the production between the market and the public sphere. Practical embodiment involved privatisation of companies, transformation of public units into private market agents. Looking at this process from the longer-term perspective,

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the transition of public ownership into private hands took place especially in the 1990s. Since the 2000s, this trend is not unidirectional even if the influence of the privatisation projects launched already in the previous decade still persists.

Not exceptionally, some previously privatised companies were bought back afterwards due to a failure of management to operate successfully on the market. Consequently, an effort to transfer a provision of certain goods and services to the market might have been partially offset by buybacks or by setting up new institutions or by an expansion in activities of already existing public institution. Thus, the aim of this paper is to analyse these trends in the Czech Republic since 2001 and to scrutinize changes in the public sector´s production structure. This reference year was chosen also due to the availability of fully consistent data in terms of sectoral classification.

1 BACKGROUND

Practically all the economies around the globe have been experiencing substantial changes in their institutional arrangements. Economic events or changes in the political sphere usually give rise to changes in the allocation of production between public and private sphere. The availability of reliable information on the size of both private and public sphere is of high importance as they operate in different sets of incentives (Buchanan, Wagner, 2000) so that the economic performance over the business cycle or wage policy (Quadrini, Trigari, 2007) can differ considerably as well as the public sector´s responses to market forces, the decision-making in financial affairs (Rybacek, 2016) or its contribution to other economic variable as unemployment or inflation (Nussbaumer, 1977).

Ongoing institutional changes can be driven by a number of forces which can be grouped into political and economic reasons whereas the line between them is rather blurred in most cases. During the current economic crisis, European governments took over a number of institutions, mostly of the financial nature, to bail them out or some of them were nationalised irrespective of current general economic situation (e.g. private pension funds). This initiates changes in the range of public goods and service provided by the public sector.

In addition, changes in demographic structure may have a similar effect as they can make it necessary to open up new public schools for baby boomers or new healthcare providers in reaction to ageing population. The same holds true for the allocation issue as the regulators aim to find the most effective way of resources allocation as well as the most appropriate extent of competition. All these factors can result in intensive changes of the production structure.

When analysing public institutions, we are not, however, concerned only with public goods and services. As the theory of public goods holds, there are two key features of the public goods. Firstly, consumption of public goods does not reduce the amount for others (non-rivalry). Secondly, there is non-excludability from consumption implying the impracticable to collect payments for the use of public goods to finance their provision (Stiglitz, 1986). This is known as so-called "free rider problem." Public defence, street lights or police services can be put as examples of goods generally considered as public goods.

The expansion of the public administration led to the current situation where public producers are engaged also in the production of goods or services not having the features of public goods as education, healthcare or electricity supply. From economical point of view, some publicly provided goods and services are of non-rival nature but excludable at different costs. In some cases, the exclusion is technically feasible, but supposedly too costly when provided by market producers. This might be the case of public access to landscapes, etc. Costliness of the exclusion is discussed in a number of texts, e.g. Buchanan (1965) or Musgrave (1959).

The reason for the government intervening in the production of goods or services not having the feature of public goods is also the existence of external effects, i.e. positive or negative externalities. We can put as an example the case of education supposedly generating highly positive effects for the society as a whole. Government thus aims to assure that every citizen consumes at least minimal amount of this service (Hyman, 2013).

One of the most difficult issues is the price strategy related to the provision of goods and service by the public sector. As Hyman (2013) points out, some of public goods have a nature of congestible goods meaning that if a number of users reach a certain level, then the benefits for other users will decrease. In other words, congestible public goods are non-rival only up to a certain point. Highways or healthcare facilities can serve as examples as they are not provided fully for free to avoid congestion.

From the national account´s point of view, a chosen price strategy might influence sector classification of units (government or non-government sectors). What matters here is the extent to which payments made by direct users of public facilities cover the production costs (Rybacek, Vebrova, 2015). As a result, the national accounts methodology divides the public sector into two parts, government units and public corporations. As our aim is to cover the public sector in its entirety, the following analysis is based on data for all public institutions irrespective of their market or non-market behaviour. It also implies that we will examine the production of not only public goods and services, but also the public provision of goods and services which do not meet the generally accepted definition of public goods.

2 METHODOLOGY

The public sector in the ESA methodology consists of producers under control of government units. Government units are grouped into the sub-industries of general government producing goods and services on the non-market basis. However, a number of units were set up to act upon social and economic policy of government institutions whereas their activities are carried out on the market basis, i.e. output is provided at economically significant prices as defined in the methodology. Such units are classified outside general government industry. To show the public activities in their entirety, the analysis below deals with all publicly controlled units as well as general government industry itself.

This means that the public sector is defined as sum of general government industry (code S13), public non-financial institutions (S11001) and the central bank. All other public financial institutions are left out because the relevant data are not available at all or in sufficiently long time series. However, a distortion is pretty negligible as nearly all public financial institutions were reclassified in the general government industry.

When analysing the economic activity of industries or industries, a value-added is commonly used to represent the performance of groups of units (Spevacek, 2010). Technically, value added is the balancing item of the production account; in other words, the excess of resources over uses (par. 6.70 SNA). Economically, value added shows the value created in the production process with the contribution of labour and capital. Adding taxes and subsidies on production, we arrive at GDP. However, this is not the case at the levels of sector or industry. For that reason, the analysis below is done by use of value added.

At this stage, it is worth mentioning that value added of most of public producers is based on the cost-approach to valuation of output. As there is not market for a great deal of goods and services provided by public producers, their output is valued at alternative way, i.e. as a sum of costs. There are pros and cons of this approach. As a large part of public goods and services are not traded on the market, this approach enables to overcome the valuation problem arising from the absence of appropriate market prices. On the other hand, the valuation at costs does not reflect the real evaluation by final users and it prevents us from a reliable calculation of changes in productivity (Murray, 1992).

The manual SNA in the paragraph 6.98 specifies two reasons for the existence of non-market output. Firstly, there are technical obstacles to collect payments from all users so that a supposed market-failure occurs. In other words, transaction costs to charge users are of such an extent that the production must be organized collectively and financed out of compulsory payments in particular. Secondly, market solution in terms of prices and volumes of goods and services does meet, in some cases, the government criteria of a fair distribution in the society. Then, market mechanism can be replaced by a redistribution system acting upon a deliberate social and economic policy of government. This might be the case not only of a redistribution of incomes, but also redistribution in kind, i.e. direct provision of goods and services at prices below a market level or purchases of goods from market producers in favour of final users.

For the public non-financial corporations classified outside the general government industry, the valuation of output follows the market approach, i.e. output valued at market prices. In these cases, the provision of output runs on the market bases as the methodology holds[2]. Thus, the value added of the public sector covers both market and non-market producers. Value added by industries will be used to analyse the structure of production of public and general government units as well as the share of value added in total value-added in the domestic economy. Using time series from 2001, we are in a position to analyse changes in the production structure of public sector over last fifteen years. The aim is to identify public activities which have been expanding and those which have been shrinking in terms of value-added. The industrial structure follows the NACE classification by section as defined in the relevant manual (Eurostat, 2008).

3 THE PUBLIC SECTOR ANALYSIS

The public sector is widely analysed by the use of a great many of indicators, preferably by total expenditures and its share on GDP (Gemmell, 1993). However, we prefer to exploit the share of individual sector in the total value added production. The reason for doing so is that we focus on the production activity in the economy and the public sector´s participation. Another reason is that using total expenditure or indicator of similar nature erroneously implies that these components are components of GDP (Blades, Pathirane, 1982). The analysis of value-added will reveal a part of the production covered by the public sector, i.e. which amount of goods and services expressed as value added is provided directly by the public producers.

3.1 The public sector´s share in total value-added

Let´s start by looking at the overall share of the public sector in the production of value added. This share is illustrated in the chart 1 showing an extent of the participation of the public sector in the production of goods and services in the society. From 2001 to 2014, the share of the public sector has declined by 0.4 percentage point. From the long-term perspective, the involvement of public units in productive activities was declining.

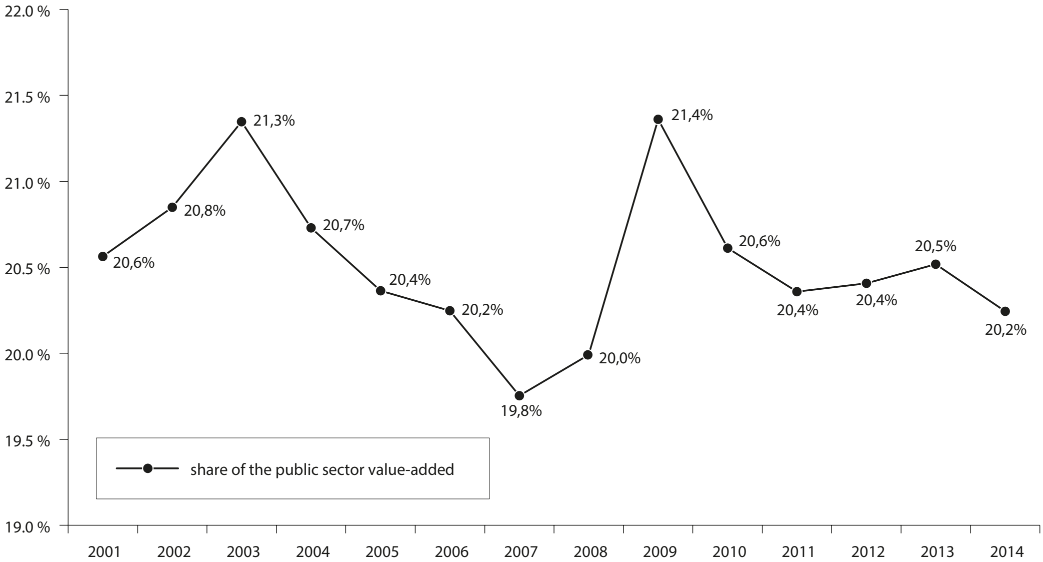
Before 2004, the share of public sector in value-added production had been steadily growing. During 2004, the Czech government approved a privatisation of the mining company OKD, a.s. This transaction led to decrease in the share of the public sector in the industry B "Mining and quarrying". The drop in the share of public sector was continuing till 2007; that can be explained by a declining share in the industries P (Education) and R (Arts, entertainment and recreation) accompanied by other significant changes in the structure as will be shown below.

In case of education, the share of the public sector went down by 3 percentage point between 2003 and 2008. This can be accounted for by growing number of students in private universities which grew from 4% in 2003 in total undergraduates to nearly 10% at the end of 2008. Nevertheless, this trend reversed then in connection with the economic crisis and changes in the demographic situation or a gradual satisfaction of deferred demand of middle-aged students.

Next, there is a striking annual increase in the share in 2009. This sharp increase by 1.4 percentage point can be accounted for by the global economic crisis. In fact, this is one of signs of the beginning

[2] This approach is a subject of controvery and discussions. For discussion on the expansion of government, see i.e. DiLorenzo (1983), DiLorenzo (2007).

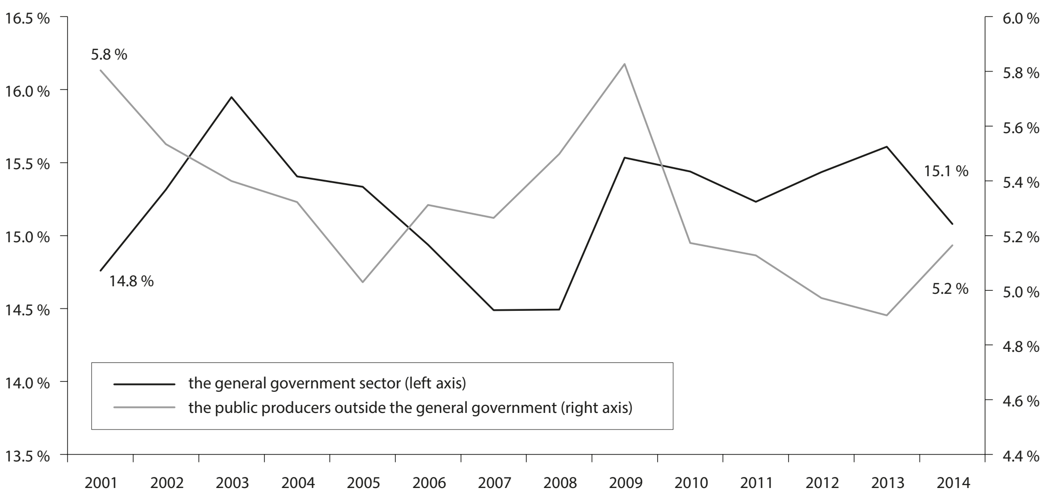
Figure 1 Share of the public industry in total value-added, the Czech Republic, 2001–2014



Source: Own calculation, <czso.cz>

of the crisis in the Czech Republic. While the nominal GDP fell by 4.3%, the value added of the public sector grew by 4 percent annually. It implies that the private industry responded more sensitively to the economic situation abroad but a reaction of the public sector was delayed by one year in reaction to the huge deficit of the state budget in 2009 (CZK 192 bill.).

Figure 2 Shares of the general government industry and other public units in value added, the Czech republic, 2001–2014



Source: Own calculation, <czso.cz>

The situation reversed in the year 2010, when the Czech economy recovered in terms of a nominal value-added growth in the private industry (1.7%), while the public sector experienced a fall by 2.7% annually. After 2010, the share of the public sector remained more or less stable slightly above 20% of total value-added, ending up at the level 20.2% at the end of 2014, i.e. by 0.4 percent point lower than the share in 2001.

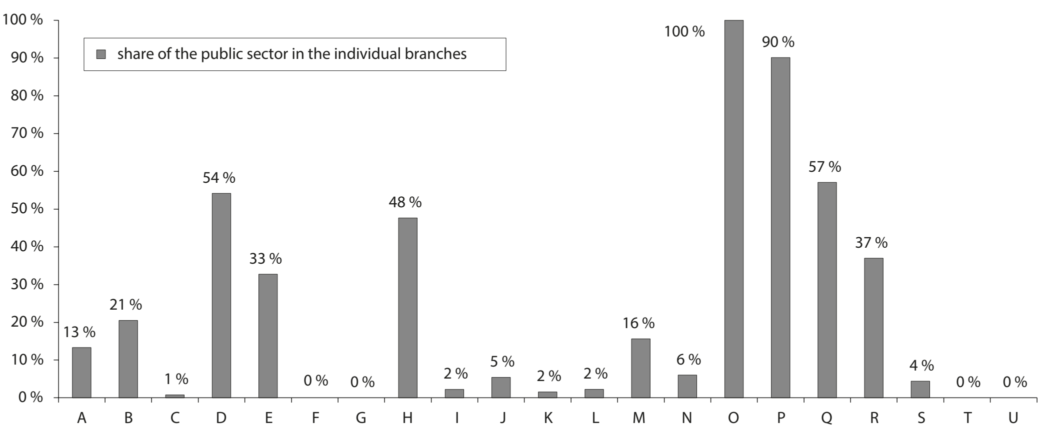
Now, we will take a look at the general government industry and the public producers outside the general government separately. As indicated in the following chart, changes in the shares of both groups were quite opposite compared with the long term perspective. However, the situation reversed in the 2014.

Both time series shows very similar cyclical trends except last years. For example in 2014, the share of the government industry fell 0.5 percentage point, due to the drop in value added produce in industries P (Education), Q (Healthcare) and R (Arts, entertainment and recreation), contrary to the other public producers whose share grew by 0.25 percentage point especially due to a sharp increase in the electric power generation, transmission and distribution (division 351 of NACE). The nominal value added in the division 351 (section D) went up by 21% annually. Resulting from these changes in last yeast, the shares of both groups returned to the level as at the end of 2011.

3.2 Industrial structure of the public sector

Let´s proceed to the industrial structure of the public sector in terms of the shares of individual industries on the industries´ value added in the economy. Logically, the public sector fully covers the provision of goods and services under the industry O (Public administration and defence; compulsory social securities). Other industries with the highest shares represent mainly the production of goods and services for households´ individual consumption. This is first of all the cases of educational service; the public sector covers about 90% of total value-added generated by the industry P. Only 10% goes for the private producers in case of the educational service.

Figure 3 The public sector by industries, the share on total industry's value added, the Czech Republic, 2014



Source: Own calculation, <czso.cz>

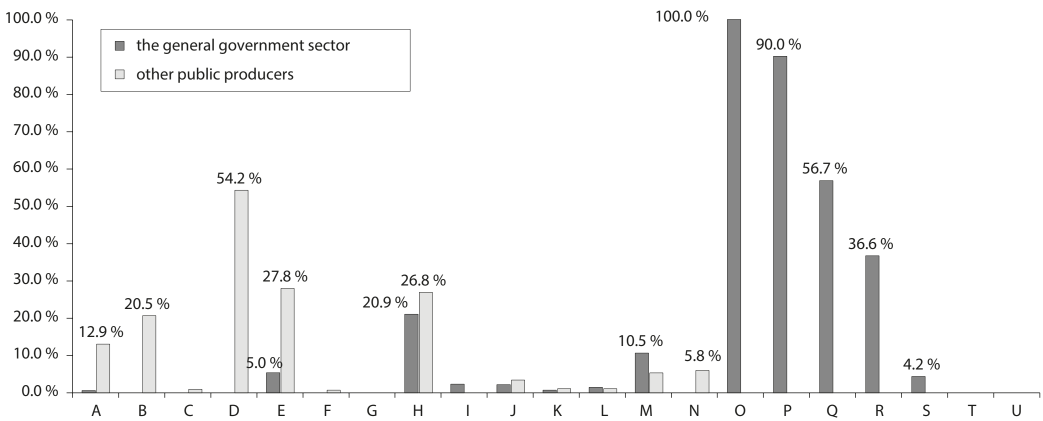
In case of the NACE Q (Human health and social work activities), the share of the public producers reached 57%. This is mainly due to the fact that financing of healthcare provision is made to a crucial degree through public finance and the terms of financing are similar for both public and private producers. This implies that the provision of the healthcare service is much more attractive for private producers so that the competition occurs in particular in the profitable areas like dental care, gynaecology, plastic surgery, etc.

The public sector takes also a large part of output in the industries H (Transportation and storage) and R (Arts, entertainment and recreation) covering 37%. In case of the industry H, the share of 54% reflects the deliberate economic policy of government institutions in the field of the passenger transportation. This service is predominantly provided by public units under the control of government institutions receiving subsidies to fill the gap between the market prices and the prices charged by these institutions. This is especially the case of the rail transportation and the public city transport companies.

One third of the value-added is generated by the public sector in case of the water supply, sewage and waste management (the industry E). This implies that a private provision of this service predominates in water management. In other cases, the provision of goods and services is mostly or almost exclusively ensured by units whose behaviour is driven by market forces. To draw the line between public and private, we found out that about 20% of goods and services are delivered by the public sector, particularly in the industries O, P, Q, D, whereas the public sector takes as well a significant part of the production in the industries H, R, E.

Now, let´s separate government sector from other public producers operating on the market basis. The following chart shows the structure of both groups in terms of NACE classification.

Figure 4 Share in total value-added of industries, the Czech Republic, 2014



Source: Own calculation, <czso.cz>

We can easily draw the number of observations. Production recorded in the industries O (Public services, etc.), P (Education), Q (Human health and social activities), R (Arts, entertainment and recreation) and S (Other service activities) go almost totally for the general government sector. It implies that virtually all public healthcare producers are treated as non-market producers providing their services at lower prices that would have prevailed on the market, had all these services been produced by market units.

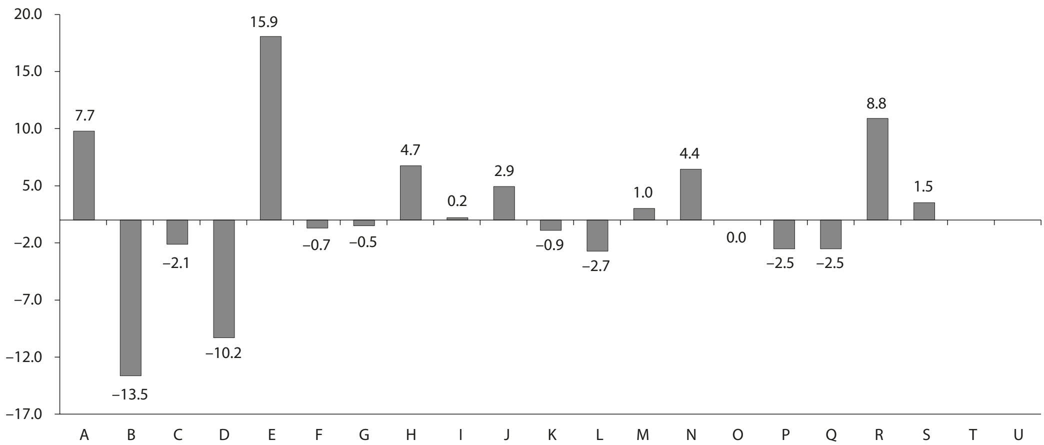
On the contrary, other public producers (market oriented) represent all the contribution of the public sector to total value-added in cases of B (Mining and quarrying) and D (Electricity, gas, steam and air conditioning supply). The other public producers also dominate in the industries A (Agriculture, forestry and fishing) and E (Water supply, sewerage, etc.). In case of NACE H (Transportation and storage), the total contributions of both groups is shared with higher input from other public producers (26.8%) while the general government sector contributes with 20.9%. On the part of other public producers, it is mainly about direct provision of transport services while the government institutions mainly deal with other activities like maintenance of roads, repairs, etc.

3.3 Changes in the production structure of the public sector

After the analysis of industrial structure of production in the public sector, we can now proceed to the analysis of changes in the structure over time. In other words, how the structure of production has evolved over last fifteen years. This can reveal changes in the delimitation between private and public sphere of the economy in individual industries. We can also identify in which activities the public institutions have become more expanded or, on the other hand, which activities were left to the market forces.

Let´s start with a graphical overview of changes in individual industries of the public sector between 2014 and 2001 as shown in Figure 5.

Figure 5 Changes in industries of the public sector between 2014 and 2001, the Czech Republic, in percentage points (p.p.)



Source: Own calculation, <czso.cz>

The public sector have experienced considerable changes especially in the industry B (Mining and quarrying), in which case the share dropped due to privatisation mentioned above (OKD, a.s.). The same trend appears in the industry D (Electricity, gas, steam, etc.) with a decrease by 10.2 p.p. However, if we compare the year 2001 to 2015, then we arrive at the decline by 24 p.p. A growing share of the public sector in this industry over last four year was made by a fall in the total value-added while the public sector experienced a growth amounting to 20% annually. As no privatisation operation took place in these years, the sharp changes can be hardly explained in different way than by economic factors affecting results of individual companies, i.e. extraordinary revenues or expenditures, an effectiveness of hedging against price changes, etc.

In case of educational service (NACE P), the share of the public sector dropped by 2.5 p.p. As the share of the public sector represents 90% of total value-added of this industry, we investigated this development in a greater detail. However, relevant information from the yearbooks of the Ministry of Education, Youth and Sports is not available before 2005 so we can compare the values at the end of 2014 to corresponding indicators in 2005. During this period, the number of public schools declined by 2% and the number of students by 3%. This trend is very striking in cases of elementary school and high schools. Contrary to public elementary schools, the number of private elementary schools went up by 55 % along with the growing number of students (89.5%). However, private high schools followed the general trend with a declining number of schools by 6.1%.

The private sector clearly outperformed the public sphere in cases of kindergartens and colleges. The number of private nursery schools grew by 416.7% concurrently with the growing number of students (308.9%). Growth in the public sector experienced much lower dynamics (1.5% in the number of schools and 30 % in the number of students). Similar holds true for private colleges where the number of student sharply increased by 42.6% contrary to 10.3% growth in the public ones. These changes can account for the general decline in the share of the public sector in the educational service provision.

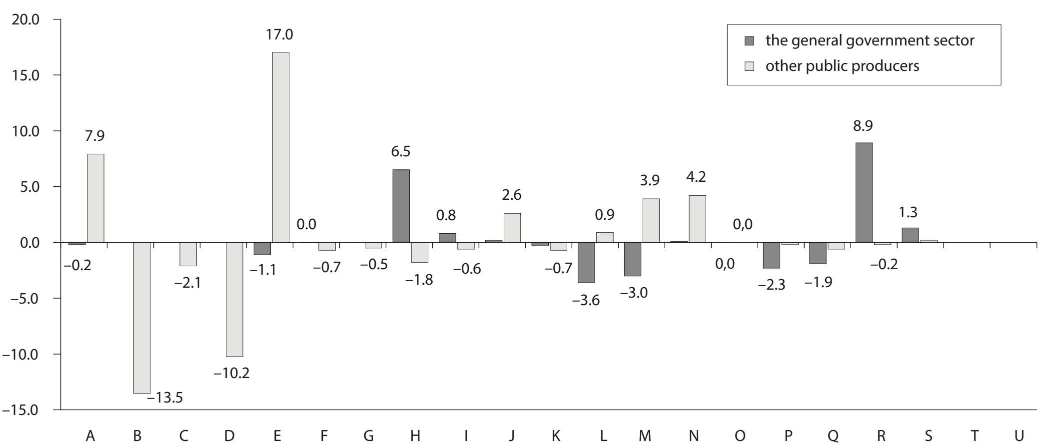
Let´s move on to the healthcare services (NACE Q). Similarly to the educational services, the share of the public sector decreased by 2.5 p.p. At this stage, we can recall that the public sector covered 57% of the healthcare services provision as shown in the Figure 3. The following information was obtained from the statistical yearbooks of the Institute of Health Information and Statistics of the Czech Republic. In 2014, there were 30 914 health establishments in the Czech Republic, with 57.6% of physicians and 42.3% of paramedical workers in the private sphere. A comparison to the 2001 reveals that the share of the private sphere went up in both indicators. In 2001, 55.2% of physicians and 36.4% of paramedical workers were in the private sector. The private sector thus slowly grew in terms of workforce over the investigated period and consequently in the production of value-added.

On the other hand, the public sector considerably expanded in some of the other industries. The involvement of public institutions has increased by 15.9 percentage points in the industry E (Water supply, etc.). The second highest growth was recognized in the industry R (Arts, entertainment and recreation) and NACE A (Agriculture, forestry and fishing). An expansion of the public sector is also remarkable in cases of transportation services (NACE H), administrative and support service activities (NACE N) and information and communication (NACE J).

The following chart is decomposing the changes in the public sector value-added into the contributions of the general government sector and of other public producers.

The industries, where the contribution to total value added is shared by both groups forming the public sector, are in most cases contradictory. This is the case of NACE M (Professional, scientific and technical activities) related to the expansion of value added predominantly caused by newly established research institutions. This can be seen as a gradual shift of research activities from the government

Figure 6 Changes in the shares between 2014 and 2001, the Czech Republic, percentage points



Source: Own calculation, <czso.cz>

institutions toward the public market producers. Besides that, the position of the government institutions in the NACE L weakened (by –3.0 p.p.) while other public producers take a larger share then at the end of 2001 (by 0.9 p.p.).

Interesting is the case of transportation and storage (NACE H) in which the share of the government sector grew by 6.5 p.p. while the share of other public producers dropped by 1.8 p.p. This can be accounted for by the development in the NACE 522 (support activities for transportation) in the general government sector which contains units dealing with the road maintenance, etc.

CONCLUSION

There are many observations which can be drawn from the analysis above. Overall size of the public sector in the Czech Republic, in terms of the share on total value added, has declined by 0.4 over last 15 years. Among the individual consumer goods, public producers take a predominant part in the provision of educational services, healthcare or in supplying electricity or gas. Looking at the changes over the period in question, the public sector´s share dropped in the mining and quarrying and electricity, gas, steam and air conditioning supply. On the contrary, the public sector has expanded in water and waste management, agriculture or arts, entertainment and recreation.

The decline in the public sector size might lead to several interpretations and macroeconomic implications. It should be stressed that this decline does not imply a decreasing quantity of goods and services supplied by the public sector. Declining share determined by our analysis is only in relative terms. This development thus signifies that a higher share in production is left to the private producers, so it is subjected to the influence of market forces. This trend has a potential to promote growth in output or productivity as the increasing share of the market production implies more intensive competitive pressures and market incentives.

Further, shrinking public sector tends to be less demanding on the State budget or the budgets of local government institutions owning or otherwise controlling public producers. However, the relation between the size of the public sector and its financial effect on the budget would require more detailed investigation as it also depends on whether public producers are entitled to raise additional funds on the capital market or if they are financially dependent notably on the government institutions.

As was also demonstrated in the text, the public sector and its size can influence the business cycle development and its analysis. In reaction to the economic crisis, there was a significant drop in the nominal value added produced by the private sphere of the Czech economy. A contraction in value-added of the public sector experienced a contraction one year later when nominal value added of the public sector fell by 2.7% annually. This supports the view of the studies concluding a different behaviour of the public sector over the business cycle.

References

BUCHANAN, J. AND WAGNER, R. E. *Democracy in Deficit.* Liberty Fund, 2000.

BUCHANAN, J. An Economic Theory of Clubs. *Economica,* Vol. 32, No. 125 (Feb. 1965), pp. 1–14.

DILORENZO, T. AND BENNETT, J. *Underground government: The Off-Budget Public Sector.* Cato Institute, Paperback, April 1983.

DILORENZO, T. *Can Government Function Like Markets? Austrian Insight into Public-Choice Theory* [online]. [cit. 23.6. 2007]. <www.mises.com>.

Europan System of National and Regional Accounts (ESA2010). 2014.

GEMMELL, N. *The Growth of the Public Sector.* Edward Elgar Publishing Lmited, 1993.

INSTITUTE OF HEALTH INFORMATION AND STATISTICS OF THE CZECH REPUBLIC. *Czech Health Statistics Yearbook* [online]. 2001.

INSTITUTE OF HEALTH INFORMATION AND STATISTICS OF THE CZECH REPUBLIC. *Czech Health Statistics Yearbook* [online]. 2014.
MINISTRY OF EDUCATION, YOUTH AND SPORTS. *Statistical yearbook of education* [online]. 2014.
NUSSBAUMER, A. *The growth in the public sector and inflation pressures.* Westview Press, 1977.
Nace Rev. 2. Statistical classification of economic activities in the European Community. Eurostat, 2008.
MURRAY, R. Measuring Public-Sector Output: The Swedish Report. In: GRIVLICHES, Z: *Output Measurement in the Service Sectors,* University of Chicago Press, 1992.
MUSGRAVE, R. A. *The Theory of Public Finance.* New York, 1959.
POSPISIL, R. The macroeconomic analysis of public goods and their influence in the Czech Republic. *Audit financiar,* 2016, XIV, No. 4(136).
Public Enterprises: Unresolved Challenges and New Opportunities. OECD, 2005.
Public Sector Debt Statistics: Guide for Compilers and Users. Washington: International Monetary Fund, 2013.
PATHIRANE, L. AND BLADES, D. Defining and Measuring the Public Sector: Some International Comparisons. *The Review of Income and Wealth,* 1982, Series 28, pp. 261–289.
QUADRINI, V. AND TRIGARI, A. Public Employment and the Business Cycle. *Scandinavian Journal of Economics,* 2008, Vol. 109, Iss. 4.
RAO, B. Government size and economic growth: a new framework and some evidence from cross-section and time-series data: Comment. *The American Economic Review,* American Economic Association, 1989, Vol. 79, pp. 272–80.
RYBACEK, V. The Public Sector in the Czech Republic in Light of the Public Choice Theory [online]. *Statistika: Statistics and Economy Journal,* 2016, Vol. 96(2), pp. 41–50.
RYBACEK, V. AND VEBROVA, L. How to Read Government Deficit and Debt [online]. *Statistika: Statistics and Economy Journal,* 2014, Vol. 94(3), pp. 32–46.
SAUNDERS, P. Recent Trends in the Size and Growth of Government in OECD Countries. In: GEMMEL, N. *The Growth of the Public Sector. Theories and International Evidence.* Edward Elgar Publishing Limited, 1993.
SPEVACEK, V. *Sektorová analýza vývoje české ekonomiky.* Centrum výzkumu konkurenční schopnosti české ekonomiky, WP No. 16/2010.
STIGLITZ, J. *Economics of the Public Sector*. W.W. Norton Company, 1986.
System of national accounts 2008. Washington, 2009.

Features of the Regional Labor Markets in the Czech Republic

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Abstract

We use the Labor Office data for the regions of the Czech Republic to investigate some of the structural features of the respective labor markets. We build our approach on the matching function of the search model of the labor market. In the paper we show how the regional labor markets differ with respect to vacancies, unemployment, matches between unemployed and vacancies, probability of finding a job and labor market tightness. We also demonstrate how these characteristics evolved over time. We show that the labor markets were really hit the hardest several years after the great recession began to affect the Czech Republic. We go on to estimate the matching function for the respective regional labor markets and show that the sensitivity of the probability of finding a job to the labor market tightness generally increased over time, which we interpret as a positive sign. We set our results in the framework of some of the earlier work which has been done. With all the data and estimates used we are able to pinpoint the most troubled regions as far as the structural features of the labor market are concerned.

Keywords

Generalized methods of moments, matching in the labor market, regional labor markets, structural features

JEL code

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INTRODUCTION

The research presented in this paper is directed at the analysis of the Czech Republic from a regional perspective, which we feel is a significantly disregarded issue.

Partially, it is comprehensible because the general economic data available for the respective regions is generally much more scarce than for the whole economy. On the other hand, the data supply for the labor market characteristics is very rich even at the level of regions. It is the regional data we explore in this paper, especially from the perspective of the search model of the labor market.

We resort to the Labor Office data which offer, in some respects, a detailed view of the regional labor markets and as it is evidenced by (non)existing research are rarely used. Of course, the Labor Office data do not enable to make comparisons between different economies due to the specifics of national laws on which this data is based. However, international comparison is not a subject of this paper.

First we give a concise overview of key economic issues of the regions which are also central to the econometrical analysis that follows.

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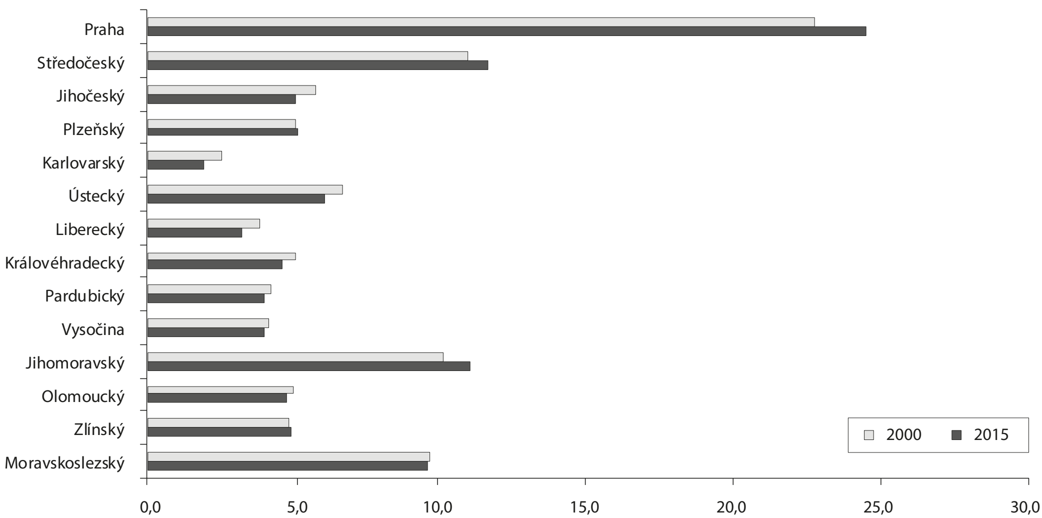
1 ECONOMIC PERFORMANCE OF THE REGIONS

In international comparison, according to the national accounts data for employment measured in persons, the Czech Republic has a high share of the secondary sector in the overall employment rate, which has slightly decreased to 37% over the years. Since the transformation of the economy in the 1990s, the tertiary sector has grown and thus has influenced positively the overall development of employment. The decline of employment in the primary sector stopped at less than 3%.

Individual sectors of the economy have considerable differences in the level of labor productivity and thus the sectoral structure of regions plays an important role in their economic performance. Figure 1 shows the share of regions in the GDP of the Czech Republic in the long-term development.

Figure 1 The share of regions in the GDP of the Czech Republic in 2000 and 2015 (in %)



Source: CZSO, based on nominal GDP (gross domestic product)

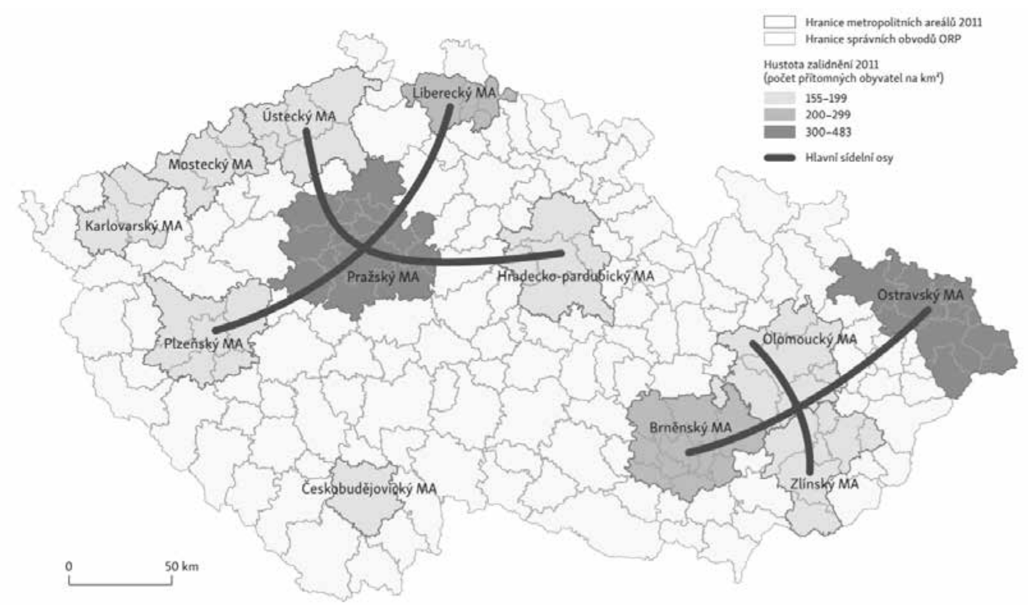
The situation in the labor markets stems, to a large extent, from the sectoral structure, and that's why it is not surprising that in most cases four economic sections (as defined by CZ-NACE classification) secure around two thirds of the economic performance given by GDP of each region. In the Czech Republic, it is particularly the manufacturing industry because after the transformation of the Czech Republic the share of raw material extraction in the formation of the gross value added fell to less than 2%, even though in regions Ústecký and Moravskoslezský it still accounts for about 5%.

However, one should not overestimate the significant role of the manufacturing industry as the whole section because it is becoming apparent that also individual subsections have an important effect on the economic performance of a region. For example, the relatively average performance of region Liberecký with the share of the manufacturing industry in the employment rate for a long time oscillating around 43% is evidence to that.

Thus, when researching regional differentiation, it is necessary to go deeper towards economic-geographical indexes describing distribution of activities. The highest values of labor productivity (both by gross value added and gross domestic product) are achieved particularly in the sections of commercial services, insurance industry, finance, the progressive tertiary sector in general and in the quaternary/

knowledge sector. Thus, the crucial conditioning agent of the regional differentiation is the concentration of these highly productive activities into core regions, metropolitan areas in the center of the regions. Due to the high concentration of population in the Czech Republic (even though in international comparison with the developed European countries is still average) in the metropolitan areas, which are present in almost all regions, differentiation on the level of regions is essentially comparable to the differentiation in accordance with metropolitan areas (Hampl and Marada, 2015), to which also their economic orientation and development are considerably related. Figure 2 shows the main areas of concentration of population on the map of the Czech Republic – the main settlement axes and metropolitan areas as defined by Hampl and Marada (2016).

Figure 2 Metropolitan areas in the Czech Republic in 2011



Source: Hampl and Marada (2016)

Due to the extremely close connection between the concentration of population and economic activities and the structure of employment, the following numbers are not surprising. According to the data for employment measured as persons in 2015, the region Vysočina has the highest share of agriculture, forestry and fishing, almost 8 %, which relates to natural conditions and vast agricultural areas but also to the non-existence of an independent core region of Jihlava, capable – as a result of the extreme attractiveness of Prague and Brno, in terms of time accessibility – to attract also better service functions. However, in accordance with the study Hampl and Marada (2016), the formation of the regional center of Jihlava can, in the longer perspective, change this in the future.

On the contrary, Prague has the lowest share of the secondary sector, almost only 15%, and thus the remaining 84% are constituted by the tertiary sector and the knowledge sector. Moreover, from the viewpoint of development, an interesting thing is the overall decrease in the share of Prague in the gross domestic product of the Czech Republic as a consequence of the transfer of a certain part of its economic potential to the region Středočeský (see Figure 2). In the Czech Republic, the dominant secondary sector was represented mostly in regions Zlínský, Liberecký and Vysočina, over 45%. Regions Zlínský, Vysočina have the lowest share in the tertiary sector, below 50%.

Region Středočeský has been getting closer to Prague in the percentage of people employed in the first four major groups, which is a direct consequence of the process of metropolization, suburbanization, thus migration i.a. of also these persons in the higher positions who commute to the city. Especially smaller regions are in most cases more sectoral narrowly focused. Olomoucký region has the most people employed in employment group 7 (craftsmen and servicemen), Plzeňský region in group 8 (machine and tool operators, assemblers), Karlovarský region in group 5 (services and sale) and Královéhradecký region in the unflattering group 9 – the least qualified and unskilled laborers.

The sectoral and professional structures and the concentration of people in the metropolitan areas are interwoven with the educational structure of population, which is shown in the last columns of Table 1. The first 4 major groups require a higher level of formal education than groups 5 and higher. Compare regions Karlovarský and Ústecký with the highest percentage of employment of people with elementary education on the one hand, and, on the other hand, Prague and region Jihomoravský employing the highest number of university educated people.

Table 1 Percentage of workers in accordance with the classification of employment in regions in 2015 (in %)

Region/NUTS 3	CZ- ISCO								Education			
	Legislators and workers in management	Specialists	Technical and professional workers	Office workers	Workers in services and sale	Craftsmen and servicemen	Machine and tool operators, assemblers	Assistants and unqualified workers	Elementary and without education	Secondary without A levels	Secondary with A levels	University
Total	5.4	15.1	17.0	9.2	15.4	17.2	13.6	5.6	4.0	35.2	37.5	23.3
Prague	8.1	29.0	17.6	11.7	14.5	10.2	5.0	3.6	2.7	17.1	39.5	40.7
Středočeský	6.6	14.9	16.9	10.2	16.0	16.2	12.9	4.8	2.8	35.3	39.4	22.5
Jihočeský	4.4	10.8	16.7	7.5	16.5	18.4	17.3	5.1	3.8	39.8	37.1	19.3
Plzeňský	5.0	11.6	16.9	8.2	14.2	16.9	19.0	6.0	5.8	38.0	37.0	19.2
Karlovarský	5.3	8.7	13.5	8.3	18.9	20.7	16.4	7.1	9.2	40.9	36.6	13.2
Ústecký	3.5	10.1	18.0	9.0	18.5	19.3	15.1	5.7	7.5	39.5	37.8	15.1
Liberecký	4.0	11.2	18.1	7.7	15.1	20.4	17.1	5.3	5.4	40.3	36.6	17.6
Královehradecký	5.4	13.5	17.3	8.8	14.1	18.6	13.2	7.6	4.5	37.5	38.1	19.9
Pardubický	4.5	11.8	17.1	8.7	13.6	19.2	15.2	7.5	3.3	40.0	37.5	19.3
Vysočina	3.9	10.7	15.6	7.9	14.7	20.7	18.4	4.9	3.1	43.2	37.2	16.6
Jihomoravský	6.4	18.0	18.9	9.4	14.1	16.3	10.4	5.2	3.0	31.4	37.2	28.5
Olomoucký	3.7	13.2	15.0	9.5	15.0	20.9	14.4	5.7	3.1	40.7	34.7	21.5
Zlínský	4.6	13.1	15.3	7.2	15.4	19.8	17.4	5.8	3.2	41.4	34.5	20.9
Moravskoslezký	5.1	13.2	16.9	9.2	15.7	17.0	14.7	7.1	4.1	37.5	37.1	21.3

Source: MLSA (2015)

2 BASICS OF THE SEARCH MODEL AND CORRESPONDING DATA

We build the analysis on the concept of the search model, which was developed by Pissarides (1979) and Pissarides (1985) and its summary can be found in Mortensen and Pissarides (1999) or Pissarides (2000). The search model has served as the key tool for analyzing the issues related to labor markets.

The model consists of three parts: the first one describes the relation between the unemployment rate and the vacancy rate under the condition of long-run equilibrium, which is known as the Beveridge curve (or function) and is frequently used to characterize the evolution of labor markets; the second is the job curve (function), which is basically the demand for labor; and the third is the wage curve reflecting the conditions of supply of labor.

There is no clear-cut way to use the whole model on regional level because it requires calibration of various parameters which are impossible to estimate for regions or it wouldn't make much sense to try to estimate them on such a level of disaggregation.

To formulate an empirical version of the model which would be able to analyze both cyclical and structural aspects of the labor market, it would be crucial to endogenize the job destruction process and search intensity of the unemployed. Versions of the search model with constant job destruction rate and search intensity cannot be considered competent to attack the issue of cyclical and structural changes in the labor market, see Pissarides (2000). To achieve the first, it would be necessary to find a way to estimate or calibrate the reservation productivity, which should be rightly considered as varied among the regions in questions. Though not an easy job, this may be done reasonably at the level of the whole economy. However, we do not think there is sufficient data to try to go into this level of precision on regional level. Also we don't employ the Beveridge function for the following reason.

Frequently the Beveridge function is plotted or estimated to draw conclusions as to whether there have been structural changes in the labor market in question. However, the shifts in the function don't need to represent structural changes as it is often assumed. If we take the basic version of the model, with exogenous separation (job destruction) rate, the demand shocks do not shift the Beveridge curve. However, with endogenous separation rate as a function of idiosyncratic shocks to productivity, increases in demand that translate into a rising productivity, the Beveridge curve does shift and thus would lead us to falsely believe, by working with the unemployment and vacancy rates only, that a structural shift has occurred. Pissarides (2008) warns against using the Beveridge curve in this widespread way.

Our analysis rests on a crucial relation of the search model which is the matching function. Let u be the unemployment rate, v the vacancy rate, m the rate of matches between the vacancies and unemployed in a given period of time, L labor force, then the matching function is defined:

$$mL = f(vl, ul). \tag{1}$$

The matching function is assumed to be homogeneous of degree one. Frequently it is assumed it has the form of the Cobb-Douglas function, nevertheless, we don't restrict the empirical model to this assumption. However, the assumption of homogeneity of degree one enables to restate the function as follows:

$$\frac{m}{\mathrm{u}} = f\left(\frac{v}{u}\right). \tag{2}$$

The ratio of the vacancy rate and the unemployment rate is called the tightness of the labor market, denoted θ, and the ratio of the rate of matches and the unemployment rate is the probability of finding a job in a given period of time, $p(\theta)$:

$$p(\theta) = f(\theta). \tag{3}$$

According to the matching function the probability of finding a job is a positive function of the labor market tightness: with increases in the number of vacancies relative to the unemployed the probability of finding a job also increases.

What we focus on in the empirical part is the exact relation between the two, i.e. the sensitivity of the probability of finding a job on the labor market tightness. It makes sense to investigate the behavior of both variables on the regional level. Differing relationship between the two may point to structural changes in the labor markets.

2.1 The empirical model

To estimate the matching function (3) it must be taken into account that the endogeneity problem arises as both sides of the relationship are functions of the unemployment rate. To tackle this problem we resort to instrumental variables, more precisely we employ the generalized method of moments.

The endogeneity problem is manifested by correlation between the explanatory variables and the residuals which precludes an efficient use of ordinary least squares. The idea of using instruments is to pick additional variables which are correlated with the explanatory variables but uncorrelated with the residuals to filter out the correlation from the original equation.

We estimate the matching function in the form:

$$p(\theta)_{\mathrm{t}} = \alpha + \beta\theta_t\, \varepsilon_t. \tag{4}$$

The parameter α represents the constant, β the sensitivity of the probability of finding a job on the labor market tightness and ε stands for the error term.

We use as instruments the current and lagged values of the gross domestic product in 2010 prices. We will give more details on the samples, data used and instruments below.

2.2 Key data

Before the analysis of the estimates of Formula (4), we will draw a more general picture of the regional labor markets using the data entering the search model of the labor market.

We use the monthly data collected by the Ministry of Labor and Social Affairs (MLSA) for the respective regions of the Czech Republic. We work with the disaggregation in form of NUTS3, which means we work with 14 regions and also with the economy as a whole.

The whole sample covers the months from 2000 to 2015. We first present the data on the probability of finding a job, the labor market tightness, the matching rate, the separation rate, the unemployment rate and the vacancy rate.

The labor force data we use in the analysis comes from Labor Force Survey (LFS) statistics as collected and presented by the Czech Statistical Office (CZSO). However, the data supplied by the CZSO are quarterly. We transformed it into monthly data using quadratic interpolation.

The matching rate is defined as the number of placed (those unemployed registered at the Labor Offices who in the given month left the Labor Office because they found a job) relative to the labor force.

The separation rate is defined as the number of those who in a given month entered the Labor Office relative to the labor force.

The unemployment rate is defined as the ratio of the registered applicants for jobs at the Labor Offices to the labor force.

The vacancy rate is defined as the ratio of the number of vacancies reported to the Labor Offices to the labor force.

However, the estimates of (4) remain unaffected by the use of labor force data from a different statistics. The reason is that labor market tightness may be computed as a ratio of vacancies and unemployed (registered applicants) and probability of finding a job as a ratio of number of placed and unemployed (registered applicants). This means that only the Labor Office data is used to compute the input for the estimation.

Figures 3–17 in the Appendix present the respective seasonally adjusted data for all the regions in question including the Czech Republic as a whole.

The data show that, naturally, the great recession, which hit the Czech Republic in the last quarter of 2008, manifested itself by a sharp decrease in the vacancy rate, which kept at low figures until 2014, and a sharp increase in the unemployment rate. This was reflected in a sharp increase in the labor market tightness, which also returned to increase in 2014. The probability of finding a job decreased with the decrease of the labor market tightness.

However, as the data show, the labor market was struck the most not with the onset of the great recession, but much later in 2011–2013. The unemployment rate increased significantly again in 2013 with an expected impact on the labor market tightness. This was also reflected in a significant decrease in the probability of finding a job in the period of 2011–2013. The matching rate also decreased significantly in this period, in 2011–2012, while the separation rated was typically marked with a sharp increase in 2009 and 2011. This pattern is found in all of the regions, of course the exact figures differ.

Now let us consider the development outside the years marked by the great recession. The labor market tightness in the Czech Republic was generally lower than before the crises. This is not true especially in Plzeňský region, Karlovarský region, Ústecký region, Pardubický region and Jihomoravský region where the figures before and after the great recession were more or less the same, and in Moravskoslezský region where it was higher after the crisis.

In the Czech Republic as a whole the labor market tightness fluctuated, with the exception of the crisis years, around 10%. It was generally higher in Moravskoslezský region and significantly lower in Ústecký region, Královéhradecký region, Jihomoravský region, Vysočina and Olomoucký region.

The question is why it was so. It might have been due to a generally higher unemployment rate or generally lower vacancy rate or both.

The lower labor market tightness is explained by a significantly lower vacancy rate in Ústecký region and Královéhradecký region.

On the other hand, in the cases of Olomoucký and Jihomoravský region it is explained especially by higher than average unemployment rate. This also holds for Ústecký region, which means that this region has both: relatively higher unemployment rate and relatively lower vacancy rate. In the case of Vysočina the reason for the relatively lower labor market tightness throughout the whole period, except for the crisis, is more related to a lower vacancy rate.

The probability of finding a job marked a significant increase in 2007 when it neared 10% for the Czech Republic as whole. The less successful regions were again: Ústecký region, Královéhradecký region and Moravskoslezský region where even in the period of the most significant positive impacts of the ongoing expansion of the economy were, in terms of the probability of finding a job, less than 10%, and in some cases less than 8%.

On the other hand, for the economy as a whole, the probability of finding a job hit the bottom in 2012 when it reached approximately 4%. Once again Ústecký region, Královéhradecký region and Moravskoslezský region reached figures under 3% together with Prague.

The inspection of the data thus shows that the less favorable regions in the Czech Republic are Ústecký region, Královéhradecký region and Moravskoslezský region, in the first place, followed by Olomoucký region and possibly Vysočina.

To shed more light on the structural nature of the regional labor markets we proceed to estimate the matching function (3).

2.3 Statistical properties of the data

The data necessary to carry out the estimation was already described above. Tables 2a and 2b present their statistical properties in the whole sample: January 2000–December 2015. Stationarity was tested by augmented Dickey-Fuller test and as it is indicated in the tables not all of the series are stationary in the whole sample.

This problem is resolved by running two estimates. The first one in the sample from January 2000 to December 2007 and the second running from January 2010 to December 2015. Within these two samples the series are stationary at the level of statistical significance of at least 10%. In other words the stationarity of some of the series in the whole sample is precluded by the significant and rather persistent changes in the years around the end of the economic expansion and the crisis.

Generally most of the series do not follow normal distribution, which, however, does not present problems to the estimation in question.

As we have already indicated above, the instrumental variable used in all of the estimations was gross domestic product (GDP). The statistical properties are given in the last row of Table 2a. As well as the labor force series, gross domestic product is published with quarterly frequency. To obtain a monthly series, we once more used quadratic interpolation. The underlying series was the seasonally adjusted one in 2010 prices as published by the Czech Statistical Office. The statistical properties presented in Table 2a as far as GDP is concerned is already for logarithmic differences, therefore the augmented Dickey-Fuller test confirms stationarity. Gross domestic product in levels is, of course, significantly nonstationary.

Table 2a Statistical Properties of Labor Market Tigntness

Region	Variable	Mean	Standard dev.	Normality	Stationarity
Prague	LMT	0.491	0.416	220.645***	–2.167
Středočeský	LMT	0.221	0.168	124.736***	–2.577*
Jihočeský	LMT	0.195	0.133	68.325***	–1.786
Plzeňský	LMT	0.284	0.259	184.886***	–3.114**
Karlovarský	LMT	0.120	0.077	68.796***	–2.356
Ústecký	LMT	0.063	0.039	80.618***	–1.541
Liberecký	LMT	0.165	0.094	21.672***	–2.806*
Královéhradecký	LMT	0.184	0.126	45.027***	–2.210
Pardubický	LMT	0.220	0.192	115.809***	–2.067
Vysočina	LMT	0.132	0.097	43.040***	–2.047
Jihomoravský	LMT	0.113	0.094	180.104***	–2.599
Olomoucký	LMT	0.103	0.073	41.325***	–1.782
Zlínský	LMT	0.128	0.110	68.839***	–2.257
Moravskoslezský	LMT	0.071	0.060	104.345***	–2.550
Czech Republic	LMT	0.150	0.110	109.644***	–2.764*
Czech Republic	GDP	0.002	0.003	1221.660***	–3.336**

Note: LMT stands for labor market tightness. GDP signifies GDP growth. Normality was tested by Jarque-Bera test under the null of normal distribution, test statistic is given; stationarity was tested by augmented Dickey-Fuller test under the null of unit root, t-Statistic is given; *, **, *** signifies rejection of the null at 10%, 5%, 1% of statistical significance, respectively. Estimates for the whole sample: 2000–2015.
Source: Own estimates

Table 2b Statistical Properties of Probability of Finding a Job

Region	Variable	Mean	Standard dev.	Normality	Stationarity
Prague	PFJ	0.082	0.020	30.013***	–2.676*
Středočeský	PFJ	0.088	0.018	40.489***	–2.486
Jihočeský	PFJ	0.109	0.022	20.841***	–2.638*
Plzeňský	PFJ	0.092	0.017	24.156***	–2.320
Karlovarský	PFJ	0.070	0.016	5.259*	–2.280
Ústecký	PFJ	0.058	0.011	14.641***	–2.648*
Liberecký	PFJ	0.084	0.019	4.401	–2.627*
Královéhradecký	PFJ	0.095	0.021	12.388***	–2.719*
Pardubický	PFJ	0.094	0.019	11.612***	–2.663*
Vysočina	PFJ	0.092	0.019	16.406***	–3.071**
Jihomoravský	PFJ	0.075	0.012	14.944***	–2.644*
Olomoucký	PFJ	0.075	0.014	13.814***	–2.657*
Zlínský	PFJ	0.079	0.037	8.242**	–2.999**
Moravskoslezský	PFJ	0.058	0.010	9.379**	–2.800*
Czech Republic	PFJ	0.076	0.014	46.256***	–2.645*
Czech Republic	GDP	0.002	0.003	1221.660***	–3.336**

Note: PFJ is probability of finding job. Normality was tested by Jarque-Bera test under the null of normal distribution, test statistic is given; stationarity was tested by augmented Dickey-Fuller test under the null of unit root, t-Statistic is given; *, **, *** signifies rejection of the null at 10%, 5%, 1% of statistical significance, respectively. Estimates for the whole sample: 2000–2015.
Source: Own estimates

3 RESULTS

The sound application of the generalized method of moments in the estimation of Formula (3) required instruments. These were in all of the cases: constant, the current GDP as described above and GDP at one lag. Only in the case of the estimation for Prague in the sample 2010–2015 two lags of GDP were used. This has no other than a purely statistical explanation: two lags were needed to obtain a set of statistically valid instruments.

Table 3 summarizes the key output of the estimates. The number of observations is given for each sample. It shows estimates of α and β as in Formula (4) and the statistical significance of the estimates. The validity of the instruments was tested by the traditional J-statistic with null hypothesis of the model being valid and also by the Eichenbaum-Hansen-Singleton test, which is based on the comparison of the J-statistic of the equation with the instruments given and of another model which excludes part of the instruments.

The autocorrelation of the residuals was first evaluated by the Durbin-Watson statistic, which is given in Table 3. We also checked it with help of Ljung-Box statistic up to the lag of 12 (that is up to one year). This result is not reported as it requires a lot of space. The tests showed no statistically significant remaining autocorrelation in the residuals.

We also checked for normality of the residuals with the help of Jarque-Bera test. We did not encounter any problems with non-normality and we do not present these results.

Throughout the estimation we used the White weighting matrix which assures heteroscedasticity consistent estimates.

The estimates of the sensitivity of the probability of finding a job on the labor market tightness are positive as expected with the exception of the estimate for Prague in the first sample; also it should be noted that the estimate for Plzeňský region was not statistically significant in the first sample.

Generally, the estimates show that the responsiveness of the probability of finding a job to the labor market tightness increased over the years, as the estimates within the second sample generally give higher values than in the first sample. The only exceptions are Liberecký region and Moravskoslezský region.

We interpret the increase in the responsiveness as a positive sign of the structural characteristic of a labor market because it means that the information which makes part of its structure, vacancies and unemployed, faster translates into results, i.e. matches. However, we elaborate more on this finding further below.

Table 3 GMM Estimates

Region	Sample (number of observations)	α	β	J-statistic	Durbin-Watson	Orthogonality test	R-squared
Prague	2000–2007 (94)	0.108***	-0.018***	5.750	2.184	4.432	0.720
Prague	2010–2015 (72)	0.017	0.104*	2.147	1.869	1.363	0.897
Středočeský	2000–2007 (95)	0.093***	0.023**	0.507	2.237	0.507	0.643
Středočeský	2010–2015 (72)	0.060***	0.115***	2.150	2.318	2.150	0.875
Jihočeský	2000–2007 (95)	0.115***	0.034**	0.498	2.159	0.498	0.691
Jihočeský	2010–2015 (72)	0.074***	0.119***	0.055	2.250	0.055	0.846
Plzeňský	2000–2007 (95)	0.099***	0.003	0.328	2.064	0.328	0.50
Plzeňský	2010–2015 (72)	0.070***	0.067***	1.445	2.318	1.445	0.830
Karlovarský	2000–2007 (95)	0.072***	0.058**	0.584	2.530	0.584	0.684
Karlovarský	2010–2015 (72)	0.051***	0.117***	2.226	2.073	2.226	0.872
Ústecký	2000–2007 (95)	0.051***	0.173***	1.329	2.400	1.329	0.640
Ústecký	2010–2015 (72)	0.027***	0.496***	1.677	2.221	1.678	0.863
Liberecký	2000–2007 (95)	0.071***	0.129***	1.781	2.333	1.781	0.776
Liberecký	2010–2015 (72)	0.060***	0.080*	0.047	2.207	0.047	0.837
Královéhradecký	2000–2007 (95)	0.074***	0.119***	0.055	2.250	2.068	0.846
Královéhradecký	2010–2015 (72)	0.054***	0.214***	1.035	1.982	1.035	0.923
Pardubický	2000–2007 (95)	0.092***	0.038***	1.257	2.168	1.257	0.618
Pardubický	2010–2015 (72)	0.062***	0.136***	1.288	2.163	1.288	0.874
Vysočina	2000–2007 (95)	0.087***	0.074**	1.291	2.390	1.291	0.699
Vysočina	2010–2015 (72)	0.061***	0.265***	0.368	2.149	0.368	0.834
Jihomoravský	2000–2007 (95)	0.070***	0.056***	0.166	2.409	0.166	0.771
Jihomoravský	2010–2015 (72)	0.052***	0.193***	0.119	2.120	0.119	0.866
Olomoucký	2000–2007 (95)	0.067***	0.103***	0.983	2.009	0.982	0.582
Olomoucký	2010–2015 (72)	0.050***	0.208***	0.754	1.839	0.754	0.871
Zlínský	2000–2007 (95)	0.074***	0.049**	0.963	2.182	0.963	0.779
Zlínský	2010–2015 (72)	0.062***	0.124***	1.003	1.884	1.003	0.892
Moravskoslezský	2000–2007 (95)	0.052***	0.115***	1.176	2.381	1.176	0.802
Moravskoslezský	2010–2015 (72)	0.052***	0.091***	0.839	2.108	0.839	0.868
Czech Republic	2000–2007 (95)	0.074***	0.034**	0.517	2.292	0.517	0.744
Czech Republic	2010–2015 (72)	0.057***	0.121***	1.089	1.981	1.089	0.903

Note: Estimates of the coefficients are under the null of being equal to zero; J-statistic refers to Sargan-Hansen test of over-identifying restrictions under the null of validity; besides Durbin-Watson the autocorrelation was also checked by Ljung-Box test up to the order of 12 lags, these results are not reported; orthogonality of instruments was tested by Eichenbaum-Hansen-Singleton test under the null of validity of instruments; *, **, *** signifies rejection of the null at 10%, 5%, 1% of statistical significance, respectively.
Source: Own estimates

In this respect the relatively highest responsiveness is found in Ústecký region, Vysočina, Královéhradecký region, and Olomoucký region. The relatively highest increases in the responsiveness between the two samples were identified in Středočeský region, Prague, and Plzeňský region.

The results of our paper may be related to Galuščák and Munich (2007). Nevertheless, not directly, because the sample is completely different and also the formulation tested differs a lot. Galuščák and Munich (2007) also use regional data but in the end make a panel estimation, which might be explained by the relatively short series they had to use. The most interesting of their results is the procyclicality of the sensitivity of the number of the newly employed to the stock of unemployed and the inflow of unemployed.

Panel data is used also by Pedraza (2008) who focuses on the examination of the efficiency of the matching process with respect to other variables. He finds that the matching efficiency is positively influenced by the level of education of the labor force.

Most recent and relevant paper by Němec (2015) also makes use of the MLSA data, however, as in the case of the already mentioned studies, he resorts to panel analysis. He finds that the matching efficiency is negatively influenced by the number of the unemployed of 50 years and older and by the number of the long-term unemployed.

The sensitivity of reactions of probability of finding a job with respect to labor market tightness to the economic cycle may be well supposed given the results presented in Table 3. However, to reach a conclusion whether or not it is really there, it should be also tested a possible structural change in the behaviour, perhaps provoked by the crisis. This, however, requires a different econometrical approach. We follow up on this question in a subsequent research.

CONCLUSION

The estimates detected as the most problematic regions: Ústecký region, Moravskoslezský region, Královéhradecký region and partially Olomoucký region and Vysočina. It was in the first three where even during the economic expansion the probability of finding a job increased relatively less than in the other regions and on the other hand dropped the most in the aftermaths of the great recession. The latter holds for Olomoucký region and Vysočina as well.

Also we found relatively lower labor market tightness due to low vacancy rate in Ústecký region, Vysočina and Královéhradecký region. Lower labor market tightness due to relatively high unemployment rate was found in Olomoucký, Jihomoravský and Ústecký region.

To draw a few connections with the socio-economic situation in the regions we presented in the paper, we saw that lower levels of education dominate in these regions: the share of secondary education without A levels together with elementary or no education dominates in Karlovarský region, Ústecký region, and Vysočina. The share of assistants and unqualified workers in the employment reaches over 6% in Plzeňský region, Karlovarský region, Královéhradecký region, Pardubický region and Moravskoslezský region, in Ústecký region it is close to 6%.

Although the Czech Statistical Office, CZSO (2016), points to an increasing level of the percentage of those with higher education across the whole economy, the situation remains quite diverse among the respective regions as we could see in the text.

The results point to some significant differences in the performance of the respective regions of the Czech Republic, which does not come as a big surprise. What comes much more baffling are discussions which proclaim that much support directed toward the technical secondary, and very often without A levels, education should be anyhow beneficial for the future development of the economy.

References

CZSO. *Čtvrtletní analýza VŠPS na aktuální téma – 4. Q. 2016* [online]. <https://www.czso.cz/csu/czso/cri/ctvrtletni-analyza-vsps-na-aktualni-tema-4-ctvrtleti-2016>

GALUŠČÁK, K. AND MUNICH, D. Structural and Cyclical Unemployment: What Can Be Derived from the Matching Function? *Finance a Úvěr*, 2007, 3-4, pp. 102–125.

HAMPL, M. AND MARADA, M. Metropolizace a regionální vývoj v Česku v transformačním období (Metropolization and Regional Development in the Czech Republic in the Period of Transformation). *Geografie*, 2016, 4, pp. 566–590.

HAMPL, M. AND MARADA, M. Sociogeografická regionalizace Česka (Socio-geographical Regionalization of the Czech Republic). *Geografie*, 2015, 3, pp. 397–421.

MLSA. *Analysis of the development of employment and unemployment in 2014* [online]. Integrated portal of the MLSA, 2015. [cit. 10.2.2017]. <https://portal.mpsv.cz/sz/politikazamest/trh_prace/rok2014/>.

MORTENSEN, D. T. AND PISSARIDES, C. A. New Developments in Models of Search in the Labor Market. In: ASHENFELTER, O. AND CARD, D., eds. *Handbook of Labor Economics*, Elsevier, 1999, Vol. 3.

NĚMEC, D. Measuring Inefficiency of the Czech Labour Market. Review of Economic Perspectives. *Národohospodářský Obzor*, 2015, 2, pp. 197–220.

PEDRAZA, DE P. Labour Market Matching Efficiency in the Czech Republic Transition [online]. *William Davidson Institute Working Paper Number 920*, 2008. [cit. 10.5.2017]. <https://deepblue.lib.umich.edu/bitstream/handle/2027.42/64357/wp920.pdf?sequence=1>

PISSARIDES, C. A. Job Matchings with State Employment Agencies and Random Search. *Economic Journal*, 1979, 356, pp. 818–833.

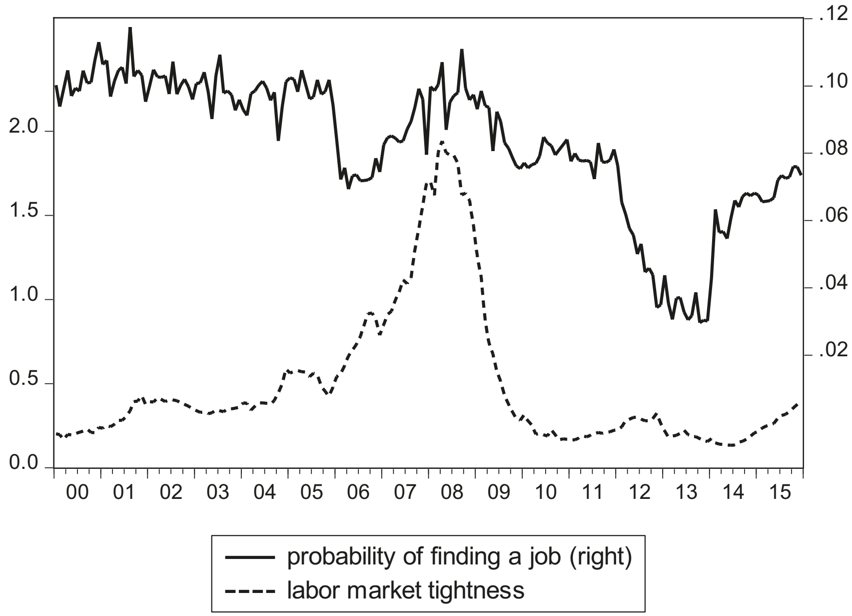
PISSARIDES, C. A. Short-Run Equilibrium Dynamics of Unemployment, Vacancies, and Real Wages. *American Economic Review*, 1985, 4, pp. 676–690.

PISSARIDES, C. A. Equilibrium Unemployment Theory. Cambridge: MIT Press, 2000.

PISSARIDES, C. A. A New Method to Estimate Time Variation in the NAIRU – Comments [online]. 2008. [cit. 8.2.2017]. <http://www.bostonfed.org/economic/conf/conf53/papers/pissarides.pdf>.

APPENDIX

Figure 3 Prague



Source: MLSA, own calculations

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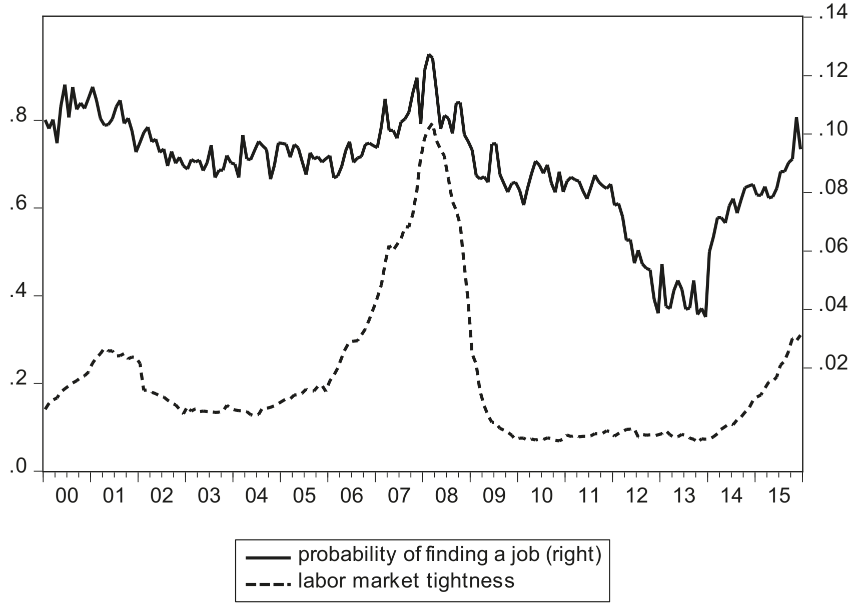
Figure 4 Středočeský region



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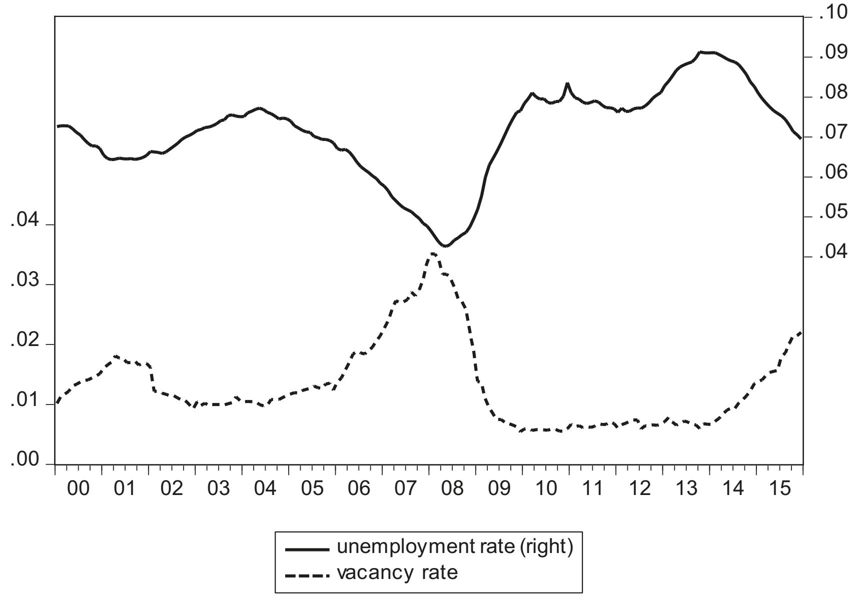

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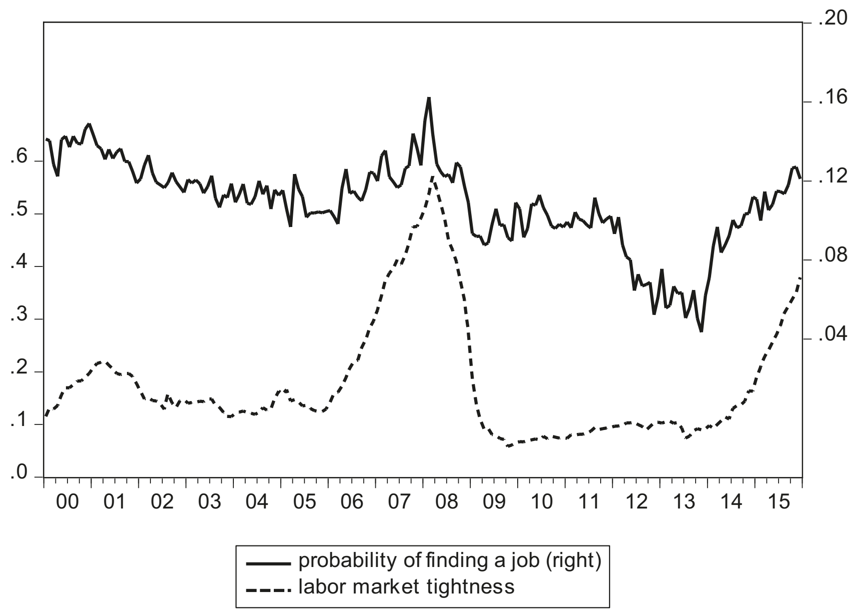
Figure 5 Jihočeský region



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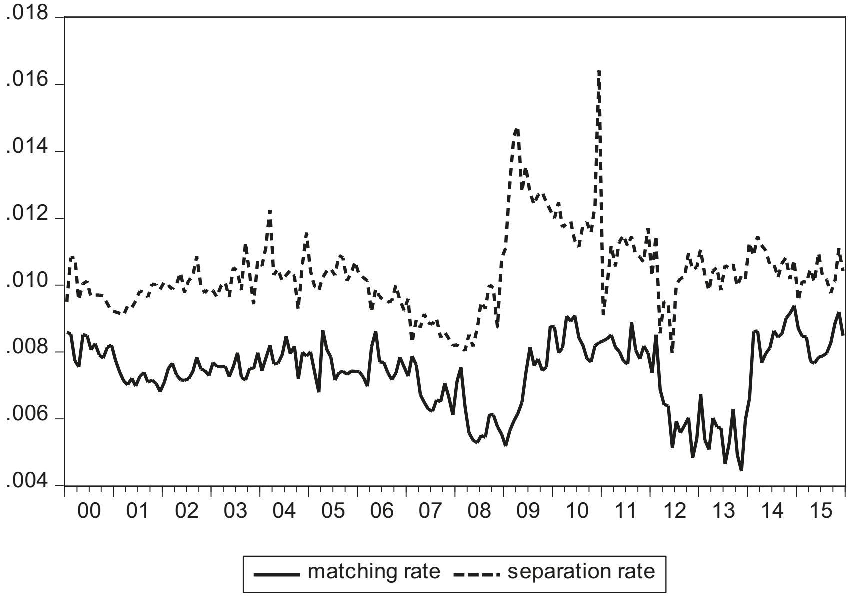

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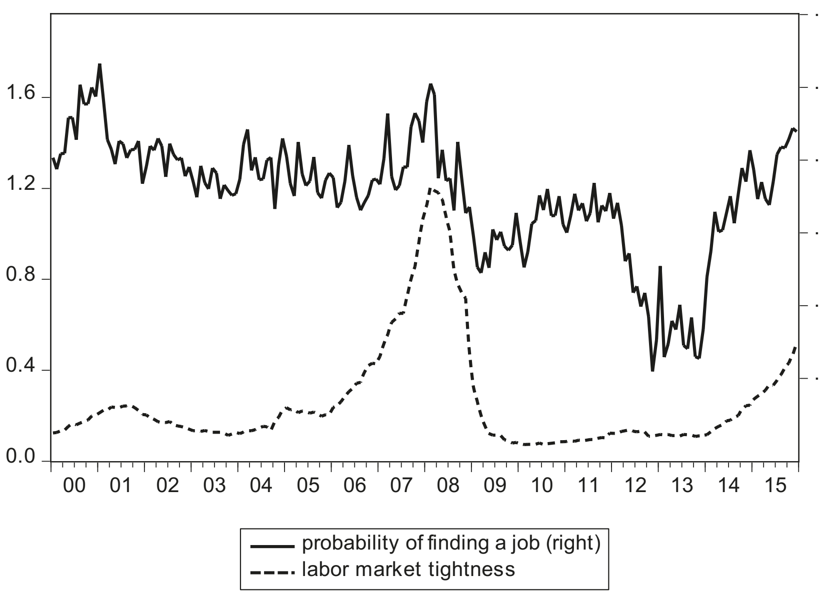
Figure 6 Plzeňský region



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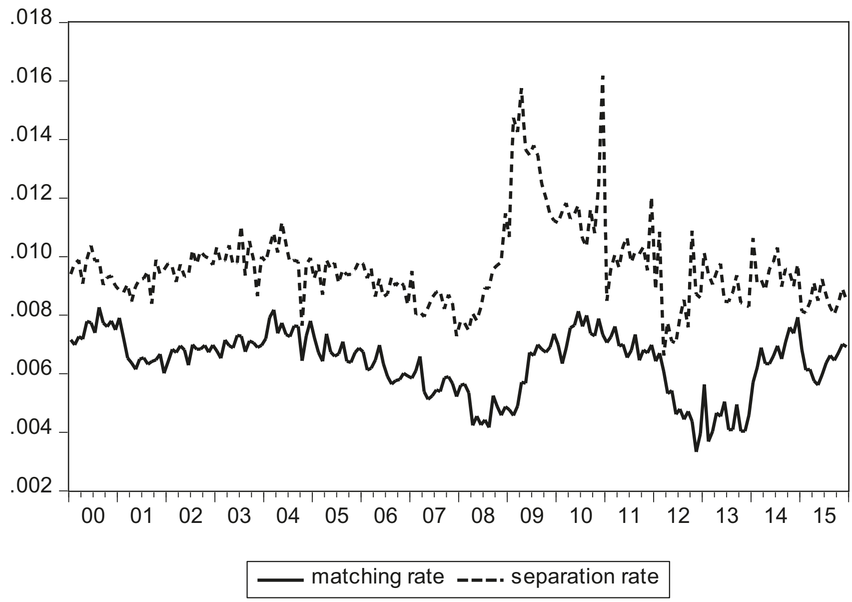

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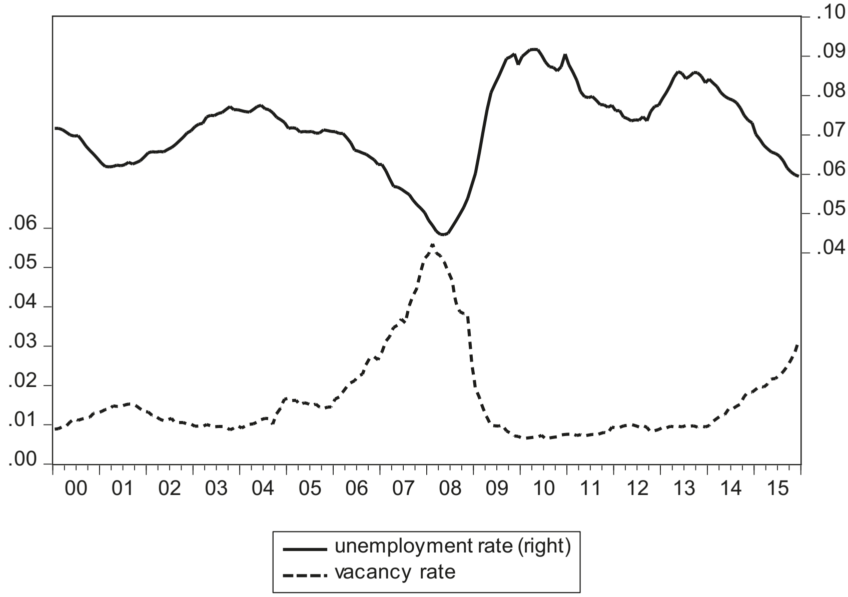

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Figure 7 Karlovarský kraj

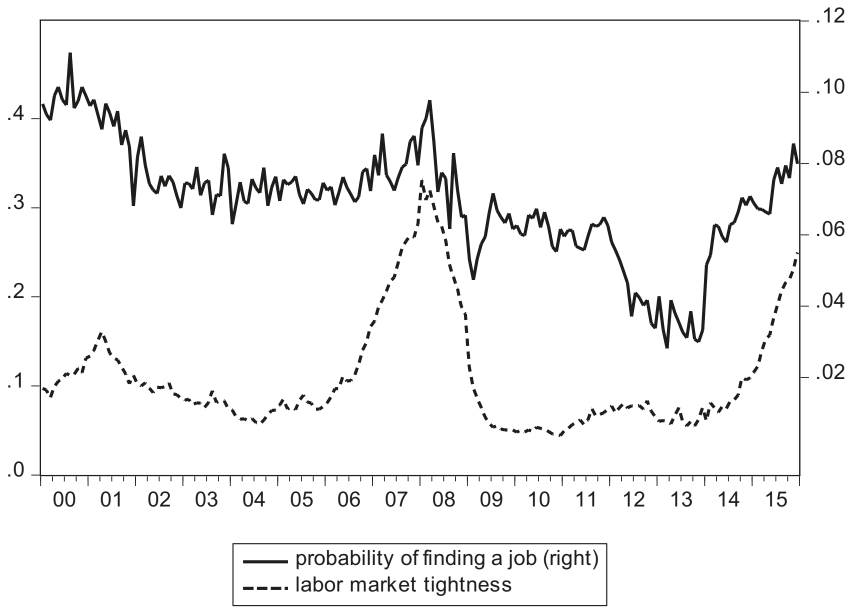

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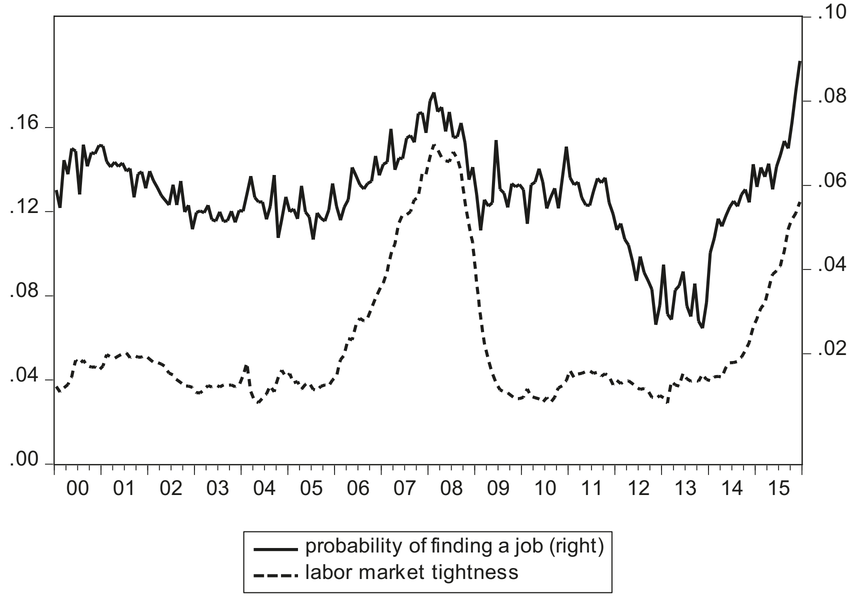
Figure 8 Ústecký kraj



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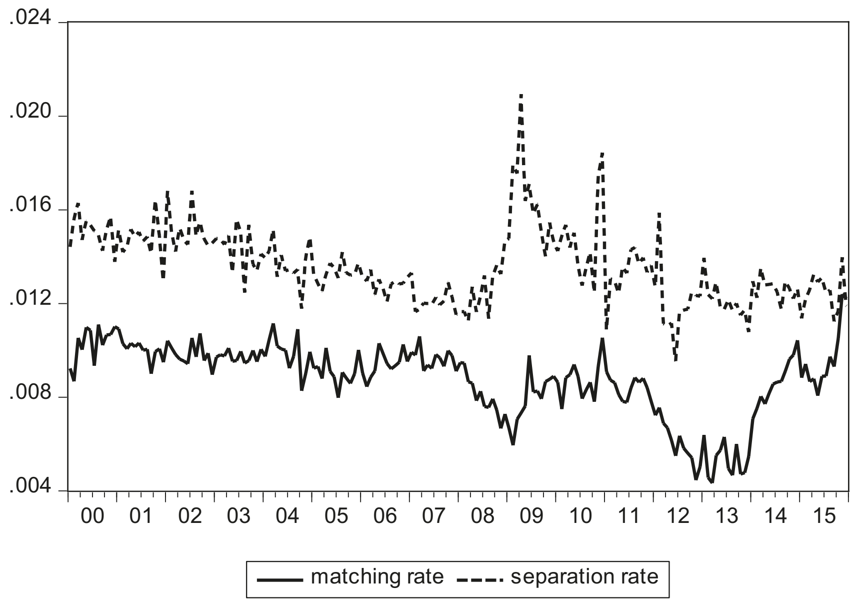

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Figure 9 Liberecký region

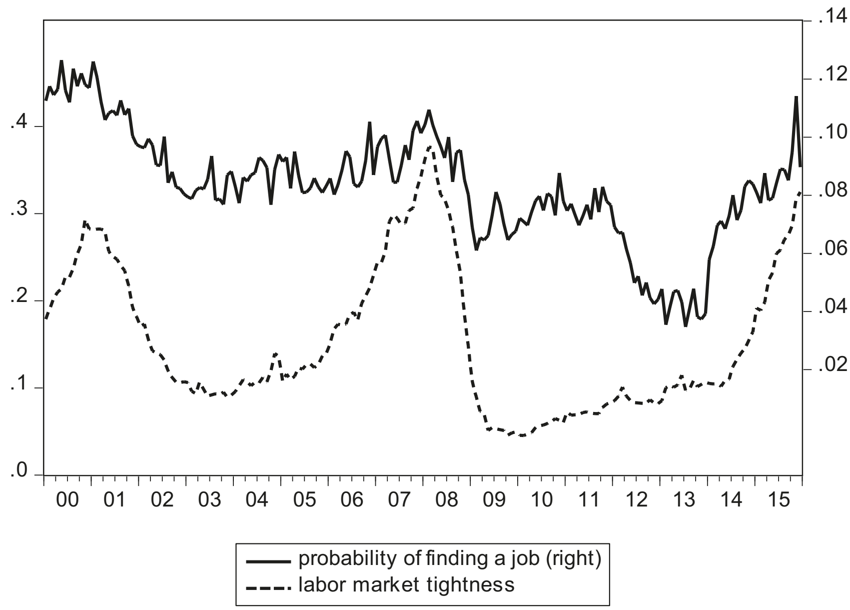

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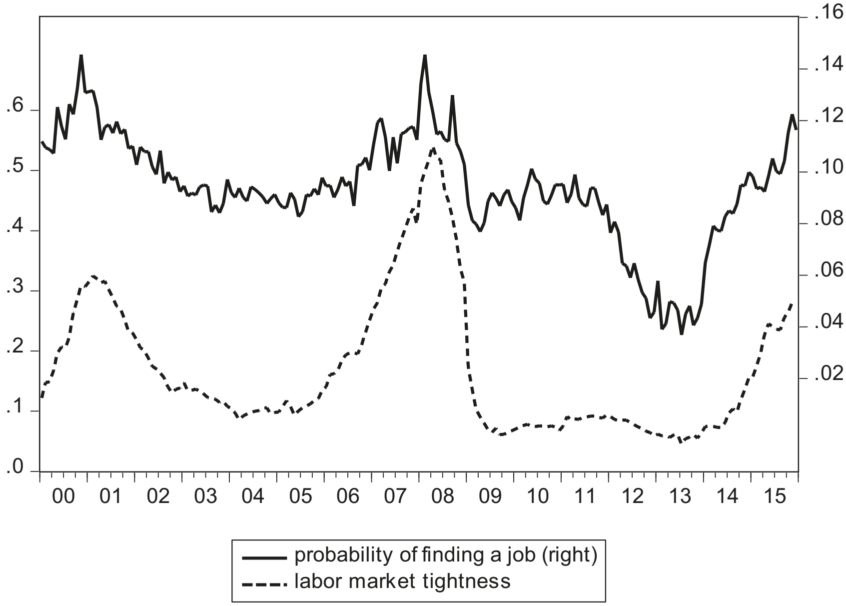
Figure 10 Královéhradecký region



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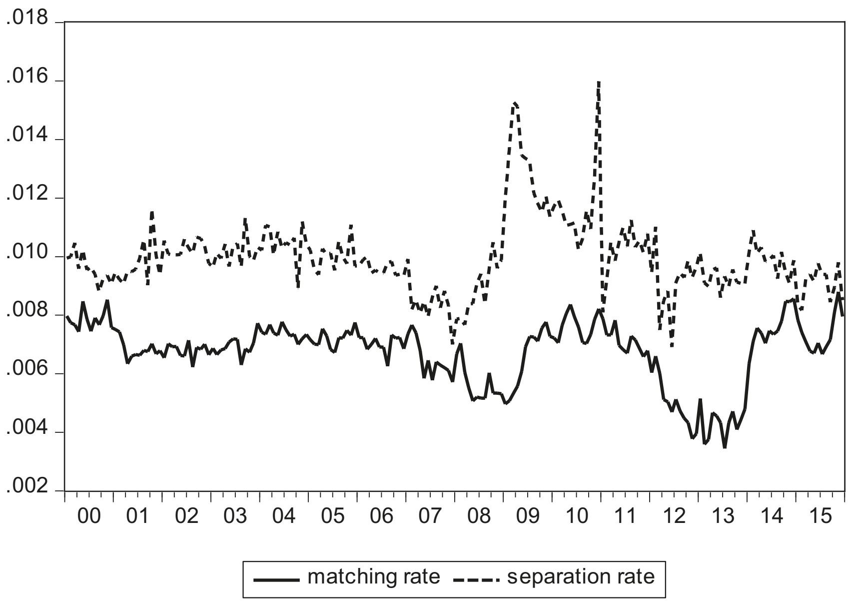

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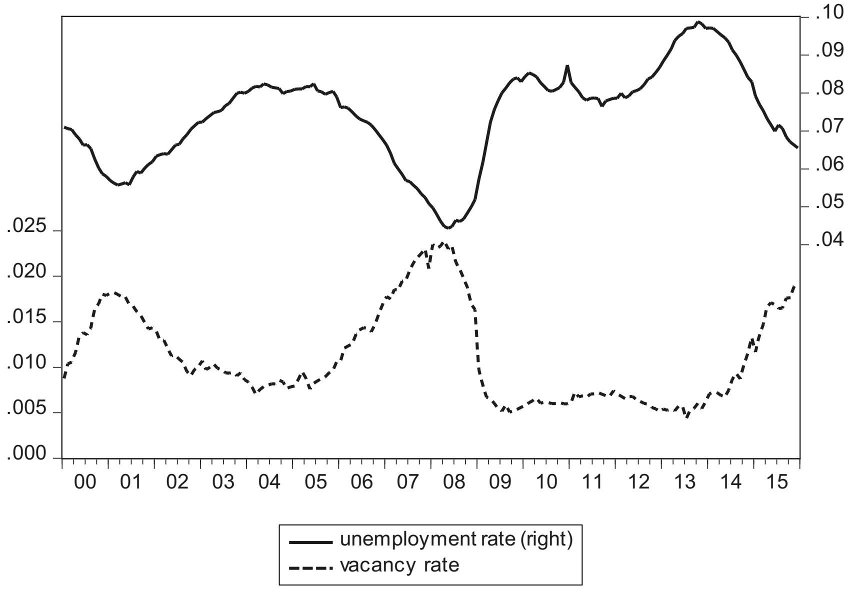

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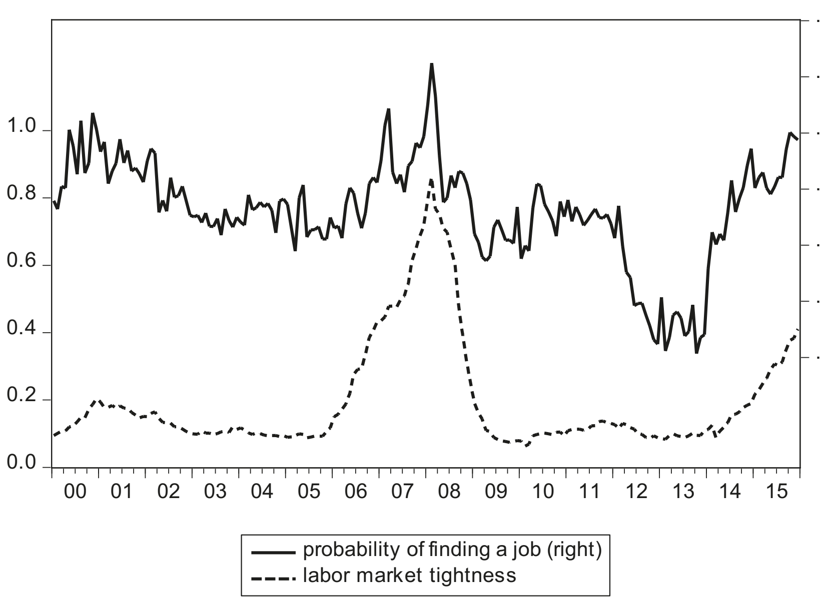
Figure 11 Pardubický region



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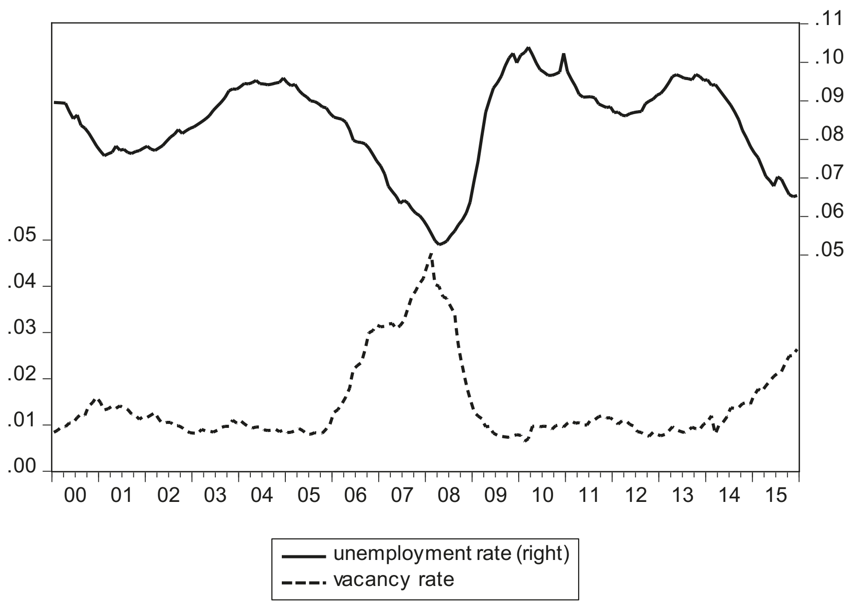

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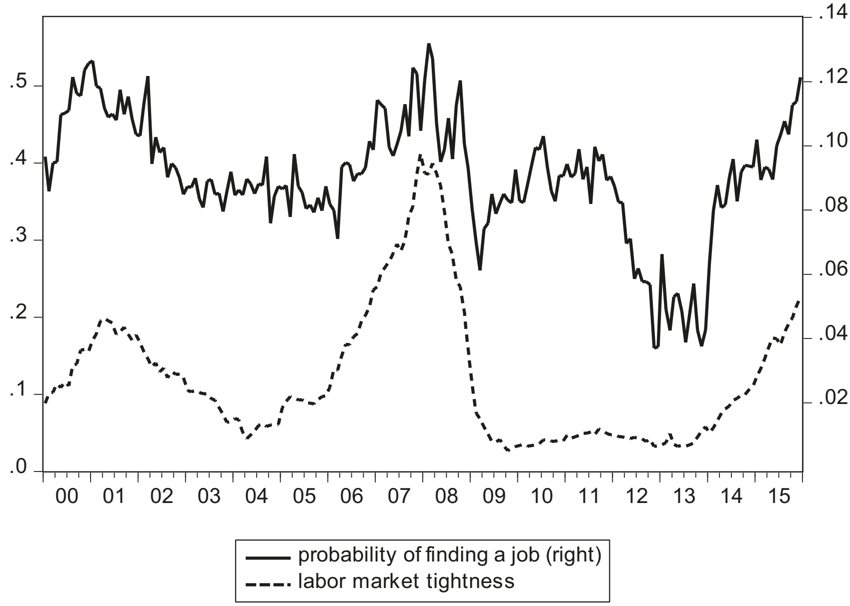
Figure 12 Vysočina region



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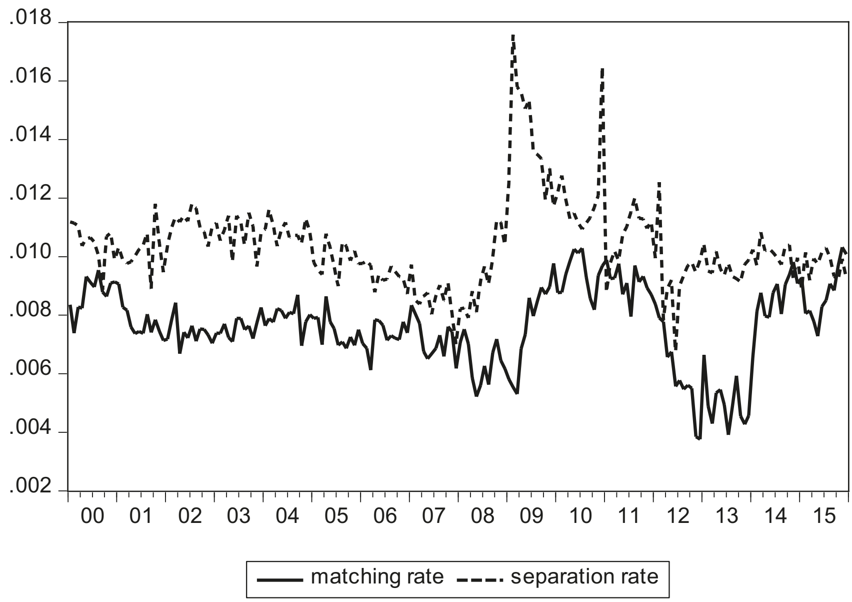

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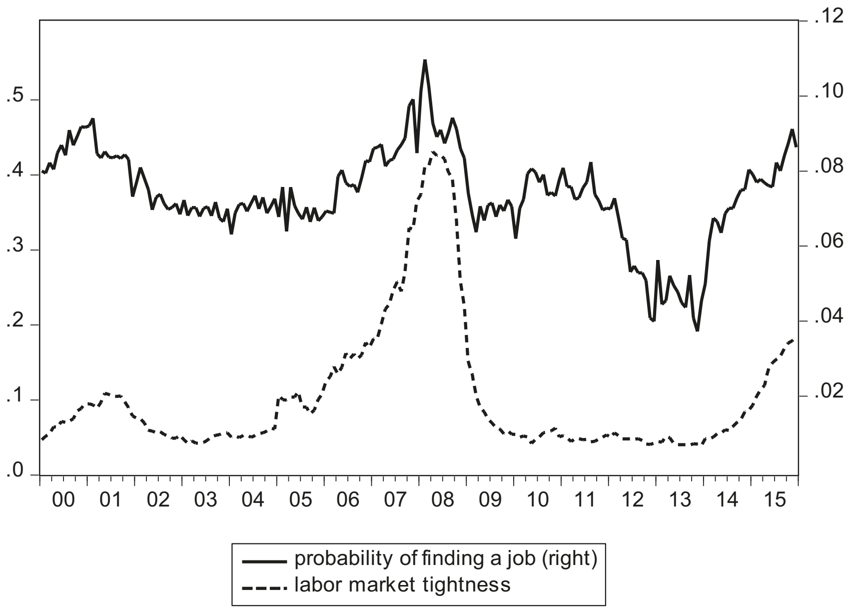
Figure 13 Jihomoravský region



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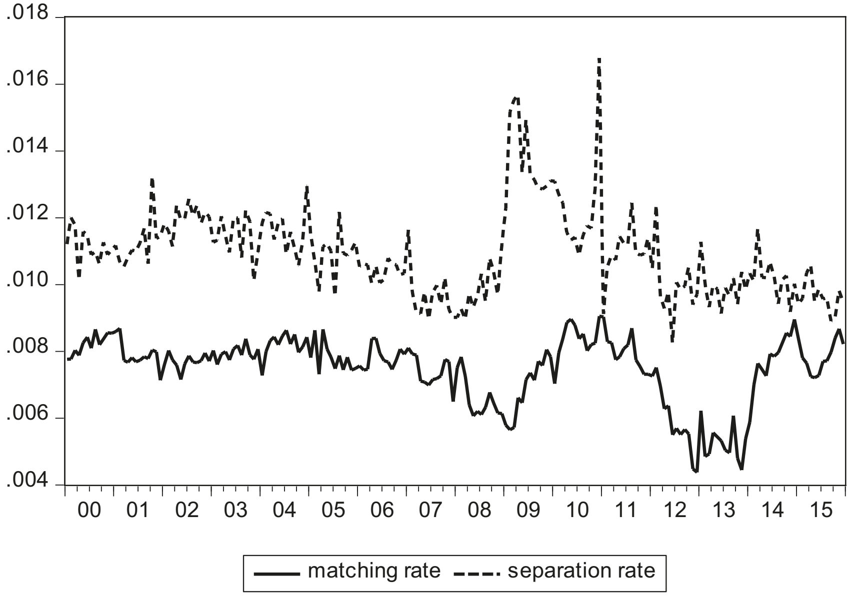

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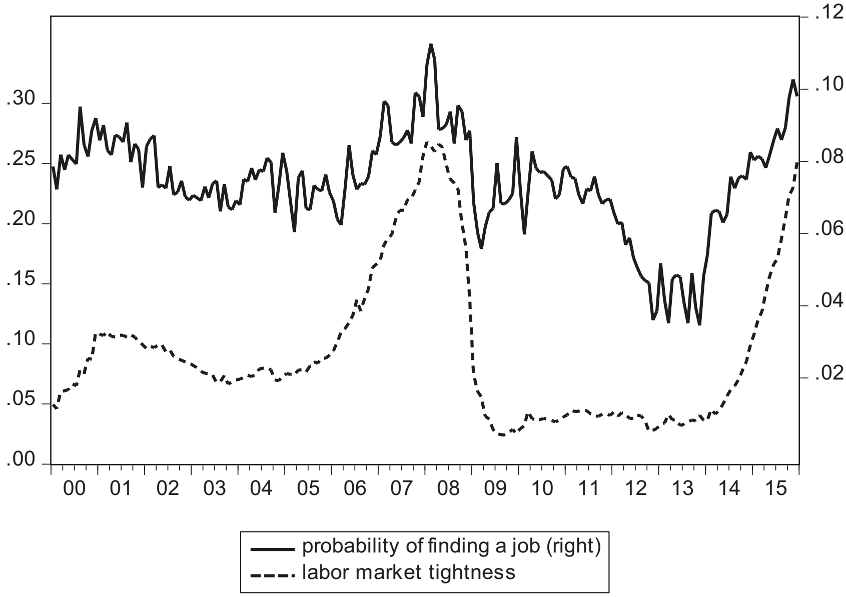
Figure 14 Olomoucký region



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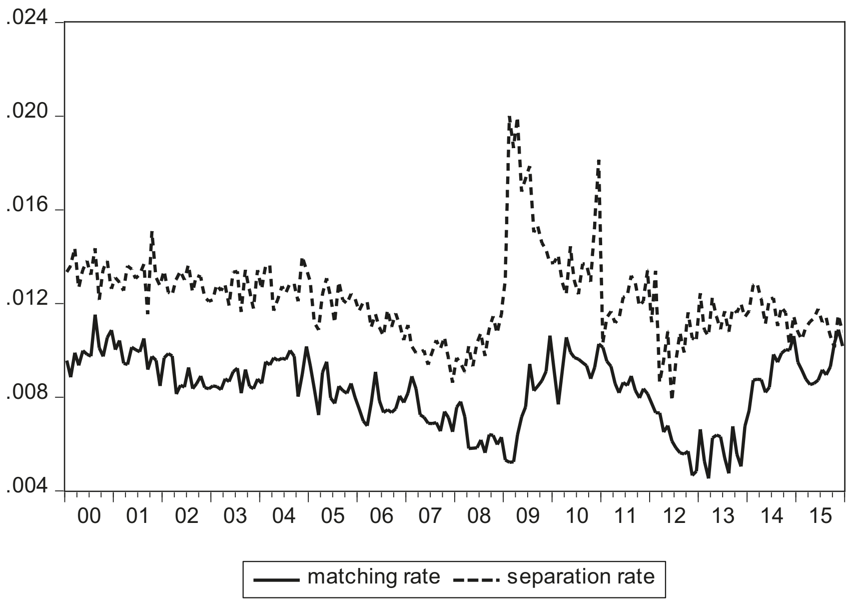

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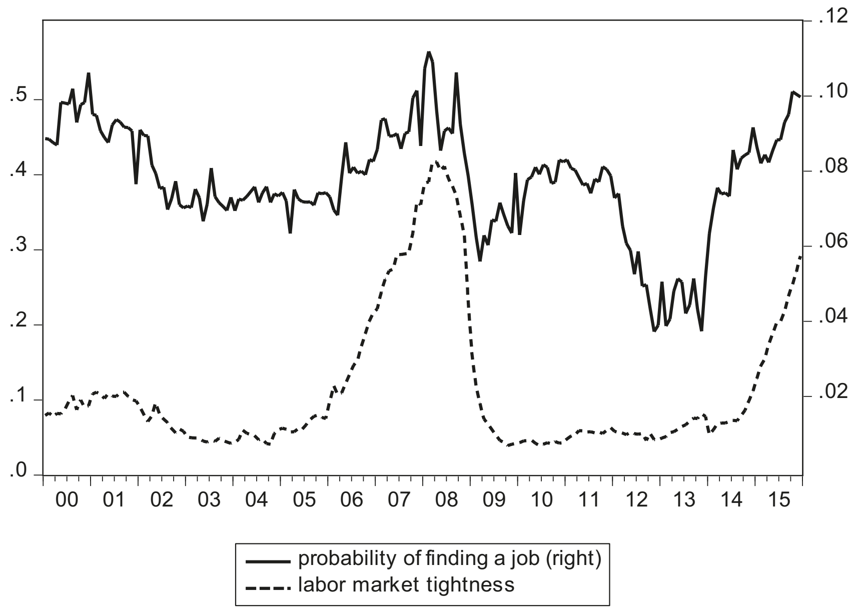
Figure 15 Zlínský region



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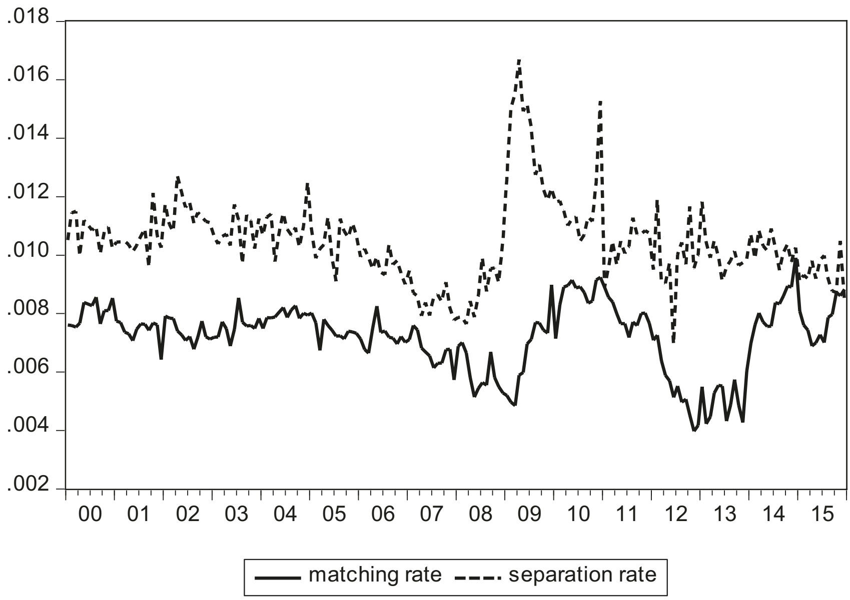

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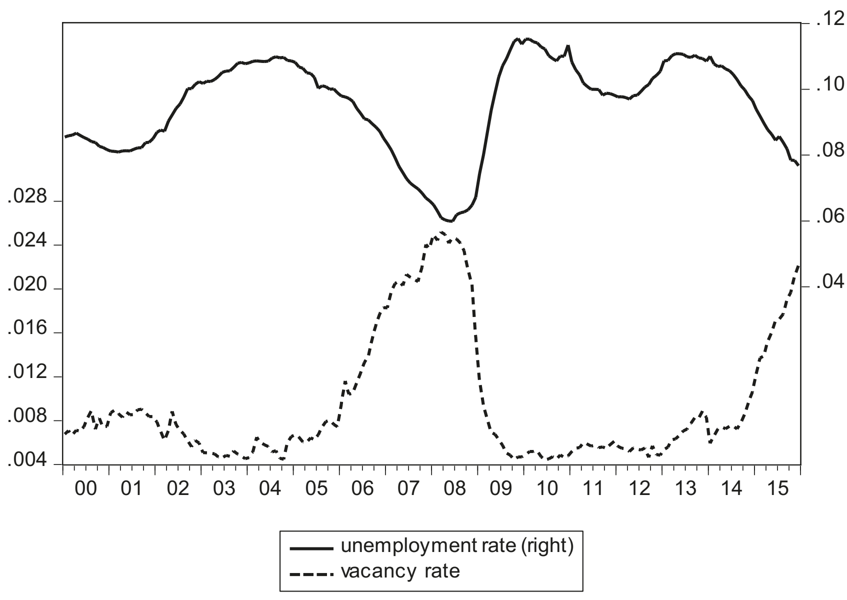

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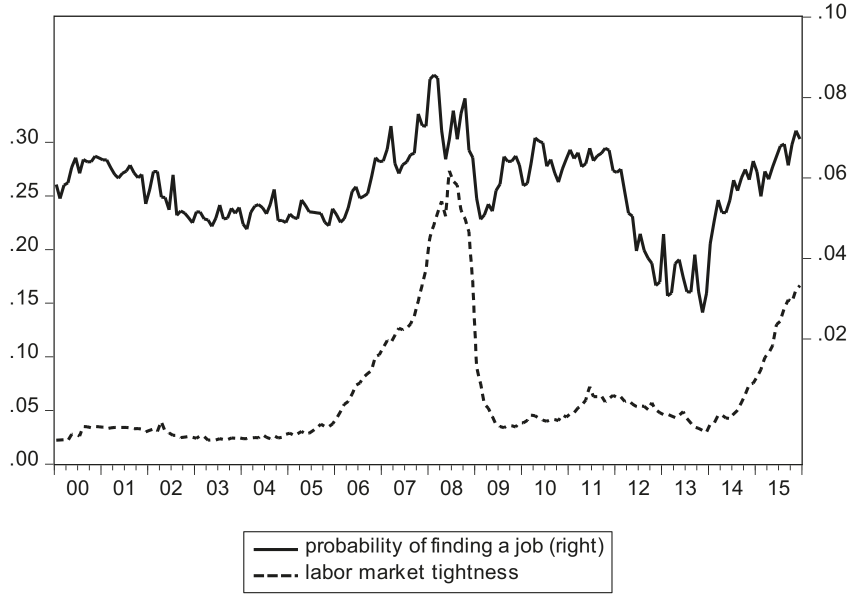
Figure 16 Moravskoslezský region



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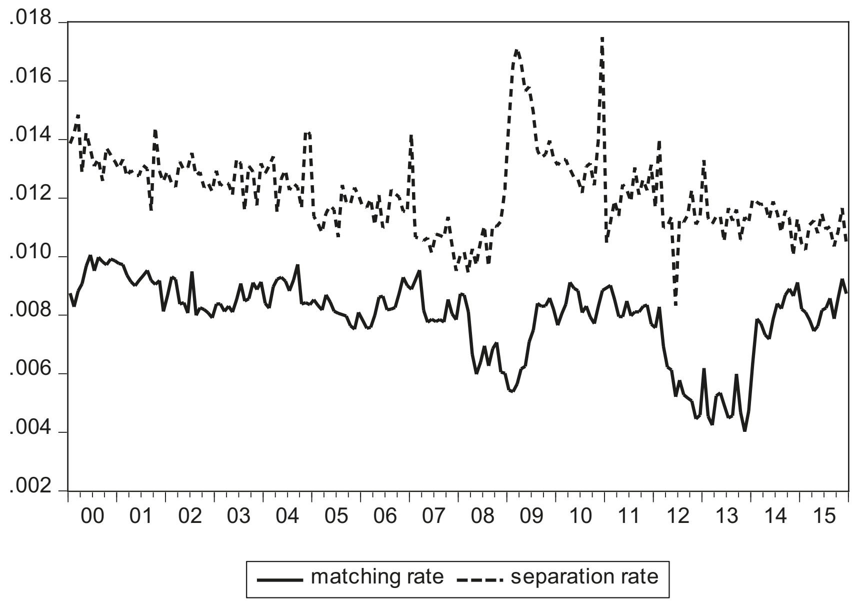

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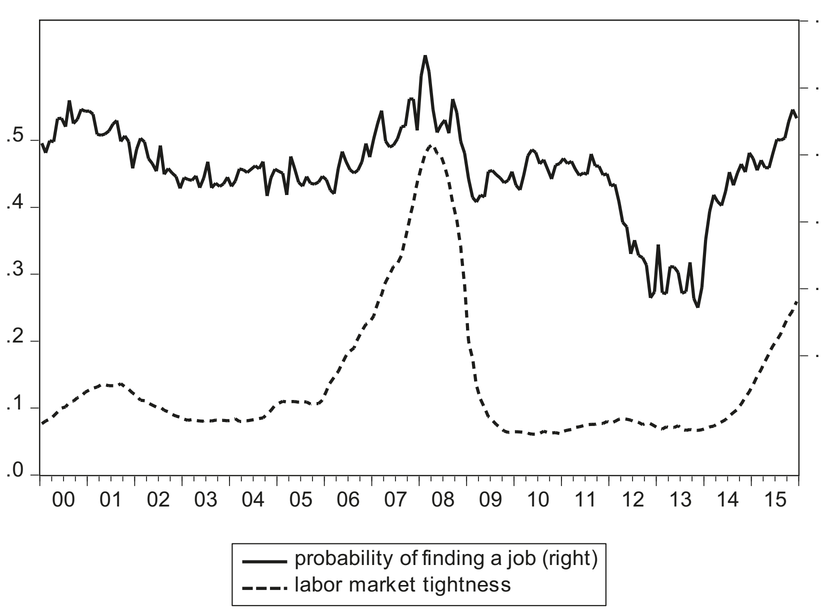
Figure 17 Czech Republic



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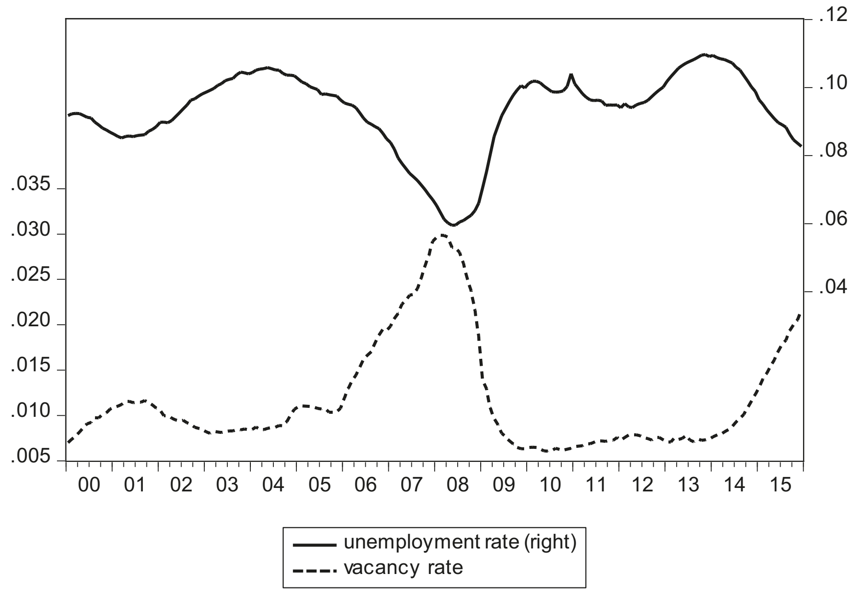

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Improving Transformation of Emissions from Industries to Products: Product Technology Assumption, Disaggregation of Key Industry and Almon's Procedure

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Abstract

An allocation of emissions from industries to product groups is an inevitable step, wherever the embodied emissions (or energy) of products are calculated with the environmentally extended input-output analysis. Within this paper, we suggest and explain steps for the improvement of commonly used techniques.

First, we explain why the widely applied industry technology assumption to construct product-by-product input-output model is an unsuitable method for the transformation of emissions and why product technology assumption should be used instead. Second, we cope with the resulting negative values, which is the well known limitation of the product technology assumption, by utilizing Almon's procedure. Third, we demonstrate how disaggregation of the industry with dominant emissions and diverse technologies for this kind of emission transformation may improve the results. We apply these steps to emissions from NAMEA for the Czech Republic and discuss the results. Additionally, we provide an easy-to-use VBA tool with Excel interface to calculate Almon's transformation automatically.

Keywords	**JEL code**
Input-output tables, product-by-product, product technology assumption, Almon's procedure, transformation of industries to products, industry disaggregation, NAMEA	*Q56, Q57*

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INTRODUCTION

Where embodied emissions of products are in scope of the scientific paper and environmentally extended input-output analysis (EE-IOA) is used as a method to calculate them, it is usually necessary to transform emissions from industries to products.[4] It is because environmental data are usually recorded for industries. This is the case of the National Accounting Matrix with Environmental Accounts (NAMEA) which includes emissions to air, that are the main objective of this paper, but it also includes energy or material consumption.

Despite the fact Eurostat (Eurostat, 2008, p. 19) recommends the local kind-of-activity as reporting units, the supply-use table framework is often set up by different types of units. It may cause that industries produce also products which do not belong to its main activity. Those products are commonly called by-products and create the off-diagonal elements of the supply table.

Creating technically sound EE-IOA models, which interlink consumption of products with emissions of industries requires not only linking of industries with products to match their classification mutually but also a transformation from industries to products or vice versa.

The last condition is the trickiest one, as the transformation of industries to products or vice versa must be carried out. Four types of transformation could be theoretically employed for EE-IOA corresponding to four types of transformation of supply and use tables in order they form symmetric input-output tables (IOT). Product-by-product IOT with product technology assumption (Model A) and with industry technology assumption (Model B) and industry-by-industry IOT with fixed industry sales structure assumption (Model C) and fixed product sales structure assumption (Model D) (Eurostat, 2008, p. 351).

The emissions associated with manufacturing are transformed by much the same way as the IOT is created, only by substituting the rows of the use table with emissions of industries.

The literature review shows that some scholars used Model D industry-by-industry technical coefficient matrix (Weber and Matthews, 2008) (Golley and Meng, 2012) and then map emission intensities directly to products without any transformation.[5] This approach has two drawbacks. First, Eurostat recommends (Eurostat, 2008, p. 24) product-by-product IOT, where homogenous product groups are the objective of the analysis, which is the case of these product consumption studies. Second, if emission transformation between industries and consumed product is skipped, it leads to an inconsistency that embodied emissions of manufactured by-products are assigned to their main industry.

Studies with other approach (Wiedmann et al., 2005; Roca and Serrano, 2007; Baiocchi et al., 2010) transforms the emissions from industries to products using Model B product technology assumption and consequently uses Model B product-by-product matrix of technical coefficients for IOA.

However, if product by product input-output tables are compiled, theoretical considerations indicate that the 'Product technology assumption' (Model A) is preferable to the 'Industry technology assumption' (Model B) according to Eurostat recommendation (Eurostat, 2008, p. 24). This is in line with the System of National Accounts which reviews these two assumptions and states that: the industry technology assumption performs rather poorly (UN, 1993, p. 465). The same point of view can be found in Almon (2000) and also ten Raa (2005), who describes that the following axioms are violated in Model B: financial balance, price invariance, scale invariance, in relation to IOT creation. The situation when model B is appropriate for emission transformation is explained in the methodology. The impact of using Model B for emission transformation with inappropriate prerequisites is described in Appendix A.

The serious issue of the preferred model A is the fact that it may create negatives in the IOT as well as for transformed emissions. IOTs are usually prepared by national statistical institutes and the negatives are removed manually. For the transformation of emissions according to Model A, the scholars

[4] Products are sometimes called product groups or commodities.

[5] At least, no trace of such transformation is described in these papers.

performing EE-IOA would have to remove the negatives manually by themselves. This is a long and tedious task, which requires deeper knowledge of the source data that are often not publicly available. This has practically disqualified model A as an option for the emissions transformation.

It is important to realize that the negatives are an outcome of the violation of the theoretical product technology assumption by different technology used for the same product in different industries (resulting in more or less emissions). The product technology assumption can be violated e.g. by actually including different products mix into one product group in different industries due to product heterogeneity (Konijn and Steenge, 1995) or by the errors in recorded data of supply table or use table or emission data, respectively.

It is theoretically impossible to correct the errors and product technology assumption violations in supply and use tables without very detailed knowledge of the original data and practically impossible even with this knowledge at hand. Thus several methods for the elimination of negatives were developed, for overview see e. g. ten Raa and Rueda-Cantuche (2013).

As a solution of emission transformation for the purpose of EE-IOA, we suggest transformation of emissions from industries to product with Almon's procedure (Almon, 2000) which reflects the model A but automatically eliminates the negatives, by decreasing the extent of by-products individually for each product and industry.

We see this method as the best solution due to its simplicity and compatibility with model A. Even though some papers criticized this method for arbitrary manipulation the source data (de Mesnard, 2009; ten Raa, Rueda-Cantuche, 2013), in our point of view, it is inevitable step of automated error correction.

Disaggregation of products/industries is another way to gain the results that catch the reality more accurately and potentially remove the unwanted negatives (Konijn and Steenge, 1995; Vollebregt and van Dalen, 2002). Here, we carried out this disaggregation of electricity production industry and electricity product to demonstrate how beneficial such disaggregation can be in the case of emission disaggregation. The real data of the Czech supply table and NAMEA was used.

1 METHODOLOGY

1.1 Transformation of emission – deciding between product and industry technology assumption

Supply and use tables are used to create a symmetrical input-output table with four different assumptions designated as models A, B, C, D (Eurostat, 2008, p. 351). In order to calculate emissions using model A or B, we substitute each row of the use matrix $\boldsymbol{U}$, representing intermediate inputs of one type of product to all industries, with emission data of one type of emissions. In notation, $\boldsymbol{U}$ becomes $\boldsymbol{U_E}$ and $\boldsymbol{R}$ becomes $\boldsymbol{R_E}$ (see the Appendix A for the full legend). Monetary units (CZK, EUR, etc.) become mass units (kg, tonnes) or possibly energy units (kJ, MJ). Since each row represents one sort of emission, the matrices $\boldsymbol{U_E}$ and $\boldsymbol{R_E}$ have as many rows as there are types of emissions.[6]

Hereinafter in this section, we explain when and why the product technology assumption (model A) should be preferred over industry technology-assumption (model B) in the case of emissions transformation.

We base our idea on the fact that despite the recommendation of Eurostat to use local kind-of-activity units for the compilation of supply and use tables, many national statistical institutes use rather institutional units (enterprises) for that purpose since it is easier to report financial transactions for the whole enterprise (Eurostat, 2015). This is also the case of the Czech Republic (Sixta, 2013). Consequently, the by-products are rather an outcome of the separable subsidiary production, defined as an independent production process (UN, 1993) (e.g. coal mining and electricity production). Then also emissions from product production stem from an independent process, which is bound to the particular product and which is not influenced by the industry in which it is recorded. This corresponds to the production

[6] National emission databases, such as NAMEA, are usually the source of data here.

technology assumption (model A), which states that "each product is produced in its own specific way, irrespective of the industry where it is produced". The production process for one particular product can in reality be different within one as well as across more industries, yet it should describe the product better than industry in which it was produced, because an industry serves rather as an administrative unit for reporting purposes with a varying scale of by-products.

An exception to this rule is the joint production, defined as the case where coproducts cannot be easily separated (UN, 1993) (e.g. brick and heat production), because the products are coming from one production process. Then model B might be seen as a suitable solution for emission transformation, since it divides the emissions in the proportion of the coproducts supply (turnover). According to our educated guess, subsidiary production largely prevails over joint production in the case where supply tables are compiled by enterprises, therefore we neglect the later option. Other and more suitable option would be the mixed technology assumption, which we do not have enough background information for to benefit from it.

The mathematical explanation and the consequences of choosing one model or another for the scenario with subsidiary production is explained in the Appendix A.

1.2 Transformation of emissions from industries to products with Almon's procedure

The transformation of emissions, described within this paper, is an analogy to the Almon's procedure (Almon, 2000). It uses the same mathematical steps. Only use matrix $\boldsymbol{U}$ is substituted with emissions by industries $\boldsymbol{U_E}$, recipe matrix $\boldsymbol{R}$ with emissions by products $\boldsymbol{R_E}$ and $\boldsymbol{T_A}$ is denoted as $\boldsymbol{M}$ in Almon's notation.

The following equations show the brief derivation of Almon's procedure (Almon, 2000), which is based on model A. For further details of model A see the Table A1 in the Appendix A.

Almon's starts his derivation with this equations:

$$\boldsymbol{M} = \boldsymbol{V}(diag(\boldsymbol{q}))^{-1}, \tag{1}$$

$$\boldsymbol{R} = \boldsymbol{U}\,(\boldsymbol{M}^T)^{-1}. \tag{2}$$

To derive his procedure, Almon first takes the inverse form of Formula (2), transposes it and segments $\boldsymbol{U}$ and $\boldsymbol{R}$ by lines representing individual products:

$$\boldsymbol{u} = \boldsymbol{Mr}, \tag{3}$$

then rewrites the Formula (3) in the following form:

$$\boldsymbol{r} = (\boldsymbol{I} - \boldsymbol{M})\boldsymbol{r} + \boldsymbol{u}, \tag{4}$$

and approximate the Formula (4) with Seidel iterative process as:

$$\boldsymbol{r}^{(k+1)} = (\boldsymbol{I} - \boldsymbol{M})\boldsymbol{r}^{(k)} + \boldsymbol{u}, \tag{5}$$

where $r^{(k)}$ represents the k-th approximation of r and $r^{(0)} = u$.

The next step of Almon's procedure decomposes the Formula (5) in the form suitable for calculation of each element j (product j):

$$r_j^{(k+1)} = u_j - \sum_{\substack{h=1 \\ h \neq j}}^{n} m_{jh} r_h^{(k)} + \sum_{\substack{h=1 \\ h \neq j}}^{n} m_{hj} r_j^{(k)}. \tag{6}$$

Here, we rewrite this equation directly with emissions of industries u_{Ej} and products r_{Ej}:

$$r_{Ej}^{(k+1)} = u_{Ej} - \sum_{\substack{h=1 \\ h \neq j}}^{n} m_{jh} r_{Eh}^{(k)} + \sum_{\substack{h=1 \\ h \neq j}}^{n} m_{hj} r_{Ej}^{(k)} . \tag{7}$$

To understand the principle of the Formula (7), it is important to remember that each column of the matrix $\boldsymbol{M}$ represents the ratio between the shares of one unit of a product between industries in which this product is produced. Any element on the diagonal represents the ratio of the industry's own product, e. g. coal produced in the coal mining industry. The elements in the row to its left and right represent the ratios of by-products produced by that industry, e.g. electricity coming from the coal mining industry. Finally, the elements in the column above and below it represent the ratios of its own product created in other industries, e. g. coal produced in the electricity generation industry. Note that these elements are actually by-products of other industries from their perspective. When the ratio m_{jh} is multiplied by the total emissions of its industry r_{Eh}, we get emissions stemming from the production of that product (the index of r_{Eh} corresponds to the row index of m_{jh}).

The overall interpretation of the right side of this equation can be interpreted as follows. The element u_{Ej}, is the original amount of emissions emitted by each respective industry j. For each such industry j, the second term removes emissions emitted during production of its by-products of the first order. The third term adds emissions which arose during the production of industry's own product but were created in other industries. Through this process, the emissions of by-products are gradually removed and reassigned to the products, where they actually belong.

The final and key point of the Almon's procedure adds scaling factors, for the case where the second term is bigger than u_{Ej} to ensure that the negative values never appear. The scaling factor actually lowers the second term so it does not remove more emissions, stemming from by-products production, than is actually recorded for that industry in total. The fact that the scaling factor is uniform for one industry (a row of $\boldsymbol{M}$) guarantees the balance between emissions of by-products removed from the industry in the second term and added back to the industry (product), where these emissions actually belong, in the third term.

$$r_{Ej}^{(k+1)} = u_{Ej} - s_j^{(k)} \sum_{\substack{h=1 \\ h \neq j}}^{n} m_{jh} r_{Eh}^{(k)} + \sum_{\substack{h=1 \\ h \neq j}}^{n} s_h^{(k)} m_{hj} r_{Ej}^{(k)} . \tag{8}$$

The scaling factors are gained from comparing u_{Ej} and the second term:[7]

$$s_j^{(k)} = 1 \ if \ u_j \geq \sum\nolimits_{\substack{h=1 \\ h \neq j}}^{n} m_{jh} r_{Eh}^{(k)} , \tag{9}$$

or:

$$s_j^{(k)} = \frac{u_j}{\sum\nolimits_{\substack{h=1 \\ h \neq j}}^{n} m_{jh} r_{Eh}^{(k)}} . \tag{10}$$

1.3 Real world numerical example

We carried out two demonstrative examples. Both apply Almon's method in order to transform Czech NAMEA 2010 (CHMI, 2012)emissions from industries to products with utilization of the Czech Supply table 2010 (CZSO, 2012). The first example uses unaltered version of the NAMEA and Supply matrix

[7] Almon (2000) instructs to base the scaling factor on the second term, but then in the formula uses the third term instead. We believe, it is only a typographical error, since the difference is only in the order of j and h indexes at m. Eurostat (2008) uses the second term, as do we in this paper.

with 184 industries and products as a source data. The second example uses the very same source of data, but with manually disaggregated Electricity gaining 185 industries and products.

1.4 Almon's transformation tool

We programmed a tool which calculates the Almon's transformation automatically. The IOA practitioners can carry out this procedure without deeper knowledge of the underlying formulas and without any additional programming. Despite it is designed primarily for transformation of emissions, it can be used for transformation of use and supply tables into input-output tables as well, by substituting emissions with rows of use table. It is programmed in VBA with MS Excel user interface. The application is accompanied with an embedded guide and is designed to be easy to use. The application is freely available. The comments in the application code include explanation of the calculation and manipulation steps. For further details see the Appendix B.

1.5 Disaggregation

The disaggregation of supply and use table is described e.g. by Konijn and Steenge (1995). They suggest, ideally, to split up a product into as many products as there are ways to produce it and then to assign the products to newly emerged industries[8] with regard to their input structure. In case of emission disaggregation, the input structure defining the production technology is substituted with the output of the emissions. It is important to realize that the different input structure basically means different output of emissions as well.

An analogous recommendation to split an industry, when the industry is in fact a mixture of two very heterogeneous production processes which should be considered separately, is also stated by Vollebregt and van Dalen (2002). In the case of NAMEA emissions transformation, this should be considered especially for industries with diverse product technologies from an emission perspective and with high volumes of emissions, due to their importance. Diverse technologies and relative importance of an industry are general criteria for decision if the industry should be split, which are applicable for other environmental extensions such as energy or material flows. A typical example is the power generation industry, because it is often the most significant industry in terms of carbon dioxide (CO_2) and other emissions and also this industry can be obviously separated according to two radically different group of technologies. The first group generates electricity by the burning of fossil fuels, emitting vast amounts of CO_2 and other emissions. The second group emits no emissions during the electricity generation or includes activities which only transmit or redistribute the electricity with no CO_2 emissions as well. In addition, the overview of local kind-of-activity units[9] is usually available from the electrical regulatory authority. This makes the separation feasible using just publicly accessible data.

Within the supply table matrix $\boldsymbol{V^T}$ in our study, we disaggregate both industry and product of *electricity* to *electricity from fossil fuels* and *electricity others*. In general, we build up the disaggregation on "trick 5" from Vollebregt and van Dalen (2002). An industry is split into two new industries. Some outputs are assigned uniquely to the first new industry and some uniquely to the second. All other products are distributed over the two new industries in the same proportion as the uniquely assigned products. General assumptions for $\boldsymbol{V^T}$ disaggregation are as follows:

a) The newly formed industry *generation of electricity from fossil fuels* produces electricity in coal or gas power plants.[10] The second newly emerged industry *generation of electricity others* includes

[8] Newly created industries are called activities by Konijn and Steenge (1995).

[9] Local kind-of-activity units according to Eurostat nomenclature (Eurostat, 1998) or units of homogeneous production, according to SNA nomenclature (SNA, 1993). In this paper, local kind-of-activity units are individual power or heating plants.

[10] The gas power plants constitute less than 1% of the GWh produced in the Czech Republic in 2010.

generation of electricity from nuclear, water and renewable resources plus all other activities such as electricity distribution. In reality, one energy producing enterprise may own both types of power plants (fossil and non-fossil).

b) The original main product of *electricity generation*, the element on diagonal of supply table, is disaggregated between *electricity from fossil fuels* industry and *electricity others* industry in the ratio of 0.3:0.7. The share of turnover assigned to *electricity from fossil fuels* is calculated based on publicly traded electricity and its weighted average of prices for 2010 (PXE, 2008, 2009, 2010) and the net production of *fossil fuel electricity* for that year (ERU, 2011). Consequently, *electricity from fossil fuels* is not to be produced in *generation of electricity others* industry and vice versa, making the value of each other's by-product 0.
c) *Electricity* product disaggregation where electricity is in the role of by-product of other industries forms the row elements of supply table to the left and right from the main diagonal element. As long as the industry in question owns coal or gas power plant we assume that it is dominant and as a consequence all production is assigned to *electricity from fossil fuels*. The opposite situation is when the industry in question owns a hydro-power plant or distribution of the electricity dominates in this industry. The rest, where no dominant source of turnovers can be identified, is divided in the same ratio as the main product 0.3:0.7.
d) For disaggregation of *electric generation* industry by-products laying under and above the main diagonal element we use the general ratio 0.3:0.7, since we lack the necessary information on how to split the electricity non-related by-products here. The only exception is *heat and hot water generation*, which is divided between coal and nuclear electric power plants, and their respective industries, in the ratio of their heat production (IEA, 2011).

General assumptions for matrix $\boldsymbol{V^T}$ disaggregation are as follows:

e) All emissions of the *electricity* industry in the $\boldsymbol{U_E}$ matrix from NAMEA are assigned to the *electricity from fossil fuels*, thus no emissions of the *electricity* industry in the $\boldsymbol{U_E}$ matrix are assigned to the *electricity others*.

2 RESULTS

The main outcome of the calculation process is that emissions from the NAMEA 2010 for the Czech Republic (CHMI, 2012) are transformed to products in such a way that the reality is captured as reliably as possible. Using the supply table with 184 industries and products from 2010 for the Czech Republic (CZSO, 2012),[11] we applied the method described in the methodology carrying out a disaggregation of electricity followed by Almon's procedure. This disaggregation was performed for an unaltered source set of emissions data and supply matrix as well as for 185 industries and products where *electricity* is manually disaggregated. The full results are available in the Appendix C. The Almon's procedure transformation eliminates 49 negatives in CO_2 emissions from regular model A. For the others, of the total 11 emissions,[12] it ranges from 36 to 104 negatives. The difference is caused, from our perspective, by the breaking product technology assumption in a different manner for each emission type and especially zero reported emissions in case of HFC, PFC, SF_6 for industries with low volumes of these emissions. The volume of negative emissions of CO_2 from model A, which is eliminated with Almon's procedure, accounts for 16% of the total emission volume.

[11] The supply matrix is available only on demand from CZSO.

[12] The calculations were performed for greenhouse gasses (CO_2, CH_4, $_N2O$, HFCs – hydrofluorocarbons, PFCs – perfluorinated compounds, SF_6), pollutants causing acidification (SO_2, NH_3, NO_X), and precursors of photochemical smog formation (NMVOC, CO).

Since the overall result would be too large for an interpretation of disaggregation, we extracted only a part of supply table with 7 or 8 industries respectively, which have results affected with the disaggregation to the highest degree, and performed the very same transformation. The disparity between these resulting emissions in Table 2 and those in the original tables with 184 and 185 industries is small, making less than 10% for CO_2 for all industries (with exception of *water treatment*). We consider this sufficient for the illustrative purpose.

Table 1 The segment of the Czech supply table displaying 8 industries including the disaggregated electricity

Supply table (mil. CZK)	Lignite production	Cellulose and paper production	Basic chemical substances production	Iron and steal production	Electricity from fossil fuels generation	Electricity others generation	Heat generation	Water treatment
Lignite	17 902	0	0	0	0	0	0	0
Cellulose and paper	0	18 897	0	45	0	0	0	0
Basic chemical substances	48	40	72 412	246	0	77	184	0
Iron and steal	0	0	0	70 678	0	0	0	0
Electricity from fossil fuels	4 684	592	920	739	67 573	0	9 979	0
Electricity others	0	0	0	0	0	157 669	0	542
Heat	438	228	1 435	454	8 406	59	44 299	0
Water	17	1	21	4	0	550	492	18 516

Source: CZSO, own calculations

Table 1 shows the supply matrix used for the transformation. Table 2 displays the original emission values from NAMEA and the resulting values after Almon's transformation[13] with non-disaggregated (7 indust.) and disaggregated *electricity* for the purpose of Almon's procedure (8 indust.). The disaggregated variant is merged back after the Almon's procedure.

Table 2 Model A – CO_2 in the original segmentation into industries and in the segmentation into products after Almon's procedure of non-disaggregated (7 indust.) and disaggregated electricity (8 indust.)

Model A Industry/Product	NACE	Original CO_2 (kt)	7 indust. CO_2 (kt)	Change CO_2 (%)	8 indust. CO_2 (kt)	Change CO_2 (%)	Difference CO_2 (%)	Difference CO_2 (kt)
Lignite	052	3 716	2 721	–26.8%	667	–82.0%	–55.3%	–2 053.6
Cellulose and paper	171	1 472	1 302	–11.6%	1 059	–28.1%	–16.5%	–242.6
Basic chemical substances	201	5 530	5 020	–9.2%	4 745	–14.2%	–5.0%	–275.0
Iron and steal	241	12 733	12 455	–2.2%	12 171	–4.4%	–2.2%	–283.8
Electricity (total)	351	44 356	45 378	2.3%	53 720	21.1%	18.8%	8 342.0
Heat	353	13 572	14 600	7.6%	9 001	–33.7%	–41.3%	–5 599.2
Water treatment	360	172	75	–56.5%	177	2.8%	59.3%	102.0

Source: CHMI, own calculations

[13] Almon's transformations gives the same results as the model A here, since it is not necessary to downscale emissions in these two cases.

The disaggregation implies that the two different technologies are used for producing of *electricity from fossil fuels* and *electricity others*. The different technologies can be viewed as two different emission volumes to produce one unit of the output. On the one hand, the volume of emissions of the *electricity from fossil fuels* is bigger then of the original non-disaggregated *electricity*, and on the other, the *electricity others* has no emissions at all. In the model A, this becomes the decisive factor for industries with a substantial electricity by-product, because only in the disaggregated scenario does it show what "type" of the electricity the by-products represent.

The disaggregation of electricity has the following consequences here:

a) The industries which produce electricity in coal power plants as a by-product (coming under *electricity from fossil fuels*) with emissions emitting technologies have consequently more emissions reassigned to *electricity industry* in the disaggregated scenario. This is the case of *lignite mining, chemical industry, steel production* and *paper production*. The most significant emission transfer takes place for *lignite mining* in which the detailed information reveals, that one of the lignite mining companies is also in possession of an important coal power plant from which the majority *lignite mining industry* CO_2 emissions come from and thus the transfer of these emission to *electricity from fossil fuels product* is in order.

b) Vice versa, where the electricity is produced with emissionless technology, as is the case of *water treatment industry* which owns water power plants, the emissions are rather kept within that industry. This signifies that they stem from other source then electricity generation. Neither of these two differences were discerned before disaggregation.

c) The *heat industry* produces electricity and vice versa. Both of them are predominantly produced with emission emitting technologies and the emissions are reassigned both ways. What changes and becomes the decisive factor in the disaggregated scenario is again the volume of emissions of *electricity from fossil fuels* by-product, which is higher then the non-disaggregated *electricity*. As a consequence more emissions is reassigned from heat industry to *electricity from fossil fuels industry*.

d) *Electricity from fossil fuels* has more emissions after disaggregation, because electricity coming from fossil fuels from other industries prevails.

e) *Electricity others* has neither emissions before and nor after disaggregation by its definition.

We have shown that the results of Almon's procedure in Table 2, equal to model A in this case, performed the requested transfer of emissions properly in the case of *mining industry* subtracting 82.0% of CO_2 emissions, as they overwhelmingly come from coal power plants. Nevertheless such considerable emission transfer is done only in the instance of disaggregated *electricity* industry to *electricity from*

Table 3 Model B – CO_2 in the original segmentation into industries and in the segmentation into products after transformation with model B of non-disaggregated (7 indust.) and disaggregated electricity (8 indust.)

Model B Industry/Product	NACE	Original CO_2 (kt)	7 indust. CO_2 (kt)	Change CO_2 (%)	8 indust. CO_2 (kt)	Change CO_2 (%)	Difference CO_2 (%)	Difference CO_2 (kt)
Lignite	052	3 716	2 881	–22.5%	2 880.9	–22.5%	0.0%	0
Cellulose and paper	171	1 472	1 416	–3.8%	1 416.3	–3.8%	0.0%	0
Basic chemical substances	201	5 530	5 454	–1.4%	5 468.5	–1.1%	–0.3%	–15
Iron and steal	241	12 733	12 470	–2.1%	12 470.4	–2.1%	0.0%	0
Electricity (total)	351	44 356	42 914	–3.3%	46 100.3	3.9%	–7.2%	–3 186
Heat	353	13 572	16 122	18.8%	12 816.7	–5.6%	24.4%	3 305
Water treatment	360	172	294	70.7%	397.8	131.3%	–60.5%	–104

Source: CHMI, own calculations

fossil fuels and *electricity others*. When the average emissions of non-disaggregated *electricity generation* industry are used instead, the effect of transformation is considerably lower and only 26.8% of the original CO_2 emissions is transformed.

Table 3 depicts the results of model B transformation for the same source data. When focusing on emissions of the *lignite mining* industry, model B subtracts only 22.5% of the original CO_2 emissions as it considers the supply of the *lignite* and *electricity from fossil fuels* has the same emission intensity.

Overall, we see that the model A with disaggregated emissions gives the more realistic picture compared to the non-disaggregated model A and both variants of model B for the *lignite mining* industry. We cannot verify if the same is true for other emissions since the production data of individual enterprises is under non-disclosure agreement. Such verification would be interesting especially for *electricity* and *heat* since these two industries are dominant sources of emissions and, at the same time, their production is closely interconnected.

CONCLUSION

In this paper, we present a suitable technique for transformation of emissions from industries to products, which might be an essential step in the process of gaining product's embodied emissions. The first, optional but beneficial, step of this technique is to disaggregate one or more crucial industries and products. The crucial industries are those with significant portion of emissions and diverse technology of production. The second step is to transform emissions with Almon's procedure which modifies product technology assumption (model A) in such way that it eliminates its resulting negatives, in case they appear. The third, also optional, phase is to merge back the resulting disaggregated emissions of products.

Apart from description of these steps, we explain when and why product technology assumption (model A) and consequently also its modified version, the Almon's procedure, should be preferred over industry technology assumption (model B) in the process of emissions transformation. We supplement this explanation with numerical illustrations showing the difference between model A and B.

To see practical consequences of the disaggregation, we utilize a section of the non-disaggregated and disaggregated Czech NAMEA and supply table from 2010 to demonstrate the effect of disaggregation on the transformation. The actual full process was than performed on data including 11 types of emissions in 184 industries for the Czech Republic for the year 2010.

Since Almon's iterative procedure is labour demanding from computational perspective, we programmed a VBA script embedded in Excel file to calculate this procedure automatically. This tool is designed with intuitive user interface so everyone can use it without knowledge of VBA and is freely available, see the Appendix B.

Although, to transform emissions by following the advices in this paper should ease the emission transformation work, one must be aware of the methods' conditions and limitations. The necessary condition is the consistency between the emission database and supply table in order model A or Almon's procedure perform correctly in transforming the emissions. Second, if Almon's algorithm turns out not to converge, we have to make sure that half of the production of each product is in the supply table in its main industry (Almon, 2000). The negatives in resulting products emissions are a sign of an error in source data and it is always better to correct the source values than to rectify the resulting negatives automatically with Almon's procedure. It is actually recommended by Almon to remove large negatives manually. Nevertheless, detailed background information for that procedure must be available. It has been properly pointed out (ten Raa, Rueda-Cantuche, 2013) that resulting values gained trough Almon's procedure do not have to necessarily converge to the correct values, thus Almon's procedure does not mean automatic virtual fix of errors of source values.

Despite all mentioned shortcomings, we would recommend to use Almon's procedure for the emission transformation, since we see it still as sufficient and easily applicable option.

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References

ALMON, C. Product-to-Product Tables via Product-Technology with No Negative Flows [online]. *Econ. Syst. Res.*, 2000, 12(1), pp. 27–43. <doi:10.1080/095353100111263>.

BAIOCCHI, G., MINX, J., HUBACEK, K. The Impact of Social Factors and Consumer Behavior on Carbon Dioxide Emissions in the United Kingdom [online]. *J. Ind. Ecol.*, 2010, 14(1), pp. 50–72. <doi:10.1111/j.1530-9290.2009.00216.x>.

CZSO. *Supply and Use Tables 2010.* Czech Statistical Office, Unpublished Data, 2012.

DE MESNARD, L. Negatives in Symmetric Input-Output Tables: The Impossible Quest for the Holy Grail [online]. *Ann. Reg. Sci.*, 2009, 46(2), pp. 427–454. <doi:10.1007/s00168-009-0332-5>.

ERU. *Electric Power Transmission Annual Report 2010, Energy Regulatory Office* [online]. 2011. <https://www.eru.cz/elektrina/statistika-a-sledovani-kvality/rocni-zpravy-o-provozu>.

EUROSTAT. *Eurostat Manual of Supply, Use and Input-Output Tables* [online]. 2008. <doi:http://ec.europa.eu/eurostat>.

EUROSTAT. *Review of National Supply, Use and Input-Output Tables Compilation* [online]. 2015. <http://ec.europa.eu/eurostat/statistics-explained/index.php/Review_of_national_supply,_use_and_input-output_tables_compilation>.

GOLLEY, J. AND MENG, X. Income Inequality and Carbon Dioxide Emissions: The Case of Chinese Urban Households [online]. *Energy Econ.*, Elsevier B.V., 2012, 34(6), pp. 1864–1872. <doi:10.1016/j.eneco.2012.07.025>.

CHMI. *Air Emission Accounts 2010 Questionare 2012.* Czech Hydrometerological Institute, 2012.

IEA. *Czech Republic: Electricity and Heat* [online]. 2011. <http://www.iea.org/statistics/statisticssearch/report/?year=2010&country=CZECH&product=ElectricityandHeat>.

KONIJN, P. J. A. AND STEENGE, A. E. Compilation of Input-Output Data from the National Accounts [online]. *Econ. Syst. Res.*, 1995, 7(1), pp. 31–45. <doi:10.1080/09535319500000009>.

PXE. *Monthly Statistics Power Exchange Central Europe* [online]. 2008. <https://www.pxe.cz/pxe_downloads/Statistics/Month/2008/>.

PXE. *Monthly Statistics Power Exchange Central Europe* [online]. 2009. <https://www.pxe.cz/pxe_downloads/Statistics/Month/2009/>.

PXE. *Monthly Statistics Power Exchange Central Europe* [online]. 2010. <https://www.pxe.cz/pxe_downloads/Statistics/Month/2010/>.

RAA, T. *The Economics of Input-Output Analysis* [online]. Cambridge University Press, 2005. <https://books.google.cz/books?id=yKaOKKr-YQMC>.

ROCA, J. AND SERRANO, M. Income Growth and Atmospheric Pollution in Spain: An Input–output Approach [online]. *Ecol. Econ.*, 2007, 63(1), pp. 230–242. <doi:10.1016/j.ecolecon.2006.11.012>.

SIXTA, J. Development of Input-Output Tables in the Czech [online]. *Statistika: Statistics and Economy Journal*, 2013(2), pp. 4–14. <http://www.czso.cz/csu/2013edicniplan.nsf/engt/9600346C97/$File/180213q2004.pdf.>.

TEN RAA, T. AND RUEDA-CANTUCHE, J. M. The Problem of Negatives Generated by the Commodity Technology Model in Input-Output Analysis: A Review of the Solutions [online]. *J. Econ. Struct.*, 2013, 2(1), pp. 1–14. <doi:10.1186/2193-2409-2-5>.

UN. *System of National Accounts* [online]. 1993. <https://unstats.un.org/unsd/nationalaccount/docs/1993sna.pdf>.

VOLLEBREGT, M. AND VAN DALEN, J. *Deriving Homogeneous Input-Output Tables from Supply and Use Tables* [online]. Montreal, Canada, Paper presented at the 14th International Conference on Input-Output Techniques, 2002. <https://www.iioa.org/conferences/14th/files/Vollebregt.doc>.

WEBER, C. L. AND MATTHEWS, H. S. Quantifying the Global and Distributional Aspects of American Household Carbon Footprint [online]. *Ecol. Econ.,* 2008, 66(2–3), pp. 379–391. <doi:10.1016/j.ecolecon.2007.09.021>.

WIEDMANN, T., MINX, J., BARRETT, J., WACKERNAGEL, M. Allocating Ecological Footprints to Final Consumption Categories with Input–output Analysis [online]. *Ecol. Econ.*, 2005(56), pp. 28–48. <doi:10.1016/j.ecolecon.2005.05.012>.

APPENDIX A

COMPARISON OF MODEL A AND B

In the model B, the resulting emissions (r_{Eij}) of a particular product within one industry are proportional to the share of the product's turnover (v_{ij}) related to the total turnover of this industry (g_i). The ratio of shares is actually based on supply (turnover) of different products within one particular industry – a row of the make table.[14] This means that this model does not consider different technologies within one industry. This reflects the model B definition that "Each industry has its own specific way of production, irrespective of its product mix". As a consequence, this model unrealistically expects that all products manufactured within one industry are produced with the same emission intensity per monetary unit.

In the model A, the source emissions of a particular product within one industry (r_{Eij}) is proportional to the share of product's turnover (v_{ij}) related to the resulting product's total across all industries (q_j). The ratio of shares is based on turnovers of the same product within different industries – a column of the make table. Because the shares are, in this case, related to the resulting products, the inverse transformation must be carried out for getting from industries to products. If the theoretical assumption of model A that "Each product is produced in its own specific way, irrespective of the industry where it is produced" is valid, than the volumes of a product as well as its associated emissions are proportional to the product shares and each product has its own emission intensity, which is the same across all industries. For that reason, model A should be used for the emissions calculations. The transformation equations and its transformation matrices are in the Table A1.

Table A1 Transformation equations for model A and model B

	Model A	Model B
Transformation of emissions from industries to products	$\boldsymbol{R_E} = \boldsymbol{U_E}\,\boldsymbol{T_A}^{-1}$	$\boldsymbol{R_E} = \boldsymbol{U_E}\,\boldsymbol{T_B}$
Transformation matrix	$\boldsymbol{T_A} = \boldsymbol{V}\,(\mathrm{diag}(\boldsymbol{q}))^{-1}$	$\boldsymbol{T_B} = (\mathrm{diag}(\boldsymbol{g}))^{-1}\,\boldsymbol{V} = \boldsymbol{V^T}\,(\mathrm{diag}(\boldsymbol{g}))^{-1}$
Inverse transformation	$\boldsymbol{T_A}^{-1} = \boldsymbol{V}^{-1}\,\mathrm{diag}(\boldsymbol{q})$	$\boldsymbol{T_B}^{-1} = (\boldsymbol{V^T})^{-1}\,\mathrm{diag}(\boldsymbol{g})$

Source: Eurostat (2008)

Alternatively, Almon uses the following notation of transformation for model A:

$$\boldsymbol{R_E} = \boldsymbol{U_E}\,(\boldsymbol{M^T})^{-1},$$

and

$$\boldsymbol{M} = \boldsymbol{V}(\mathrm{diag}(\boldsymbol{q}))^{-1}.$$

Legend for input-output analysis

The following legend defines the variables which are used in the transformation:

$\boldsymbol{U}$ use table intermediates,
$\boldsymbol{U_E}$ emissions of industries,
u_{Eij} one type of emission of one industry,

[14] Since the make matrix of make table is equal to transposed supply matrix of supply table, the transposed supply matrix is interchangeable with make matrix. Consequently, rows of make table are columns of the supply table.

$\boldsymbol{R}$ resulting Almon's recipe matrix,[15]
$\boldsymbol{R_E}$ resulting matrix of emissions of products,
r_{Eij} emissions of one product within one industry,
$\boldsymbol{V^T}$ supply table intermediates,
$\boldsymbol{V}$ make table intermediates,
v_{ij} element of make table intermediates,
$\boldsymbol{g}$ sums of rows of the make table,
g_i sum of a row of the make table,
$\boldsymbol{q}$ sums of columns of the make table,
q_j sum of a column of the make table,
$\boldsymbol{T_A}$ transformation matrix of the model A, equal to $\boldsymbol{M}$,[16]
$\boldsymbol{M}$ $\boldsymbol{M}$ matrix of Almon's procedure, equal to $\boldsymbol{T_A}$,[17] it has industries in rows and products in columns,
$\boldsymbol{T_B}$ transformation matrix of the model B.[18]

ILLUSTRATIVE NUMERICAL EXAMPLE OF MODEL A AND B

The following Tables A2a–A2f illustrates the difference between model A and B. We present the scenario where we suppose that all emissions are coming from electricity production of which part is produced in the power plant recorded in the electricity generation industry. Model A correctly transforms all emission to the electricity, whereas model B only a certain part, as it assumes that both production processes in electricity generation industry have the same emission intensity.

Table A2a Source emissions of industries – $\boldsymbol{U_E}$

Industry	Coal mining	Electricity
CO_2	10 000	generation

Table A2b Make table – $\boldsymbol{V}$

Industry \ Product	Coal	Electricity
Coal mining	12 000	20 000
Electricity generation	0	80 000

Table A2c Transformation matrix – $\boldsymbol{T_A}$

Industry \ Product	Coal	Electricity
Coal mining	1	0.2
Electricity generation	0	0.8

Table A2d Transformation matrix – $\boldsymbol{T_B}$

Industry \ Product	Coal	Electricity
Coal mining	0.375	0.625
Electricity generation	0	1

Table A2e Resulting emissions – **Model A**

Product	Coal	Electricity
CO_2	0	50 000

Table A2f Resulting emissions – **Model B**

Product	Coal	Electricity
CO_2	3 750	46 250

Source: Own construction (demonstrative examples)

15 $\boldsymbol{R}$ matrix is equal to the symmetrical input-output matrix of intermediates S of model A in Eurostat (2008).
16 $\boldsymbol{T_A}$ matrix is equal to the transposed inverse of the transformation matrix $(\boldsymbol{T^T})^{-1}$ of the Model A in Eurostat (2008).
17 $\boldsymbol{M}$ matrix is also equal to the matrix $\boldsymbol{D}$ – Market shares (contribution of each industry to the output of a product) in Eurostat (2008).
18 $\boldsymbol{T_B}$ matrix is equal to the transformation matrix $\boldsymbol{T}$ of the Model B in Eurostat (2008).

ILLUSTRATIVE NUMERICAL EXAMPLE OF MODEL A AND ALMON'S PROCEDURE

Unfortunately, the resulting emissions of products from model A can suffer from the same shortcoming as the symmetrical-input output table from this model, the negatives in the resulting matrix, as shown below in the Tables A3a–A3e.

Table A3a Emissions in industries – $\boldsymbol{U_E}$

Industry	Coal mining	Electricity
CO_2	4 000	40 000

Table A3b Make table – $\boldsymbol{V}$

Industry \ Product	Coal	Electricity
Coal mining	12 000	20 000
Electricity generation	0	80 000

Table A3c $\boldsymbol{M}$ matrix

Industry \ Product	Coal	Electricity
Coal mining	1	0.2
Electricity generation	0	0.8

Table A3d Inverse transposed $\boldsymbol{M}$ matrix

Industry \ Product	Coal	Electricity
Coal mining	1	0
Electricity generation	–0.25	1.25

Table A3e Resulting emissions – **Model A**

Product	Coal mining	Electricity production
CO_2	–6 000	50 000

Source: Own construction (demonstrative examples)

This is the point where we can make use of Almon's procedure in the same way as with the creation of the symmetrical input-output table. For a trivial illustrative example of Almon's procedure we use the same source values as in the example of the model A transformation with negative values. We proceed as follows:

$$r_{E1}{}^{(1)} = u_{E1} - s_1{}^{(0)}\, m_{12}\, r_{E2}{}^{(0)} + s_2{}^{(0)}\, m_{21}\, r_{E1}{}^{(0)}, \tag{A1}$$

$$s_1^{(0)} = \frac{u_{E1}}{m_{12}\, r_{E2}^{(0)}},$$

$$s_1^{(0)} = \frac{4\,000}{0.2 \times 40\,000} = 0.5,$$

$$s_2{}^{(0)} = 1,$$

$$r_{E1}{}^{(1)} = 4\,000 - 0.5 \times 0.2 \times 40\,000 + 1 \times 0 \times 4\,000 = 0,$$

$$r_{E2}{}^{(1)} = u_{E2} - s_2{}^{(0)}\, m_{21}\, r_{E1}{}^{(0)} + s_1{}^{(0)}\, m_{12}\, r_{E2}{}^{(0)}, \tag{A2}$$

$$r_{E2}{}^{(1)} = 40\,000 - 1 \times 0 \times 4\,000 + 0.5 \times 0.2 \times 40\,000 = 44\,000.$$

Table A4 Resulting emissions of products gained from Almon's procedure

Product	Coal mining	Electricity
CO_2	0	44 000

Source: Own construction (demonstrative examples)

It is not necessary to calculate approximations of higher orders here, since it would make no difference to the result in this example. This trivial example in Formulas (A1) and (A2) shows how Almon's procedure scales down transferred emissions to prevent the product emissions r_{Ej} from becoming a negative number, see the Table A4.

Legend for Almon's procedure

$\boldsymbol{u_E}$ vector of emissions of industries for one type of emissions,
u_E element of $\boldsymbol{u_E}$,
$\boldsymbol{r_E}$ resulting vector of emissions of products for one type of emissions,
r_{Ei} element of $\boldsymbol{r_E}$,
m_{ij} element of $\boldsymbol{M}$ matrix,
s_i scaling factor.

APPENDIX B

The tool for Almon's transformation in Excel and VBA is available at the webpage of *Statistika: Statistics and Economy Journal*, see the online version of No. 2/2017 (Excel file) at: <http://www.czso.cz/statistika_journal>.

APPENDIX C

Original and resulting values for 184 and 185 industries can be found online at the webpage of *Statistika: Statistics and Economy Journal*, see the online version of No. 2/2017 (Excel file) at: <http://www.czso.cz/statistika_journal>.

Investigation of the Relationship between Renewable Energy, Tourism Receipts and Economic Growth in Europe

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Abstract

By using the Pedroni and Kao panel co-integration techniques, and FMOLS, DOLS and OLS methods, this study explores the long-run relationship among tourism receipts, renewable energy consumption and economic growth for the European Union countries. The long-run estimators report that "renewable energy increases economic growth", "tourism receipts increase economic growth", "capital increases economic growth" and "labor force increases economic growth". Further results and some policy implications are discussed in this empirical study.

Keywords	***JEL code***
Tourism receipts, renewable energy, economic growth, European Union, Pedroni panel Co-integration tests	*C32, C33, L83, O44, Q20, Q28, Z32*

INTRODUCTION

Tourism represents the major socio-economic activity in the European Union (EU) with a wide-ranging impact on the economic growth, trade, investments, employment and social development. Tourism can be a powerful tool in fighting the economic decline and unemployment, especially in the Member States in the Southern Europe, where tourism represents a large section of the domestic economy. During the financial crisis, tourism has proven to be a resilient element in the European economy. Taking into account the sectors that are connected to tourism, it generates over 10% of the European gross domestic product (GDP) and employs 10% of the European citizens (Slager, 2013; European Commission, 2013a). Europe has a large variety of top cities and popular travel destinations, with the highest density and diversity of tourist attractions. Europe is a high-quality tourist destination and offers a wide variety

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of products. Europe differs from other tourist destinations, because it aims a sustainable and high-quality tourism, plays to its comparative strengths, in particular the diversity of its countryside and the extraordinary cultural wealth (Slager, 2013; European Commission, 2013b).

Tourism represents one of the fastest growing industries in the world. The travel costs have decreased and the information on destinations are available almost all over the world. All of these represent elements that make the tourism sector a significant source of revenues and an engine of economic growth for the local economies (Işık et al., 2017; Işık, 2015; Paci and Marrocu, 2012; Akan et al., 2008).

Europe is considered as a prominent tourist destination, holding approximately a 51% share of the global tourist arrivals in 2014 and this share was increasing (UNWTO, 2015). For this reason, the European Union (EU) has placed much emphasis on the tourism sector as an engine of the economic prosperity for its member countries (Lee and Brahmasrene, 2013). In a global scale, the total contribution of the tourism industry accounted for almost 10% of the world GDP and world employment in 2014 and these numbers are expected to increase in the long-run (WTTC, 2015). The tourism development has been established as a popular strategy for the economic growth not only in Europe but worldwide (Matarrita-Cascante, 2010; Andereck et al., 2005).

The total contribution of Travel & Tourism to employment grew by 2.3% in 2014, while its contribution to GDP grew by 3.6%, faster than wider economy in 2014 (especially for Greece and Turkey in Europe) (WTTC, 2015). Tourism lowered unemployment and increased the household income and government income (Mello-Sampayo and Sousa-Valea, 2012). Thus, tourism has determined the economic growth in many countries, especially in small countries where the tourism represents the main sector bringing high revenues, such as in Malta, but also in larger countries (Spain).

Europe remains the top destination region around the world due to its rich cultural heritage, high quality of the tourism service infrastructure, hygiene conditions, and high level of international openness and integration. Spain and Italy lead this ranking, but Spain displays a more pro-active strategy in the tourism area, while Italian strategy is more passive. The business climate is also important for tourism. In the Northern European countries, it is lean, while in South-Eastern Europe it is less sound (WEF, 2015).

In 2014, Spain was the first tourism destination in the EU for non-residents, with 260 million nights spent, or 21.5% of the EU-28 total. Across the EU, the top four most popular destinations for non-residents were Spain, Italy (187 million nights), France (131 million nights) and the United Kingdom (105 million nights), which together accounted for more than half (56.6%) of the total nights spent by non-residents in the EU-28 (Eurostat, 2015).

The economic importance of international tourism can be stressed if we consider the share of international travel receipts of GDP. In 2014, this share was highest in Croatia (17.2%), Malta (14.4%) and Cyprus (12.3%), confirming the importance of tourism to these small countries. The contribution of the tourism sector to GDP increased if we compare with the data available at the end of 2010: the contribution of tourism to the GDP growth was highest in Cyprus (10,4%), Malta (7,9%), Spain (6,3%), Greece (6,5%), Portugal (5,9%), Austria (5,5%) and Croatia (5,1%) (Eurostat, 2015).

In absolute terms, the highest international travel receipts in 2014 were recorded in Spain (EUR 49 billion) followed by France (EUR 43 billion), United Kingdom (EUR 35 billion), Italy (EUR 34 billion) and Germany (EUR 32 billion). In Europe, Turkey displayed travel receipts in 2014 of 22 billion EUR, Austria reached 15 billion EUR, Greece 13 billion EUR, Netherlands 11 billion EUR, Belgium and Portugal each with 10 billion EUR. Spain was the EU Member State with the highest level of net receipts from travel in 2014 (EUR 35.4 billion), while Germany recorded the biggest deficit (EUR –37.6 billion) (Eurostat, 2015).

Spain ranks first in the Top Travel and Tourism Competitiveness Index 2015. It is the third most visited country in the world in 2015, with approximately 60.6 million arrivals in 2015. It displays many beautiful heritage sites and it has large cultural resources (WEF, 2015). France ranks 2nd overall in the Top Travel and Tourism Competitiveness Index 2015 and it displays over 84 million arrivals, ranking first in Europe in 2015. France displays large cultural and natural resources. Even during the crisis, the hospitality sector played an important role in job creation and supported the economic recovery. During the crisis, France reduced VAT tax for accommodation and food served in the hotels and restaurants and thus supported the hospitality sectors. Switzerland has world-class tourist services infrastructure and an extremely conducive business environment. Switzerland has some beautiful mountain landscapes. Italy is famous for its towns, monuments and its numerous World Heritage sites. The Russian Federation ranks 45th overall. Although in the Russian Federation the tourism is not a national priority, its natural and cultural heritage shows how the tourism industry could potentially play a bigger role in the country's economy (WEF, 2015). Russian Federation together with Poland have currently a market share of 2.4% in Eastern Europe regarding the tourism receipts. They are the only Eastern competitors among the European countries (if we consider tourism receipts in million Euro) (WEF, 2015).

The continued success of the hospitality sector in Austria is in part due to the stability of the tax climate with a reduced VAT tax for its major hospitality services. A reduction of VAT for the hospitality sector could have been seen in all major tourism destination countries all over the Europe during the crisis period for supporting the hospitality sector (Turkey, Spain, France, Germany, except Greece and Portugal where the tax on hospitality services have increased after 2009 and Italy where the overall levels of taxation in the hospitality sector have increased after 2011, although the VAT is reduced for almost all of the hospitality services). The Netherlands faced the same situation regarding taxation in the hospitality sector as in Italy, while in Eastern European countries the overall levels of tax have increased during the crisis. UK is among the few European countries that doesn't apply a reduced VAT for the hospitality services (WEF, 2015).

This empirical research contributes to the economic literature in several aspects. First, it is the first study that applies and the ordinary least squares (OLS) with fixed effects, the fully modified OLS (FMOLS) and the dynamic OLS (DOLS) along with co-integration tests to analyze the impact of renewable energy and tourism on economic growth in the European Union countries. The tourism and renewable energy sectors play an important role for the economic developments, especially in the Southern Europe. The Southern European countries are in the top 10 of the most visited countries around the world. Moreover, this study uses renewable energy and its relationship with the tourism receipts and economic growth.

The aim of this empirical research is to analyze the relationship between international tourism receipts, renewable energy consumption, capital, labor and economic growth. To achieve this aim, we use the Pedroni and the Kao panel co-integration tests to see if there is a long-term relationship between the analyzed variables and the FMOLS, the DOLS and the OLS estimation methods to mainly analyze the impact of the tourism receipts and renewable energy on economic growth in the European Union countries. Section 2 presents some findings of the economic literature on the topic of our study. Section 3 presents the methodology and data we have used to study the relationship between the tourism receipts, renewable energy and economic growth and discusses the results. Section 4 concludes the paper and presents some policy recommendations.

1 LITERATURE REVIEW

A number of studies have examined the long-run the relationship between tourism or renewable energy consumption measures and economic performance within a country-specific context. Determining the long-run relationship between tourism development, economic growth, and renewable energy is of paramount importance for designing a sustainable growth agenda regarding tourism development and environmental issues. However, it is not clear whether renewable energy consumption induces economic growth and tourism development (or vice versa) because there is a few research that tests the long-run relationship between these factors.

The rapid growth in both international and domestic travel, the trends to travel farther and over shorter periods of time, and the preference given to energy-intensive transportation are increasing the non-renewable energy dependency of tourism, resulting in the sector's contribution of 5% to global GHG emissions. The greening of tourism is expected to reinforce the employment potential of the sector with increased local hiring and sourcing and significant opportunities in the tourism oriented toward the natural environment (Lawrence Pratt et al., 2011).

The tourism sector's growing consumption of energy, especially in the travel and accommodation, and its dependence on fossil fuels has important implications for the global GHG emissions and climate change as well as for the future business growth. The sustainability and competitiveness of tourism depends in part on the energy efficiency (reductions in the overall energy use) and a more intensive use of the renewable sources (Dogan et al., 2015; Işık, 2013; Işık, 2010).

Growth, conservation, feedback and neutrality hypotheses are committed to investigate the relationship between economic growth and energy consumption or tourism. However, the literature reports mixed results supporting unidirectional relationship from tourism or energy consumption to economic growth (growth hypothesis) and from economic growth to tourism or energy consumption (conservation hypothesis), bidirectional relationship between economic growth and tourism or energy consumption (feedback hypothesis), and no relationship (neutrality hypothesis). So the relationship between the tourism or energy consumption and economic growth differs in time and across countries or regions around the world. Table 1 presents a comprehensive review of studies found in both energy economics and tourism literature.

Table 1 Long-term Energy Growth – Tourism Relationship

From Energy Consumption or Tourist to Growth

Author	Time	Destination	Methodology	Variables	Results
Dogan (2015)	1990–2012	Turkey	ARDL	RE&Y	Neutrality hypothesis between RELC and GR, and between NRELC and GR in the short run and from RELC, NRELC, *K* and *L* to GR as well as from GR, RELC, *K* and *L* to NRELC in the long run, growth hypothesis between RELC and GR, and feedback hypothesis between NRELC and GR in the long run.
Işık and Shahbaz (2015)	1980–2010	OECD	Pedroni, Kao and Johansen Fisher Cointegration, Kao and Fixed Effect	RE&Y	RE → Y
Rezitis and Ahammad (2015)	1990–2012	South and Southeast Asian Countries	Dynamic Panel Data	RE&Y	RE → Y
Leon et al. (2014)	1998–2006	14 Developed, 31 less developed	The Generalized Method of Moments, GLS	Tourism, GDP, CO2, Population, Energy	Tourism has positive effect on 14 developed and 31 less developed countries
Lee and Brahmasrene (2013)	1988–2009	European Union Countries	Panel Cointegration & Fixed-Effects Models	Tourism, GDP, CO2	T → Y Y → CO2
Adhikari and Chen (2012)	1990–2009	80 Developing Countries	Panel Unit Root Test, DOLS	RE&Y	RE → Y
Tiwari (2011)	1965–2009	Europe and Eurasian Countries	PVAR approach	RE&Y	RE → Y
Ozturk et al. (2010)	1971–2005	51 Low and middle income countries	Panel Vector Error Correction Model	Energy & GDP	Y → RE (low income countries) RE ↔ Y (middle income countries)

Table 1 Long-term Energy Growth – Tourism Relationship continuation

Author	Time	Destination	Methodology	Variables	Results
From Economic Growth to Energy or Tourism					
Azam et al. (2015b)	1980–2012	Indonesia, Malaysia, Philippines, Singapore and Thailand	Johansen–Juselius Co-integration, Granger Causality	Energy & GDP	Y → RE REC (Malaysia) RE — Y (Indonesia, Philippines, Singapore and Thailand)
Menegaki (2011)	1997–2007	27 European countries	Random effect model	RE&Y	∅
Ozturk et al. (2010)	1971–2005	51 Low and middle income countries	Panel Vector Error Correction Model	Energy & GDP	Y → RE (low income countries) RE ↔ Y (middle income countries)
No Relationship between Energy Consumption and Economic Growth					
Tugcu et al. (2012)	1980–2009	G7 countries	Hatemi-J causality tests	RE&Y	∅ for France, Italy, Canada and USA Y → RE for Germany Y ↔ RE for England and Japan
Menegaki (2011)	1997–2007	27 European countries	Random effect model	RE&Y	∅
Bidirectional Relationship between Energy Consumption and Economic Growth					
Shahbaz et al. (2015)	1972 Q1–2011 Q4	Pakistan	ARDL model Rolling window approach (RWA) Granger causality test	RE&Y	Y ↔ RE
Tang and Abosedra (2014)	2001–2009	MENA	Panel Data/General Ised Method of Moment	Energy, GDP, Tourism, Political Stability, Capital	Y ↔ RE
Al Mulali et al. (2014)	1985–2012	Middle East	Pedroni cointegration/ Panel Granger-VECM	Tourism, GDP, Real Exchange Rate, Total Trade	Y ↔ T
Bildirici (2013)	1980–2009	10 Latin American emerging and developing countries	ARDL approach ECM Model Granger causality test	RE&Y Biomass energy	Y ↔ RE
Tiwari et al. (2013)	1995–2005	OECD	Panel VAR/IRF/VD ARDL	Tourism, Energy, CO2	T ↔ RE
Kadir and Karim (2012)	1998–2005	ASEAN	Pedroni cointegration/ Panel Granger-VECM	Tourism, GDP	Y ↔ T

Notes: GDP = Y, E = Energy, T = Tourism, FDI = Foreign Direct Investment, C = Capital, CO2 = Carbon Dioxide Emission, GC = Granger Causality, JJ = Johansen–Juselius, VEC = Vector Error Correction Model, VAR = Vector Autoregressive Model, ECM = Error Correction Model, ARDL = Autoregressive-Distributed Lag, DOLS = Panel Dynamic Ordinary Least Squares and →, ←, ∅, ↔ shows unidirectional relationship, bidirectional relationship, and no relationship, respectively.
Source: Authors' construction

As shown in Table 1, there is no consensus on both theoretical and empirical grounds on whether the tourism leads to growth, or growth leads to the tourism or bidirectional relationship between the variables and no relationship. This could be due to the fact that changes in the economic and/or the tourism conditions can alter the nature and magnitude of the long-run relationship between these two series over time, among others.

2 DATA, METHODOLOGY AND EMPIRICAL RESULTS

2.1 Data

Following researches Tang and Abosedra (2014), Leon et al. (2014), Dogan et al. (2015) and Tang et al. (2016) we have concentrated on the relationship of tourism – renewable energy – growth relationship. According to the World Development Indicators (WDI, 2016), 28 European countries are Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxemburg, Malta, Netherland, Poland, Portugal, Romania, Slovak Republic, Slovenia, Spain, Sweden and the UK. Regarding to data description, economic growth is measured by real GDP (in constant 2005 US$); renewable energy consumption (REN) is the share of renewable energy in the final energy consumption; tourism receipts (RCPT) are expenditures by international inbound visitors, including payments to national carriers for international transport (in constant 2005 US$); capital (K) is gross fixed capital formation (in constant 2005 US$) and labor (L) is number of labor force. The model also includes the capital use and labor force, because it derives from a Cobb-Douglas function which determines the GDP growth as consistent with Paci and Marrocu (2012). The annual data for the analyzed variables are from 1995–2012 and provided by the WDI (2016). It is important that we use the available longest data.

2.2 Methodology and empirical results

As it is the main research proposal of this research to investigate the long-run relationship among economic growth, renewable energy consumption, tourism receipts, capital and labor, we should find appropriate and reliable estimation techniques. The standard OLS can be used to compare the outcomes with the FMOLS and the DOLS. The FMOLS, a non-parametric method, investigates adjustments for serial correlation whereas the DOLS, a parametric method, calculates lagged first-differenced terms. The lags, lead and contemporaneous values of the regressors are augmented when the DOLS is used (Pedroni, 1999).

Table 2 Panel Unit Root Tests Results

	Levels				
	GDP	REN	RCPT	K	L
LLC	4.05	–0.50	–2.47*	2.03	0.04
Breitung	8.99	4.13	–0.46	7.99	3.01
IPS	5.44	1.50	–0.66	2.83	1.21
Fisher-ADF	34.46	49.59	62.59	52.53	44.83
Fisher-PP	10.25	55.82	65.40	25.92	47.49
	First-differences				
	GDP	REN	RCPT	K	L
LLC	–11.54*	–14.56*	–7.81*	–13.15*	–11.95*
Breitung	–6.36*	–6.31*	–8.30*	–6.25*	–6.86*
IPS	–6.46*	–12.44*	–8.58*	–8.59*	–8.74*
Fisher-ADF	133.26*	230.41*	164.91*	158.76*	173.09*
Fisher-PP	192.04*	300.39*	251.03*	179.15*	210.81*

Note: * denotes the statistical significance at 1% level.
Source: Authors' own estimations

Table 2 shows results from the Levin-Lin-Chu (LLC) panel unit root test (Levin et al., 2002), the Breitung panel unit root test (Breitung, 1999), the Im-Pesaran-Shin (IPS) panel unit root test (Im et al., 2003), the Augmented Dickey-Fuller (ADF) and the Phillips-Perron (PP) panel unit root tests (Maddala and Wu, 1999). According to the reported results, the analyzed variables are not stationary at levels but become stationary at first-differences at 1% level of significance. Thus, we need at least one co-integration test to see whether there is a long-run relationship among them. Otherwise, estimated coefficients will be without economic meaning.

Table 3 Pedroni panel and Kao panel Co-integration Test Results

a) Pedroni panel test

Common AR coefs. (within-dimension)				
	Statistic	Prob.	Weighted Statistic	Prob.
Panel v-Statistic	11.62*	0.00	7.85*	0.00
Panel rho-Statistic	2.65	0.99	2.98	0.99
Panel PP-Statistic	–5.11*	0.00	–5.86*	0.00
Panel ADF-Statistic	–5.28*	0.00	–5.43*	0.00

Individual AR coefs. (between-dimension)		
	Statistic	Prob.
Group rho-Statistic	4.82	1.00
Group PP-Statistic	–12.71*	0.00
Group ADF-Statistic	–8.29*	0.00

b) Kao panel test

	t-statistic	Prob.
ADF	–6.70*	0.00

Note: * denotes the statistical significance at 1% level.
Source: Authors' construction

This research uses the Pedroni panel co-integration test (Pedroni, 1999; 2004) and the Kao panel co-integration test (Kao, 1999). Results are reported in Table 3. Both methods suggest that the analyzed variables are co-integrated and thus have a long run relationship at 1% level of significance.

Table 4 Panel Long-Run Estimators

	Grouped-mean FMOLS		Grouped-mean DOLS		Fixed-effect OLS	
	Coefficient	**Prob.**	**Coefficient**	**Prob.**	**Coefficient**	**Prob.**
REN	0.04*	0.03	0.01	0.61	0.09**	0.00
RCPT	0.06**	0.00	0.06*	0.02	0.05**	0.00
K	0.40**	0.00	0.37**	0.00	0.45**	0.00
L	0.77**	0.00	0.84**	0.00	0.62**	0.00

Note: * and ** denote the statistical significance at 5% and 1% level, respectively.
Source: Authors' own estimations

This study further applies the OLS with fixed effects, the grouped-mean DOLS (Pedroni, 2001), the grouped-mean FMOLS (Pedroni, 2000; 2001) in order to estimate the long run coefficients of tourism receipts, renewable energy consumption, capital and labor and to stress their impact on economic growth. Table 4 reports relevant outcomes. Because this study takes natural logarithmic of the analyzed variables, the reported coefficients can be interpreted as the elasticities of the dependent variable with respect to the independent variables. A 1% increase in renewable energy consumption stimulates economic growth by ranging from 0.04–0.09%. Similarly, a 1% increase in international tourism receipts boosts real GDP by around 0.06%. In addition, 1% rises in capital and labor increase economic growth by ranging from 0.37–0.84%. The reported coefficients are statistically significant at 1% or 5% level. In short, increases in the analyzed variables (REN, RCPT, K and L) boost economic growth for the EU.

CONCLUSION AND POLICY RECOMMENDATION

Tourism and energy sectors involve a relatively low concentration in the literature focused on economic growth until recent years. As economic growth plays a key role in the economy, it is important for researchers to concentrate on the relationship between these two most essential industries and economic growth. Therefore, this empirical research aims to investigate the long-run dynamics of economic growth, renewable energy consumption, tourism receipts, capital and labor for the 28 European countries. By using several panel long-run estimators (FMOLS, DOLS and OLS), we find that results from the FMOLS, the DOLS and the OLS with fixed effects are consistent with each other. Increases in renewable energy consumption, tourism receipts, capital and labor stimulate economic growth in different magnitudes.

It is yet important to note that tourism sector is closely related to energy sectors. Tourism needs energy in order to keep on and thus energy sources should be used rationally for supporting a sustainable tourism and economic growth. Thus, a coherent and comprehensive policy frameworks renewable energy and tourism policies can contribute to economy in the long-run.

An interesting direction for a further research should be analyzing the causality between renewable energy, tourism receipts and economic growth using Granger causality tests. This way we can establish if there is a unidirectional, a bidirectional causality or no causality between economic growth-tourism receipts-renewable energy. A limitation of this research is represented by the fact that the paper doesn't present if there is an influence in terms of structure of the panel or if there is an influence in terms of size of the panel. The European countries are not homogenous as far as economic growth or the tourism receipts are concerned. A further research should be dividing the panel countries into separate groups and analyzing them separately because they present different features in terms of the tourism receipts or economic growth.

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References

ADHIKARI, D. AND CHEN, Y. Energy Consumption and Economic Growth: A Panel Cointegration Analysis for Dev. Countries. *Review of Econ. & Finance*, 2012, 3(2), pp. 68–80.

AKAN, Y., ARSLAN, I. AND IŞIK, C. The impact of tourism on economic growth: The case of Turkey. *Journal of Tourism*, 2008, 9(2), pp. 47–69.

AL-MULALI, U., FEREIDOUNI, H. G., LEE, J. Y. M. AND MOHAMMED, A. Estimating the Tourism-Led Growth Hypothesis: A Case Study of the M. East. *Anatolia*, 2014, 25, pp. 290–298.

APERGIS, N. AND DANULETIU, D. C. Renewable energy and economic growth: evidence from the sign of panel long-run causality. *Int. J. of Energy Economics and Policy*, 2014, 4(4), p. 578.

ANDERECK, K. L., VALENTINE, K. M., KNOPF, R. C. AND VOGT, C. A. Residents' perceptions of community tourism impacts. *Annals of Tourism Research*, 2005, 32(4), pp. 1056–1076.

AZAM, M., KHAN, A. Q., BAKHTYAR, B. AND EMIRULLAH, C. The Causal Relationship between Energy and Growth in the ASEAN-5. *Ren. & Sus. En. Rev,* 2015b, 47, pp. 732–745.

BILDIRICI, M. E. Economic Growth and Biomass Energy. *Biomass and Bioenergy*, 2013, 50, pp. 19–24.

BREITUNG, J. The local power of some unit root tests for panel data. *Discussion Papers*, *Interdisciplinary Research Project 373: Quantification and Simulation of Economic Processes*, 1999, 69.

DOGAN, E. The Relationship between Economic Growth and Electricity Consumption from Renewable and Non-renewable Sources: A study of Turkey. *Renewable and Sustainable Energy Reviews*, 2015, 52, pp. 534–546.

DOGAN E., SEKER, F. AND BULBUL S. Investigating the impacts of energy consumption, real GDP, tourism and trade on CO_2 emissions by accounting for cross-sectional dependence: A panel study of OECD countries. *Current Issues in Tourism,* 2015. DOI: 10.1080/13683500.2015.1119103.

EUROSTAT. *Statistics explained, Tourism statistics* [online]. November 2015. [cit. 28.4.2016]. Available online at: <http://ec.europa.eu/eurostat/statistics-explained/index.php/Tourism_statistics#Main_statistical_findings>.

EUROPEAN COMMISSION. *Europe, the world's No 1 tourist destination – a new political framework for tourism in Europe* [online]. 2013a.

EUROPEAN COMMISSION. *Cultural tourism* [online]. 2013b.

IM, K. S., PESARAN, M. H. AND SHIN, Y. Testing for unit roots in heterogeneous panels. *Journal of econometrics*, 2003, 115(1), pp. 53–74.

IŞIK, C., KASIMATI, E. AND ONGAN, S. *Analyzing the Causalities between Economic Growth, Financial Development, International Trade, Tourism Expenditure and/on the CO_2 Emissions in Greece, Energy Sources.* Part B: Economics, Planning and Policy, 2017. DOI:10.1080/15567249.2016.1263251.

IŞIK, C. Foreign Direct Investment in Tourism: Panel Data Analysis of D7 Countries. *Athens Journal of Tourism*, 2015, 2(2), pp. 93–103.

ISIK, C. AND SHAHBAZ, M. Energy Consumption and Economic Growth: A Panel Data Approach to OECD Countries. *Int. Journal of Energy Science*, 2015, 5(1), pp. 1–5.

IŞIK, C. The Importance of Creating a Competitive Advantage and Investing in Information Technology for Modern Economies: An ARDL Test Approach from Turkey. *J Knowl Econ*, 2013, 4, pp. 387–405.

ISIK, C. Natural Gas Consumption and Economic Growth in Turkey: A Bound Test Approach. *Energy Systems*, 2010, 1(4), pp. 441–546.

KADIR, N. AND KARIM, M. Z. A. Tourism and Econ. Growth in Malaysia: Evidence from Tourist Arrivals from ASEAN-5. *Economic Research*, 2012, 25, pp. 1089–1100.

KAO, C. Spurious Regression and Residual-based Tests for Cointegration in Panel Data. *Journal of Econometrics*, 1999, 90(1), pp. 1–44.

LEE, J. W. AND BRAHMASRENE, T. Investigating the influence of tourism on economic growth and carbon emissions: Evidence from panel analysis of the European Union. *Tourism Management,* 2013, 38, pp. 69–76.

LEÓN, C. J., ARANA, J. E. AND HERNÁNDEZ, A. A. CO_2 Emissions and tourism in developed and less developed countries. *Applied Economics Letters,* 2014, 21(16), pp. 1169–1173.

LEVIN, A., LIN, C. F. AND CHU, C. S. J. Unit root tests in panel data: asymptotic and finite-sample properties. *Journal of econometrics*, 2002, 108(1), pp. 1–24.

MADDALA, G. S. AND WU, S. A comparative study of unit root tests with panel data and a new simple test. *Oxford Bulletin of Economics and statistics*, 1999, 61(S1), pp. 631–652.

MATARRITA-CASCANTE, D. Beyond Growth: Reaching tourism-led development. *Annals of Tourism Research*, 2010, 37(4), pp. 1141–1163.

MELLO-SAMPAYO, F. AND SOUSA-VALEA, S. *Tourism and Growth in European Countries: An Application of Likelihood-Based Panel Cointegration* [online]. ISEG-School of Economics and Management Technical University of Lisbon, Department of Economics, Working Paper, 2012/17. [cit. 27.4.2016]. <http://pascal.iseg.utl.pt/~depeco/wp/wp172012.pdf>.

MENEGAKI, A. N. Growth and renewable energy in Europe: A random effect model with evidence for neutrality hypothesis. *Energy Economics*, 2011, 33, pp. 257–263.

OZTURK, I., ASLAN, A. AND KALYONCU, H. Energy and Growth Relationship: Evidence from Panel Data for Low-Middle Income Countries. *Energy Policy*, 2010, 38, pp. 4422–4428.

PACI, R. AND MARROCU, E. *Tourism and regional growth in Europe* [online]. CRENOS, Working Paper No. 35, 2012. [cit. 27.4.2016]. Available online at: <http://www-sre.wu.ac.at/ersa/ersaconfs/ersa13/ERSA2013_paper_00040.pdf>.

PEDRONI, P. Panel cointegration: asymptotic and finite sample properties of pooled time series tests with an application to the PPP hypothesis. *Econometric theory*, 2004, 20(03), pp. 597–625.

PEDRONI, P. Purchasing power parity tests in cointegrated panels. *Review of Economics and Statistic*, 2001, 83, pp. 727–731.

PEDRONI, P. Fully Modified OLS for Heterogeneous Cointegrated Panels. In: BALTAGI, B. H., eds. *Nonstationary Panels, Panel Cointegration and Dynamic Panels*, 2000, 15, Amsterdam: Elsevier, pp. 93–130.

PEDRONI, P. Critical values for cointegration tests in heterogeneous panels with multiple regressors. *Oxford Bulletin of Economics and statistics*, 1999, 61(S1), pp. 653–670.

PRATT, L. (coord.) *Tourism. Investing in energy and resource efficiency* [online]. World Tourism Organization, United Nation Environment Program, 2011. [cit. 28.4.2016]. Available online at: <http://www.unep.org/resourceefficiency/Portals/24147/scp/business/tourism/greeneconomy_tourism.pdf>.

REZITIS, A. N. AND AHAMMAD, S. M. Energy and Growth in South-Southeast Asian C.: Evidence from a D. Panel Data Approach. *Int. Energy Journal*, 2015, 15, pp. 103–116.

SHAHBAZ, M., LOGANATHAN, N., ZESHAN, M., ZAMAN, K. Does Renewable Energy Consumption Add in Economic Growth? An Application of Autoregressive Distributed Lag Model in Pakistan. *Renewable and Sustainable Energy Reviews*, 2015, 44, pp. 576–585.

SLAGER C. *European tourism as a driving force for economic growth and job creation European Commission 2014–2019* [online]. Netherland, Hague, August 2013. [cit. 28.4.2016]. Available online at: <http://www.nritmedia.nl/file/European%20tourism%20as%20a%20driving%20force%20for%20economic%20growth%20and%20job%20creation%20-%20European%20Commission%202014%20-%202019.pdf>.

TANG, C. F. AND ABOSEDRA, S. The impacts of tourism, energy consumption and political instability on economic growth in the MENA countries. *Energy Policy*, 2014, 68, pp. 458–464.

TANG, C. F., TIWARI, A. K. AND SHAHBAZ, M. Dynamic inter-relationships among tourism, economic growth and energy consumption in India [online]. *Geosystem Engneering*, 2016. Available online at: <http://dx.doi.org/10.1080/12269328.2016.1162113>.

TIWARI, A. K. Comparative Performance of Renewable and Nonrenewable Energy Sources on Economic Growth and CO_2 Emissions of Europe and Eurasian Countries: A PVAR approach. *Economics Bulletin*, 2011, 31, pp. 2356–2372.

TIWARI, A. K., OZTURK, I., ARUNA, M. Tourism, energy consumption and climate change in OECD countries. *International Journal of Energy Economics and Policy*, 2013, Vol. 3, Iss. 3, pp. 247–261.

TUGCU, C., OZTURK, I. AND ASLAN, A. Renewable and Non-Renewable Energy and Growth Relationship Revisited: Evidence from G7. *Energy Econ*, 2012, 34, pp. 1942–1950.

UNWTO. *Tourism highlights 2015* [online]. 2015. [cit. 2.1.2017]. Available online at: <http://www.e-unwto.org/doi/pdf/10.18111/9789284416899>.

WORLD BANK. *World Development Indicators* [online]. Available online at: <http://data.worldbank.org/data-catalog/world-development-indicators>.

WORLD ECONOMIC FORUM. *Travel and Tourism Competitiveness Report* [online]. Chapter 1.1. The Travel & Tourism Competitiveness Index 2015: T&T as a Resilient Contribution to National Development, 2015. [cit. 28.4.2016]. Available online at: <http://reports.weforum.org/travel-and-tourism-competitiveness-report-2015/index-results-the-travel-tourism-competitiveness-index-ranking-2015>.

WTTC. *Travel and Tourism. World Economic Impact 2015* [online]. 2015. [cit. 2.1.2017]. Available online at: <http://sete.gr/media/2614/150430-economic-impact-2015.pdf>.

Pro Poor Growth in Cameroon

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Abstract

The purpose of this paper is to analyze the relationship between economic growth, poverty and income distribution in Cameroon, using both the data derived from three Cameroonian household surveys and the Poverty Equivalent Growth Rate (PEGR) methodology developed by Kakwani et al. (2004), The study found that economic growth in Cameroon was pro poor over the period 1996–2007, which suggests that instead of increasing the economic growth rate alone, the poverty equivalent growth rate should also be maximized to achieve the poverty reduction objective, meaning that on the one hand, the growth rate should be boosted, and on the other, the distribution of income should also be concurrently improved.

A decomposition of changes in poverty using the Kakwani (1997) approach reveal that the growth component dominates the redistribution component in the reduction of poverty. This suggests that the fall in absolute poverty over the survey period may be attributed to an increase in average household income, and not to the redistributive policies of the government.

Keywords

Economic growth, pro poor growth, poverty, inequality, decomposition, Cameroon

JEL code

D63, I32, O49

INTRODUCTION

The reduction of poverty has become a major preoccupation of development policy. The level of poverty depends both on income and on income inequality. Thus, changes in absolute poverty may be considered as a result of two factors: firstly, an increase in the income of the population, keeping income distribution constant, leads to a reduction in poverty and vice-versa; secondly, a reduction in income inequality while keeping growth in average income fixed has the same impact. As a result, changes in the levels of poverty may be attributed not only to a growth effect relative to changes in average income, but also to inequality originating from changes in the levels of equality.

However, the relationship between poverty, income inequality and economic growth is not so simple. The issue is complex and interdependent. A view that is largely held in the area of economic development is that the benefits of economic growth spread automatically through all the segments of society. This is the well-known « trickle down » hypothesis which was dominant in the 1950s and 1960s. Similarly, the results derived from a number of recent studies (see for instance, Dollar and Kraay, 2002; Christiaensen et. al., 2002; White and Anderson, 2001; and World Bank, 2000) suggest that economic growth by and large reduces poverty. These studies, which are based on cross-sections of countries, have been criticized because they only depict an average image of the relationship between growth and poverty. When big differences between countries are considered in terms of averages, the results are potentially deceptive because the specific experiences of a country may largely be different (Kakwani et al., 2008).

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The relationship between growth and inequality has also been the object of intense debates. Kuznets (1955) found an inverted-U relationship between per capita income and inequality based on country cross-section data: as per capita income increases, inequality first worsens and then improves afterwards. The main driving force of this hypothesis was presumed to be the structural change which had occurred because of changes in jobs, employments, etc. from the poor and less productive traditional sector of the economy towards the more productive and differentiated modern sector. This hypothesis was maintained by a number of studies, including those of Kravis (1960), Oshima (1962), Adelman and Morris (1971), Paukert (1973), Ahluwalia (1976), Robinson (1976), and Ram (1988).

To date, and with better quality databases and tests on individual countries, the U-inverted curve of Kuznet constitutes a challenge and seems to have vanished (see for instance, Anand and Kanbur 1984, Fields 1989, Oshima 1994, Deininger and Squire 1996). For example, Deininger and Squire (1996) have carried out very detailed tests of hypotheses and confirmed the fact that there was no evidence proving the existence of a U-inverted curve for countries taken individually.

Authors such as Deininger and Squire (1996), Ravallion and Chen (1997), and Dollar and Kraay (2002) have found that growth has no impact on inequality. On the other hand, Kaldor (1956), Li and Zou (1998), and Forbes (2000) maintain that inequality leads to growth. But Alesina and Rodrick (1994) show that inequality adversely affects economic growth.

Datt and Ravallion (1992) decompose changes in poverty into growth and redistribution components between two survey periods. Kakwani (1997) also decomposes changes in poverty into growth and redistribution components between two survey periods. Both of these approaches provide information concerning changes in poverty between both periods.

By and large, the relationship between growth and poverty is complex and is determined by the level of, and changes in inequality. Pro poor growth deals with the interrelations between growth, poverty and inequality. Although there is no consensus on the definition or the measure of pro poor growth, this issue has attracted a lot of attention both in the academic world and among the practitioners of development. The debate on pro poor growth originates from the pro income distribution arguments of Chenery and Ahluwalia which were advocated in the 1970s. Pro poor growth was also implicit in the expression "broad-based growth" used in the 1990 Report on Development in the World by the World Bank. Even though the concept of pro poor growth was not yet defined at that time, it was subsequently enlarged to refer to the concept of pro poor growth during the 1990s. The basic papers on pro poor growth examine how economic growth affects the poor, how the benefits of economic growth are distributed and how much the poor profit from the benefits of growth (Ravallion, 2004; Kakwani and Son, 2008; Klasen, 2008; Son and Kakwani, 2008).

The present study analyzes the pro poor growth in Cameroon, that is to say, the relationship between growth, poverty and income using the data derived from the Cameroonian household surveys ECAM1, ECAM2 and ECAM3 that were conducted by the National Institute of Statistics (NIS) of Cameroon respectively in 1996, 2001 and 2007. The relationship between growth, inequality and poverty in Cameroon is analyzed following the methodology developed by Kakwani and Khandker (2004). This methodology proposes the use of the Poverty Equivalent Growth Rate (PEGR) which considers not only the magnitude of growth in itself, but also the degree to which the poor benefit from the growth process. Moreover, in order to measure the specific impacts of growth and income distribution on the reduction of poverty, a decomposition of changes in poverty is carried out over the periods 1996–2001, 2001–2007 and 1996–2007, using the decomposition of changes in poverty developed by Kakwani (1997). The use of this methodology leads us to a better understanding of the effects of growth and distribution which may help to formulate the necessary developmental policy that may eradicate poverty in the country.

After the severe economic crisis which occurred at the end of the 1980s, Cameroon witnessed an economic recovery and then an acceleration of growth during the second half of the 1990s, followed by a slowdown in the rhythm of growth during the first half the years 2000. It would be interesting to find out how much of the proportional benefits of growth befell the poor.

The rest of the paper is organized as follows. After the Introduction, Section 1 summarizes different pro poor growth definitions and measures, Section 2 explains the data and the methodology used in the study, Section 3 deals with the background of Cameroon's economy, while Section 4 displays the results. Finally, last Section concludes the study and provides some policy recommendations based on the paper's findings.

1 "PRO POOR GROWTH": CONCEPTS AND MEASURES

1.1 Concept of Pro Poor Growth

To examine whether growth is pro poor first requires the clarification of the concept of the pro poorness character of growth which generally refers to the idea that the poor benefit more from growth than from a certain pre-defined reference.

Although it is largely used by economists interested in questions of development and poverty reduction, the term "pro-poor growth" is the subject of much controversy related to its definition. We may distinguish two rival definitions of the "pro poor growth" concept in the recent literature: an absolute definition and a relative definition.

According to the absolute definition, growth is said to be "pro-poor" if it reduces absolute poverty (Ravallion, 2004; Ravallion and Chen, 2003). This definition simply says that any increase in average income which results in a decrease in poverty is "pro-poor", even if growth is accompanied by an increase in income inequality. On the other hand, the relative definition put more emphasis on the effects of growth on the distribution of income, that is to say the changes in inequality during the growth process (Baulch and McCulloch, 1999; Kakwani and Pernia, 2000; Son, 2004). Thus, according to this second definition, growth may be considered as being "pro poor" if it reduces relative inequality, i.e. since the distributive changes accompanying growth proportionally favour the poor more than the non poor (the incomes of the poor must grow at a higher rate than those of the non poor).

Both of these definitions of the "pro-poor" growth concept present certain limitations. In effect, Lopez (2004) and Osmani (2005) note that to assess the more or less favourable character of growth for the poor, one should not be interested solely in the nature of the growth process, that is, in its impact on the distribution of income, as suggested by the preceding relative definition. It is also necessary to take into account the reduction of poverty in absolute terms caused by the level of the aggregated growth rate, as recommended by the absolute definition presented above. In other words, the concept of "pro-poor" growth must take into consideration both the magnitude of growth and the way in which the fruits of this growth are distributed among the poor and the non poor. Thus, from this perspective, Kakwani, Khandker and Son (2004) have developed some new measures of "pro-poor growth" out which present the major interest of combining both of these definitions.

1.2 Measuring Pro Poor Growth

In the literature, several measures of pro poor growth are proposed in relation to definitions of pro poor growth. Four pro poor growth measures are used in the analysis as follows:

The first measure of pro poor growth is proposed by Ravallion and Chen (2003), and it is called "the growth incidence curve (GIC)", which is an interesting tool used to measure the impact of growth on poverty. It is defined in the following manner: on the horizontal axis we note the different percentiles of the distribution of income (consumption). As a consequence, at the 50^{th} percentile, the growth incidence curve (GIC) will indicate the growth rate of median income. It is clear that if the curve lies above the horizontal axis at all points up to a certain percentile p^*, we can conclude that poverty has fallen when it is measured through the poverty ratio, and when the poverty line is not greater than p* (see Atkinson, 1987). Let us note that the area under the growth incidence curve up to the poverty ratio will yield total growth in the incomes of the poor during the period being analyzed. Ravallion and Chen (2003) have therefore defined the “pro poor growth rate” as the average growth rate of the poor. They also have shown that the pro poor growth rate is equal to the change in the Watts poverty index by unit of time. It is clear that there is a difference between this average growth rate of the poor and the average growth rate of the income (consumption) of the poor.

The second approach to pro poor growth is the one developed by Kakwani and Pernia (2000). These authors first define what they call the total poverty elasticity of growth, that is, the percentage change in poverty when growth in income (consumption) is equal to 1%. They then define a second elasticity which measures the percentage change in poverty that is observed when growth in income (consumption) is equal to 1%, and there is no change over time in relative inequality.

For Kakwani and Pernia (2000), the pro poor growth index (PPGI) is equal to the ratio of both of these elasticities, and they conclude that growth is pro poor if this PPGI ratio is larger than one.

Let us note that if growth is negative, it will be defined as being pro poor in relative terms if the relative loss in income due to negative growth is smaller for the poor than for the non poor, that is to say, if the PPGI ratio is smaller than one.

The third approach to pro poor growth is that of Kakwani and Son (2002) who define what they call the “poverty equivalent growth rate” (PEGR). The PEGR refers to the growth rate which will result from the same level of poverty reduction as the one observed at present, assuming that there was no change in inequality during the growth process. Growth will consequently be considered as being pro poor if the PEGR is larger than the present growth rate. If the PEGR is positive but smaller than the present growth rate, this implies that growth is accompanied by an increase in inequality, but the reduction in poverty is still observed. In such a case, Kakwani et al. (2004) speak of a “trickle down” process in which the poor receive proportionally less of the benefits of growth than the non poor. Finally, if the PEGR is negative, we have the case where positive economic growth leads to an increase in poverty.

In a more methodological section (Section 2) we will make a detailed presentation of this approach to pro-poor growth analysis.

The fourth approach to pro poor growth is that developed by Son (2004). This author proposes what she calls a poverty growth curve (PGC), which is defined as follows: let $g(p)$ be the growth rate of the average income (consumption) of the lowest p percent of the population. By reporting $g(p)$ on the vertical axis and p on the horizontal axis, we obtain the poverty growth curve developed by Son (2004).

It should be clear that if $g(p) > 0$ ($g(p) < 0$) for all the ps, poverty has decreased (increased) during the period under study.

If $g(p)$ is greater than the average growth rate for all $p < 100\%$, it may be concluded that growth is pro poor. If $g(p)$ is positive for all $p < 100\%$ but smaller than the average growth rate, it may therefore be concluded that growth reduced poverty, but that inequality also increased during the period. Such a situation may be referred to as “trickle down growth”, which is a situation in which growth reduces poverty, but the benefits of growth are smaller for the poor than for the non poor.

Finally, if $g(p)$ is negative for any $p < 100\%$, we face a situation in which the increase in inequality more than « compensates » for growth, so that the net effect of growth is to increase poverty, a situation which corresponds to what has been called “immiserizing growth”.

2 DATA AND METHODOLOGY

2.1 Poverty Measures

As measures of poverty, we use three poverty measures of the Foster-Greer-Thorbecke (1984, FGT) class of poverty measures, namely: the incidence of poverty P_0, the poverty gap index P_1, and the severity of poverty index P_2. These three indexes can be expressed in a general form and differ from one another by the different weights attributed to the distance between the incomes of the poor and the poverty line. P_0 allocates a weight equal to all the incomes of the poor, whereas P_1 and P_2 allocate an increasingly greater weight to the incomes of the poor that are distant from the poverty line.

The general formula of the FGT-poverty indexes is:

$$P_\alpha = FGT\,(\alpha) = \frac{1}{n}\sum_{i=1}^{q}\left(\frac{z-y_i}{z}\right)^{\alpha}, \tag{1}$$

where n = population; q = population above the poverty line; yi = income of person i; z = the poverty line and α = the parameter of aversion to poverty. For $\alpha = 0$, we have P_0 which is the incidence of poverty; for $\alpha = 1$ we obtain P_1 which is the poverty gap index, and for $\alpha = 2$, we have the severity of poverty index P_2 (see Ravallion (1994) for a detailed description of these poverty indexes).

2.2 Inequality Measures

As a measure of inequality, this paper will use the Gini index and three inequality indexes of the class of generalized entropy GE (α) with the parameter α fixed at 0, 1 and 2.

The general formula of the class of generalized entropy is:

$$GE\,(\alpha) = \frac{1}{\alpha^2 - \alpha}\left\{\frac{1}{n}\sum_{i=1}^{n}\left(\frac{y_i}{\bar{y}}\right)^{\alpha} - 1\right\}, \tag{2}$$

where n = population, y_i = income of person i, $\bar{y}$ = average income, α = parameter of aversion to inequality.

The three indexes derived from Formula (2) are also known respectively as the mean log-deviation GE (0), Theil's index GE (1), and half of the coefficient of variation squared GE (2). They possess sensitivities that are different from the differences in the different parts of the distribution, with GE (0) being the most sensitive to differences in the lowest part of the income distribution and GE (2) being the most sensitive to the high values of the income distribution.[2]

2.3 Decomposition of Changes in Poverty

The analysis of the decomposition of poverty that is used in this study is the decomposition of Kakwani (1997). Before presenting this decomposition technique, let us first note that there exist several approaches that offer ways to break down changes in poverty into growth and redistribution components (Jain and Tendulkar, 1990; Kakwani and Subbarao, 1990; Datt and Ravallion, 1992; Kakwani, 1997; Shorrocks, 1999). The methodologies used in these approaches are very similar, and the differences between them may be explained by the period of reference considered, the treatment of a residual which may emerge from certain decompositions, and the poverty measures used.

Datt and Ravallion (1992) decompose a change in the poverty measure between two periods into components of growth, redistribution and a residual term. The residual exists when the poverty measure is not additively decomposable into average income and distribution.[3]

[2] The formal definitions and the reviews of different properties of inequality indexes may be found in Cowell (2000), and Jenkins and Van Kerm (2009).

[3] The residual is due to the fact that the decomposition is sensitive to the choice of the period of reference. Given that the initial year and the final year are the two possible choices of the period of reference, the residual disappears if either average income or distribution remains unchanged over both periods.

Datt and Ravallion (1992) have in fact found that the residual may be quite large, and this is a serious limitation on this decomposition approach. To overcome this limitation, Kakwani (1997) derives an axiomatic approach in which the residual term is removed by a simple average procedure. The decomposition by Kakwani (1997) of poverty measures into growth and redistribution components is the following:[4]

$$\Delta P = P_2 - P_1 = G + D \,, \tag{3}$$

$$G = \frac{1}{2}\left[\left[P\left(\frac{z}{\mu_2}, L_1\right) - P\left(\frac{z}{\mu_1}, L_1\right)\right] + \left[\left(\frac{z}{\mu_2}, L_2\right) - \left(\frac{z}{\mu_1}, L_2\right)\right]\right], \tag{4}$$

$$D = \frac{1}{2}\left[\left[P\left(\frac{z}{\mu_1}, L_2\right) - P\left(\frac{z}{\mu_1}, L_1\right)\right] + \left[\left(\frac{z}{\mu_2}, L_2\right) - \left(\frac{z}{\mu_1}, L_1\right)\right]\right], \tag{5}$$

where, ΔP = change in poverty, G = growth component, D = distribution component, P_t is a poverty measure at time t, z is the poverty line, μ_t is average income at time t, L_t is the vector of parameters which completely describes the Lorenz curve at time t, where $t = 1, 2$.

2.4 The Poverty Equivalent Growth Rate (PEGR)

To analyze the relationship between growth, inequality and poverty in Cameroon, we use the pro poor growth methodology developed by Kakwani and Khander (2004). This methodology proposes a poverty equivalent growth rate (PEGR) which considers not only the magnitude of growth in itself, but also the degree to which the poor benefit from the growth process.

Kakwani et al. (2004, 2008) define the poverty equivalent growth rate (PEGR) denoted by γ^*, as the rate of growth that will provide the same decline in the poverty ratio like the actual real growth rate γ if the growth process had a zero change in inequality (i.e. when everybody in society receives the same proportional benefits of growth). The real proportional change in poverty is given by $\delta\gamma$, where δ is the growth elasticity of poverty. If growth were distribution-neutral (i.e. when inequality did not change), then the rate of growth γ^* would consequently have a proportional reduction in poverty equal to $\eta\gamma$, where η is the elasticity of neutral relative growth in poverty derived by Kakwani (1983), which measures the percentage change in poverty when there is a 1% growth in the average income of society, provided the growth process does not change relative inequality (i.e. when everybody in society receives the same proportional benefits of growth).

Thus, the PEGR denoted by γ^*, may be expressed as follows:

$$\gamma^* = \left(\frac{\delta}{\eta}\right)\gamma = \phi\gamma \,, \tag{6}$$

[4] Shorrocks (1999) arrives at the same conclusion as Kakwani through a different reasoning. He applies Shapley's rule (Shapley (1953) – a concept borrowed from cooperative game theory) to a range of decompositions of poverty and inequality, including the one we are using in this paper, and develops a general framework for this type of analyses, thus providing a mathematical foundation for this framework and deriving the application formulas to each case. By comparing the formulas proposed by Kakwani (1997) and Shorrocks (1999) for the case of two periods, it is evident that they are one and the same. In fact, both of these authors refer to Datt and Ravallion (1992), and with different methodologies they arrive at the same conclusion that there is no reason for the residual term to exist. Consequently, we will use the formula of Formula (3) to decompose changes in poverty into growth and distribution effects.

where $\phi = \dfrac{\delta}{\eta}$ is the pro poor index derived by Kakwani and Pernia (2000). According to both of these authors, growth will be pro poor if $\phi > 1$, thus implying that the poor benefit proportionally more than the non poor. Consequently, the growth process occurs with redistribution in favour of the poor. When $0 < \phi < 1$, growth cannot be considered as being strictly pro poor (due to the fact that growth takes place with redistribution adversely affecting the poor) even if there is no reduction in the poverty ratio. If $\phi < 0$, economic growth will lead to an increase in poverty. Similarly for the PEGR index, growth will be pro poor (anti-poor) if γ^* is greater (smaller) than γ. When $0 < \gamma^* < \gamma$, the growth process shows, as a consequence, an increase in inequality, but the incidence of poverty will be deceasing. This situation is defined by Kakwani, Khandker and Son (2003) as a "trickle-down" in which the poor receive proportionally less benefits stemming from growth than the non poor. It is also possible for the PEGR to be negative with a positive economic growth leading to an increase in poverty. This situation is similar to what Bhagwati (1988) defines as "immiserising" growth. This situation may occur when inequality increases with the result that the positive effects of growth are more than compensated by the adverse impact of increasing inequality.

2.5 The Data

This paper uses the data derived from three Cameroonian household surveys, namely ECAM1, ECAM2 and ECAM3 conducted by the National Institute of Statistics (NIS) in 1996, 2001 and 2007, respectively.[5] These three ECAM surveys are representative at the national level and provide information on 1 731, 10 992 and 11 391 survey households for the years 1996, 2001 and 2007, respectively. These surveys also provide detailed information notably on all the sources of household consumption expenditures (such as the non-food retrospective household expenditures, daily household expenditures), the socio-demographic characteristics and the composition of the household, including employment, migration, education and health.

In this study, we have chosen household consumption expenditure per adult equivalent as welfare indicator. Consumption expenditure is the main welfare indicator commonly used in developing countries, while income plays a more important role in studies carried out on developed countries. In this paper, the emphasis put on consumption expenditures will capture the living conditions among the low income groups better.

Since households have different sizes in terms of the number of children and adults, we use the distribution of total expenditures per adult equivalent as welfare indicator. Besides, several researchers require the use of expenditures per adult equivalent as welfare indicator to take into account the economies of scale and the different costs of children (Deaton and Muellbauer, 1986; Deaton and Paxson, 1998;

[5] The ECAM1 survey is a national survey whose sample comprises about 1 700 households selected randomly by a two-step probability in urban regions, and three-step probability in rural regions. Two types of questionnaires were designed, one type for cities and large cities, and the other type for the rest of the country. These questionnaires were administered to selected households, and they comprised 11 sections, several of which could be used to analyze poverty and income distribution in Cameroon. The ECAM2 and ECAM3 surveys covered the whole national territory and gathered a random sample of about 12 000 households, each. They were particularly aimed at the construction of a poverty profile for Cameroon at the national level and at the levels of the ten provinces of the country, as well as for the two largest cities of Douala and Yaoundé (respectively the economic and political capitals of the country) each of the latter being considered as separate strata, while each of the ten provinces was divided into two strata, one rural and the other urban. The sampling basis of the two surveys was that of the second General Census of the Population and the Habitat (RGPH) of April of 1987, which was updated to take account of its dated nature. Two types of draws were made according to residence area: a two-degree draw in the major cities of Douala and Yaoundé, and a three-degree draw with equal probability in the semi-urban sub-strata, and the rural strata of the provinces.

Lanjouw and Ravallion, 1995). The adult equivalent scale used by the National Institute of Statistics (NIS) is 1 for each adult in the household and 0.5 for each child in the household.

Several adjustments were made in the initial data before estimating inequality, poverty and the poverty equivalent growth rate (PEGR), notably by making the values of consumption expenditures for the years 1996 and 2007 comparable to those of the year 2001. The poverty line used in the present study is the official 2001-poverty line calculated by the National Institute of Statistics (NIS) of Cameroon, using the basic needs costs method which consists of determining a food poverty threshold first, and then adding to it an amount corresponding to the non-food basic needs. This poverty line takes into account the regional variations of the cost of living.

3 BACKGROUND OF CAMEROON'S ECONOMY

To analyze the factors and forces affecting growth, poverty and inequality in Cameroon, it is necessary to examine the economic conditions during the period under study 1996–2007.

The Cameroonian economy recorded a sustained average annual growth rate of 5% up to 1978, a performance which was mainly attributed to agricultural exports. The discovery and exploitation of oil in 1978 brought this growth rate to 7% up to 1986, a situation which helped boost the contributions of the oil sector respectively to 20% of GDP, to 44% of government revenues, and to 54% of the country's exports. However, shortly after this period, the country was suddenly stricken by a serious economic crisis which was to last for a decade from 1987 to 1997, and whose underlying causes most particularly included the combined effects of a significant reduction in oil production, a fall in the prices of the country's traditional exports, and a rise of about 40% in the effective real exchange rate of the CFA Franc. The combination of these factors led perforce to a fall of 40% in GDP per head and to serious macroeconomic imbalances, which in turn led to the increasing recourse by the government to the external financing necessary to redress the public finance balance and shift the economy back to its sustained growth path.

To reverse this trend, public authorities put in place at the beginning of 1987, a series of domestic measures aiming at reducing government expenditures and economic reform programs with the support of the international community.[6] These programs were essentially concerned with policies whose objectives were to reduce the budget deficit through an increase in tax rates, cuts in the payroll and subsidies to public enterprises, the restoration of external competitiveness centred on the reduction of the costs of factors of production, and the restructuring of public enterprises. In this context, the government introduced drastic cuts in civil servants' salaries of about 50% in 1993, a measure which led to a considerable deterioration of the socioeconomic conditions of civil servants. Nevertheless, in the absence of monetary adjustment, the results obtained after the implementation of these programs remained quite unsatisfactory.

In January 1994, the devaluation of the CFA Franc relative to the French Franc by 50% in nominal terms took place, and the implementation of additional trade and fiscal reforms were initiated at the regional level by the Economic and Monetary Community of Central African States (EMCCA),[7]

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[6] The crisis and the initial responses to it led to a severe economic depression and to an increase in the incidence of poverty according to the World Bank Report (1995). This report pointed out that in 1990, real GDP fell and stood at 20% under its 1985 level. Moreover, per capita income plummeted by about 50% between 1986 and 1993. The loss in competitiveness also led to the loss of export markets for agricultural products, thus making it difficult for food and industrial products to compete against imports; this loss of export markets also resulted into a decrease in the demand for labour in the domestic markets for exchangeable and non exchangeable goods, with adverse effects on employment and the living standards of populations residing in both rural and urban areas. Likewise, the slowdown in economic activity combined with the slackening of tax collection to paralyze the capacity of the State to provide social services, thus aggravating the impoverishment of Cameroonian citizens.

[7] This Organization is mostly known under its French acronym CEMAC for *Communauté Economique et Monétaire d'Afrique Centrale.*

of which Cameroon is a member. These measures provided Cameroon with the opportunity to reverse its socio-economic decline. The country thus witnessed some positive growth after the devaluation of the CFA Franc, but it was not until the middle of 1996, after a few failures in stabilization and adjustment efforts,[8] that the government showed a strong commitment to implement in-depth reforms.

During the period 1997–2000, economic programs implemented by the government included radical economic reforms whose objectives were to enhance the productive potential of the economy: firstly, to reinforce the functioning of the market economy notably by privatizing public enterprises and liberalizing markets; and secondly, to improve the environment for the development of the private sector through sector-wide reforms in the areas of energy, forestry, transports, and finance, and to reinforce public administration through the reforms of public services and of the judicial system. These reforms continued during the period 2000–2003, when they were supplemented by policies designed to accelerate the reduction of poverty by developing a poverty reduction strategy and by improving the delivery of social services.[9]

The successful implementation of these reforms, combined with the CFA franc devaluation vis-à-vis the French Franc, led to macroeconomic stability and to an increase in average real GDP growth rates of about 5% over the period 1997–2000, and 3.5% over the period 2001–2007. Per capita GDP increased by nearly 2.2% during the period 1996–2001 and by 1.3% over the period 2001–2007 (WDR, 2011). Exports and most particularly non oil exports responded positively to improvements in price competitiveness so that in 2002, export volumes jumped to 50% above their 1993 level. However, despite some diversification in export products, oil, wood, aluminium, and a reduced number of agricultural products continued to account for nearly 70% of Cameroon's exports (Word bank, 2005).

After this brief description of the Cameroon's economic development during the 1996–2007 period, it is important to mention that, there exist a limited number of empirical studies on the levels and changes in monetary poverty and inequality in Cameroon (Lynch, 1991; Dubois and Amin, 2000; Fambon, 2006; Baye, 2006; Fambon et al., 2000; Fambon, 2005; Fambon, 2010; National Institute of Statistics (NIS), 2002; and National Institute of Statistics (NIS), 2008). These studies analyze either the poverty profile in 1983 or the evolution of poverty over the sub-periods 1978–1996, 1983–1996, 1996–2001 and 2001–2007. None of these studies tackles the analysis of changes in poverty and inequality over the long period between 1996 and 2007 simultaneously using the data of the last three Cameroonian household surveys ECAM1, ECAM2, and ECAM3, which are consistent and comparable.[10]

[8] It is opportune to note at this point that following the devaluation of the CFA Franc in January 1994, Cameroon received from the IMF in March 1994, a standby credit to support the reform efforts. This programme was interrupted because of poor performances in the areas of public finance and structural adjustment. However, the reforms resumed in September 1995, following the signature of a new standby IMF credit facility. The objective was to take advantage of the gains in competitiveness resulting from the monetary adjustment of January 1994. The first review of this programme by the IMF was positive, but the performance criteria of subsequent reviews were not met. The IMF, the World Bank, and the Cameroon government then put in place an IMF staff-monitored programme covering the period extending from July 1st to December 30th, 1996.

[9] In 2003, Cameroon adopted a poverty reduction strategy (PRS), the implementation of which was supported by the international community (see Government of Cameroon, 2003). The results obtained in terms of improvements in the macroeconomic framework made it possible for Cameroon to reach the decision and completion points of the HIPC Initiative respectively in 2003 and 2006, to increase the level of investment in the priority sectors identified in the Poverty Reduction Strategy Paper (PRSP), and to undertake structural reforms particularly in the public utilities sectors. Most government programs were implemented according to sequences defined in the PRSP, which enabled the government to bring to completion the six Growth and Poverty Reduction Facilities (GPRFs) funded by the IMF, and to receive the support of the other development partners in the implementation of its poverty reduction strategy (see IMF, 2006).

[10] For a comprehensive literature review on poverty in Cameroon, see for instance, Fambon (2013).

4 RESULTS AND DISCUSSION

4.1 Poverty Trends in Cameroon

Table 1 presents an overall view of the evolution of poverty in Cameroon and according to the residence area of the household head over the period 1996–2007.

Table 1 Monetary Poverty Trends over the Period 1996–2007

Poverty index	1996	2001	2007
P_0	0.5327	0.4022	0.3988
P_1	0.1908	0.1414	0.1231
P_2	0.0900	0.0698	0.0503

Source: Computed by the Author from ECAM1, ECAM2 and ECAM3 Survey data

At the national level, we note that monetary poverty decreased over the period 1996–2001, and remained almost stable between 2001 and 2007. Actually, between 1996 and 2001 all the poverty measures, namely P_0, P_1, and P_2 indicate a non negligible reduction of this phenomenon. The percentage of individuals in the Cameroonian population who lived in poverty in 1996 (about 53%) decreased considerably, and amounted approximately to 40% five years later in 2001. This reduction of poverty at the national level did not only concern a fall in the number of poor individuals, but it did also concern the decrease in the indicators of the measures of the depth and severity of poverty, which assign a greater weight to those who are poorer. In fact, the poverty gap index witnessed a 5 percentage points reduction during the period going from 19% in 1996 to 14% in 2001, while the poverty gap index squared (P2) also decreased by 2 percentage points over the same period.

On the other hand, we note the quasi-stability of poverty over the period 2001–2007, characterized by a marginal decrease in the incidence, depth and severity of poverty. In fact, the poverty ratio only declined from 40.2% in 2001 to 39.9% in 2007. This result reveals that the government of Cameroon did not take advantage of the macroeconomic stability and the opportunities offered during this period, notably the resources engaged when the country reached the decision and completion points of the Highly Indebted Poor Countries (HIPC) Debt Relief Initiative of the IMF.

The depth of poverty also remained stable over the period, going from 12.8% in 2001 to 12.3% in 2007. In other words, individuals who remained poor in 2007 did not witness the substantial fall in their consumption deficit relative to the year 2001. This result thus shows that the poor did not draw any benefits from the effects of economic growth during this period, in order for the average gap between their level of consumption and the poverty threshold to witness a significant reduction. Finally, as to the index of the severity of poverty, it only decreased from 5.55% in 2001 to 5.03% in 2007.

4.2 Trends of Inequality in Cameroon

Table 2 below presents the evolution of the inequality of total household expenditures per adult equivalent over the period 1996–2007, using the Gini coefficient and three inequality indices belonging to the entropy class of inequality measures.

Examination of the data in Table 2 above shows that at the national level, the inequality of total expenditures per adult equivalent increased between 1996 and 2001, whatever inequality measure is considered. The Gini coefficient displays a less important increase in inequality than the one given by the inequality measures of the entropy class of inequality measures. $GE(0)$shows the strongest percentage increase in inequality, therefore indicating that an increase in inequality is produced when a higher weight is attached to the lower tail of the expenditures distribution.

Table 2 Indices of Income Inequalities in Cameroon (1996–2007)

Inequality index	1996	2001	2007
Gini	0.4062	0.4078	0.3896
GE(0)	0.2722	0.2906	0.2477
GE(1)	0.3174	0.3163	0.2787
GE(2)	0.5442	0.2787	0.4449

Source: Computed by the Author from ECAM1, ECAM2 and ECAM3 Survey data

However, the decrease in inequality at the national level is observed over the period 2001–2007. We note a fall in the different inequality measures considered. The Gini index which amounted to 0.404 in 2001 decreased to 0.390 in 2007. The three entropy inequality measures witnessed more important falls than that of the Gini coefficient over this sub-period. Definitely, it may be said that the low rate of economic growth registered over the period 2001–2007 was not accompanied by an increase in inequalities.

4.3 Poverty Equivalent Growth Rates (PEGRs)

Table 3 presents the actual growth rates of consumption expenditures per adult equivalent and the poverty equivalent growth rates (PEGRs) in Cameroon. Over the period 1996–2001, the PEGR of the poverty ratio was higher than the average annual growth rate of expenditures per adult equivalent (15.8% for Cameroon taken as a whole), which as a result had a stronger reduction in poverty than the one indicated by the actual growth rate. This result indicates that the growth process in Cameroon was pro poor in the sense that the poor benefited proportionally more from it than the non poor. On the other hand, over the same period, the PEGRs of the poverty gap, and the index of the severity of poverty were lower than the average annual growth rate of expenditures per adult equivalent. These results imply that during the period 1996–2001, the impact of economic growth in Cameroon was not beneficial to the ultra-poor.

As for the period 2001–2007, the PEGRs were systematically higher than the average annual growth rate of the expenditures per adult equivalent (4.1% for Cameroon taken as a whole). This indicates that the growth process in this country was pro poor in the sense that it was proportionally more beneficial to the poor than to the non poor. The PRGR of the severity of poverty index was higher than those of the poverty gap ratio and the incidence of poverty. This implies that during the period 2001–2007, growth in Cameron had a more beneficial impact on the ultra poor. Pro poor growth occurred because the country witnessed a decline in inequality as estimated respectively by the Gini index, GE (0) and GE (1). The Gini index decreased from 40.78% in 2001 to 38.96% in 2007 and GE (0) fell from 29.06% in 2001 to 24.77% in 2007, while GE (1) declined from 31.63% in 2001 to 27.87% in 2007 (see Table 2).

Over the period 1996–2007, the PEGRs were largely higher than the average annual growth rate of expenditures per adult equivalent (20.5% for Cameroon taken as whole). This indicates that the growth process in the country was pro poor in the sense that it was proportionally more beneficial to the poor than to the non poor. The PEGR of the index of the severity of poverty is smaller than those of the poverty gap ratio and the incidence of poverty. This implies that during the period 1996–2007, the impact of economic growth in Cameroon was more beneficial to the poor than to the ultra-poor.

Cameroon recovered economic growth during the period 1994–2007, after witnessing a period of economic crisis which began in 1987. More important still, our results have shown that its growth process, which started during the period 1996–2007 was pro poor, thus benefiting more proportionally to the poor than to the non poor. This may be attributed to the reforms undertaken by the government which were combined with the devaluation of the CFA franc relative to the French franc that took place in January 1994.

Table 3 Poverty Equivalent Growth Rate (PEGR)

Actual growth rate		Poverty Equivalent Growth Rate (PEGR)		
		Headcount ratio P_0	Poverty gap P_1	Squared poverty gap P_2
1996–2001	0.158033	0.247099	0.151158	0.114622
2001–2007	0.041264	0.077905	0.094426	0.102747
1996–2007	0.205818	0.344883	0.246638	0.221730

Source: Computed by the Author from ECAM1, ECAM2 and ECAM3 Survey data

4.4 Decomposition of Changes in Poverty

Table 4 presents the decomposition of changes in poverty into growth and redistribution components method in Cameroon according to the Kakwani (1997) method over the period 1996–2007. We note that the decline in all the three poverty measures, namely the incidence of poverty, the poverty gap index, and the poverty gap index squared was explained by the change in growth rather than the change in the distribution. The growth component dominates the redistribution component in all the sub-periods and over the entire period of the study in terms of contribution to the fall in poverty.

Table 4 Decomposition of Changes in Poverty (1996–2007)

Period	Poverty change	Growth Component	Redistribution Component
		Headcount Index P_0	
1996–2001	−0.135818	−0.083241	−0.052577
2001–2007	−0.045056	−0.023341	−0.021715
1996–2007	−0.180874	−0.107790	−0.072933
		Poverty Gap Ratio P_1	
1996–2001	−0.057562	−0.039807	−0.017755
2001–2007	−0.030402	−0.009074	−0.021328
1996–2007	−0.087965	−0.049785	−0.038180
		Squared Poverty Gap Ratio P_2	
1996–2001	−0.028094	−0.022178	−0.005916
2001–2007	−0.021462	−0.004608	−0.016855
1996–2007	−0.049556	−0.026689	−0.022868

Source: Computed by the Author from ECAM1, ECAM2 and ECAM3 Survey data

Between 1996 and 2001, both the growth and redistribution components contributed to the reduction of poverty. Economic growth explained 8.32 percentage points of the decline in the poverty ratio, while the redistribution component explained but 5.25 percentage points of the fall in the poverty ratio.

Similarly, economic growth explained 3.98 percentage points of the decline in the poverty gap index squared, and 2.21 percentage points of the decline in the poverty gap index squared, while redistribution explained a marginal 1.77 percentage point and 0.59 percentage point of the decline in the poverty gap index and the poverty gap index squared respectively.

The same trend is observed over the period 2001–2007 in which both the growth and redistribution components contributed to the decline in poverty although the total fall in poverty was more pronounced over the 1996–2001 sub-period.

Over the entire period of the study from 1996 to 2007, the incidence of poverty fell by 18.08 percentage points, while the poverty gap index and the poverty gap index squared fell by 8.79% and 4.75%

respectively. This enormous fall in absolute poverty was attributed to the increase in economic growth witnessed by Cameroon over the survey period.

We may conclude this section by saying that during the 1996–2001 period Cameroon witnessed rapid economic growth, poverty reduction, and an increase in income inequality. In addition, the poverty equivalent growth rate (PEGR) analysis indicates that the growth process was pro-poor, and the decline in absolute poverty was mainly explained by the growth component according to the Kakwani (2007) decomposition of changes in poverty. During the 2001–2007 period economic growth slowed down, poverty decreased marginally, and inequality also decreased as compared with that of the 1996–2001 period. The PEGR shows that growth was pro poor, and again, the decline in absolute poverty was mainly explained by the growth component of poverty reduction.

All in all, during the entire period of the study, poverty declined (and inequality increased in the period 1996–2001), economic growth was pro poor, and the growth component of poverty reduction overwhelmingly explained poverty reduction.

CONCLUSION AND ECONOMIC POLICY IMPLICATIONS

The purpose of this study was to analyze pro poor growth in Cameroon to determine the relationship between growth, poverty and income distribution, using the data drawn from the Cameroonian household surveys ECAM1, ECAM2 and ECAM3 conducted by the National Institute of Statistics (NIS) of Cameroon, respectively in 1996, 2001 and 2007. We used as an indicator of pro poor growth, the poverty equivalent growth rate (PEGR) of Kakwani et al. (2004) to find how growth affected the poor in Cameroon during the period 1996–2007.

The estimation results of the poverty equivalent growth rate (PEGR) show that growth was pro poor for the poverty ratio, the poverty gap index, and the poverty gap index squared, both during the two sub-periods 1996–2001 and 2001–2007, as well as over the entire period of the study 1996–2007, meaning that the poor received proportionally more benefits than the non poor. This result is due to the fact that the impact of improved inequality reinforced the favourable impact of growth and led to a larger reduction in poverty than if inequality had remained constant. This result suggests that to achieve the poverty reduction objective, instead of increasing the growth alone, the poverty equivalent growth rate (PEGR) should be maximized, meaning that on the one hand, the growth rate must be boosted and, on the other hand, the income distribution also should concurrently be improved.

Moreover, to quantify the specific impacts of growth and income distribution on the reduction of poverty, we carried out a decomposition of changes in poverty during the periods 1996–2001, 2001–2007 and 1996–2007 using the decomposition of changes in poverty (Kakwani, 1997). The results reveal that the level of absolute poverty declined during the periods 1996–2001, 2001–2007 and 1996–2007, and the growth component overwhelmingly dominated the redistribution component in the reduction of the level of poverty. As concerns policy formulation, the above results emphasize the importance of sustained economic growth in the reduction of the incidence of poverty. However, despite the dominance of the growth component, it has been observed that inequality as well as poverty decreased during the 2001–2007 period. This result thus highlights the fact that economic growth alone should not be the only priority in the poverty reduction process. It is essential that an efficient income distribution policy which mainly targets the poor in society should also be undertaken.

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References

ADELMAN, I. AND MORRIS, C. T. *Economic Growth and Social Equity in Developing Countries.* Stanford, CA: Stanford University Press, 1971.

AHLUWALIA, M. S. Inequality, Poverty and Development. *Journal of Development Economics*, 1976, Vol. 3(4), pp. 307–42.

ALESINA, A. AND RODRIK, D. Distributive Policies and Economic Growth. *Quarterly Journal of Economics*, 1994, 109, pp. 465–490.

ANAND, S. AND KANBUR, S. M. R. The Kuznets Process and the Inequality Development Relationship. *Journal of Development Economics*, 1984, Vol. 40, pp. 25–52.

ARAAR, A. AND DUCLOS, J. Y. *User Manual for Stata Package DASP: Version 2.1: PEP.* World Bank, UNDP and Université Laval, 2009.

BAYE, M. F. Growth, Redistribution and Poverty Changes in Cameroon: A Shapley Decomposition Analysis. *Journal of African Economies*, 2006, Vol. 15, No. 4.

BHAGWATI, J. N. *Poverty and Public Policy*. World Development Report, 1988, Vol. 16(5), pp. 539–654.

BOURGUIGNON, F. *Can redistribution accelerate growth and development?* Paper presented at the World Bank ABCDE Europe Conference, Paris, 2000.

CHENERY, H. AND AHLUWHALIA, M. *Redistribution with Growth.* Oxford: Oxford University Press, 1974.

CHRISTIANENSEN, L., DEMERY, L., PATERNOSTRO, S. *Economic Growth and Poverty in Africa: Message from the 1990s.* World Bank, unpublished, 2002.

COWELL, F. A. Measurement of inequality. In: ATKINSON, A. B. AND BOURGUIGNON, F. eds. *Handbook of income distribution*, North Holland: Elsevier, 2000, Vol. 1, pp. 87–166.

DATT, G. AND RAVALLION, M. Growth and Redistribution Component of changes in poverty measures: A Decomposition with applications to Brazil and India in the 1980s. *Journal of Development Economics*, 1992, Vol. 38, pp. 275–95.

DEATON, A. S. AND MUELLBAUER, J. On measuring child costs: with applications to poor countries. *Journal of Political Economy*, 1986, Vol. 94(4), pp. 720–744.

DEATON, A. AND PAXSON, C. Economies of scale, household size, and the demand for food. *Journal of Political Economy*, 1998, Vol. 106(5), pp. 897–930.

DEININGER, K. AND SQUIRE, L. Measuring income inequality: a new data-base. *World Bank Economic Review*, 1996, Vol. 10(3), pp. 565–91.

DOLLAR, D. AND KRAAY, A. Growth is Good for the Poor. *Journal of Economic Growth*, 2002, Vol. 7, pp. 195–225.

DOLLAR, D. Reform, Growth, and Poverty Reduction in Vietnam. *Policy Research Working Paper No. 2837*, Washington D.C.: World Bank, 2002.

DSCN/MINEFI. *Enquête Camerounaise Auprès des Ménages (ECAMI)*. Yaoundé, Cameroun, 1996.

DUBOIS, J. L. AND AMIN, A. A. *An Update of the Cameroon Poverty Profile Reducing the Current Poverty and Tempering the Increase in Inequality.* A World Bank Study, 2000.

FAMBON, S., MCKAY, A., TIMNOU, J. P., KOUAKEP, O. S., DZOSSA, A., TCHAKOUTE, R. Growth, poverty, and inequality: the case study of Cameroon. *WIDER Working Paper 154*, November 2014.

FAMBON, S. *Comparisons of Urban and Rural Poverty determinants in Cameroon.* Final Report, African Economic Research Consortium, Nairobi, Kenya, 2013.

FAMBON, S. Poverty and Growth in Cameroon during the Post Devaluation Period (1996–2001). *Journal of African Studies and Development*, 2010, Vol. 2(4), pp. 81–98.

FAMBON, S. Pauvreté, croissance et redistribution au Cameroun. In: MOURJI, F., DECALUWE, B., PLANE, P. *Le Développement face à la pauvreté*, Economica, 2006.

FAMBON, S. Croissance économique, pauvreté et inégalité des revenus au Cameroun. *Revue d'économie de développement*, Economica, 2005.

FAMBON, S., AMIN AJAB, A., BAYE MENJO, F., NOUMBA, I., TAMBA, I., TAWAH, R. *Pauvreté et Répartition des Revenus au Cameroun durant les Années 1990* [online]. Research papers 1–6 of the University of Laval, 2000. <http://www.crefa.ecn.ulaval.ca/cahier/liste01.html>.

FIELDS, G. S. *Changes in poverty and inequality in the developing countries.* Mimeo, 1989.

FORBES, K. A Reassessment of the Relationship Between Inequality and Growth. *American Economic Review*, 2000, Vol. 90, pp. 869–97.

FOSTER, J., GREER, J., THORBECKE, E. A Class of Decomposable Poverty Measures. *Econometrica*, 1984, Vol. 52(3), pp. 761–766.
INS. *Enquête Camerounaise Auprès des Ménages (ECAMIII)*. Yaoundé, Cameroun: Institut National de la Statistique, 2007.
INS. *Enquête Camerounaise Auprès des Ménages (ECAMII)*. Yaoundé, Cameroun: Institut National de la Statistique, 2001.
JENKINS, S. P. AND VAN KERM, P. Trends in income inequality, pro-poor income growth, and income mobility. *Oxford Economic Papers*, 2006, Vol. 58, No. 3, pp. 531–548.
LANJOUW, P. AND RAVALLION, M. Poverty and household size. *The Economic Journal*, 1995, Vol. 105(433), pp. 1415–1434.
LYNCH, S. G. *Income Distribution, Poverty and Coonsumer Prefences in Cameroon.* Cornell Food and Nutrition Policy Program,Washington D.C., 1991.
JAIN, L. R. AND TENDULKAR, S. D. The Role of Growth and Redistribution in the Observed Change in Head-count Ratio Measure of Poverty: A Decomposition Exercise for India. *Indian Economic Review*, 1990, Vol. XXV, pp. 165–205.
KAKWANI, N. On Measuring Growth and Inequality Components of Poverty with Applications to Thailand. *Discussion Paper,* School of Economics, The University of New South Wales, Australia, 1997.
KAKWANI, N. C. AND PERNIA, E. M. What is Pro-Poor Growth? *Asian Development Review*, 2000, Vol. 18(1), pp. 1–16.
KAKWANI, N. AND SON, H. H. *Pro-Poor Growth and Poverty Reduction: The Asian Experience.* The Poverty Center, Office of the Executive Secretary, Bangkok: ESCAP, 2002.
KAKWANI, N., KHANDKER, S., SON, H. H. Pro-Poor Growth: Concepts and Measurement with Country Case Studies. *Working Paper Number* 1, International Poverty Centre, Brasilia, 2004.
KAKWANI, N. AND SON, H. H. Poverty Equivalent Growth Rate. *Review of Income and Wealth*, 2008, Vol. 54(4), pp. 643–655.
KALDOR, N. Alternative Theories of Distribution. *Review of Economic Studies*, 1956, Vol. 23, pp. 83–100.
KRAVIS, I. B. International Differences in the Distribution of Income. *Review of Economics and Statistics*, 1960, Vol. 42, pp. 408–16.
KUZNETS, S. Economic Growth and Income Inequality. *American Economic Review*, 1955, Vol. 45, pp. 1–28.
LI, H. AND ZOU, H. Income Inequality is Not Harmful for Growth: Theory and evidence. *Review of Development Economics*, 1998, Vol. 2(3), pp. 318–334.
MCCULLOCH, N., ROBSON, M., BOULCH, B. *Growth, Inequality and Poverty in Mauritania: 1987–1996*. IDS working paper, Sussex: Institute of Development Studies, 2000.
OSHIMA, H. International comparison of size distribution of family incomes with special reference to Asia. *Review of Economics and Statistics*, 1962, Vol. 44, pp. 439–45.
OSHIMA, H. Kuznets curve and Asian income distribution. In: MIZOGUCHI, T. eds. *Making Economies More Efficient and More Equitable: Factors Determining Income Distribution*, Economic Research Series, No. 29, The Institute of Economic Research, Hitotsubashu University, Tokyo: Oxford University Press, 1994.
PAUKERT, F. Income Distribution at different levels of development: a survey of evidence. *International Labour Review*, 1973, Vol. 108(2), pp. 97–125.
RAM, R. Economic development and income inequality: further evidence on the U-curve hypothesis. *World Development*, 1988, Vol. 16(11), pp. 1371–1376.
RAVALLION, M. AND CHEN, S. Measuring Pro-poor Growth. *Economic Letters*, 2003, Vol. 78 (1), pp. 93–99.
RAVALLION, M. AND HUPPI, M. Measuring changes in poverty: a methodological case study of Indonesia during an adjustment period. *World Bank Economic Review*, 1991, Vol. 5, pp. 57–84.
RAVALLION, M. AND CHEN, S. Measuring Pro-poor Growth. *Economic Letters*, 2003, Vol. 78(1), pp. 93–99.
RAVALLION, M. *Pro-poor Growth: A Primer*. Development Research Group, Washington D.C.: World Bank, 2004.
ROBINSON, S. Sources of Growth in Less Developed Countries. *Quarterly Journal of Economics*, 1976, Vol. 85(3), pp. 391–408.
SHORROCKS, A. F. *Decomposition Procedures for Distributional Analysis: A Unified Framework Based on the Shapley Value.* Mimeo, University of Essex, 1999.
SON, H. H. A Note on Pro-Poor Growth. *Economics Letters*, 2004, Vol. 82, pp. 307–314.
WHITE, H. AND ANDERSON, E. Growth versus Distribution: Does the pattern of growth matter? *Development Policy Review*, 2001, Vol. 19(3), pp. 267–289.
WORLD BANK. *World Development Report 1990.* New York: Oxford University Press, 2000.
WORLD BANK. *World Development Report 2006: Equity and Development.* Washington D.C.: World Bank, 2005.

Regional Price Levels in the Czech Republic

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Abstract

International comparison belongs to statistical topics which attracts either experts or general public. Official statistics provides estimates of national price levels only. Therefore, official regional analysis is based on national price levels and does not take into account potential differences in prices among regions within a country. Fortunately, researchers have been dealing with them and estimates for several countries are available.

The topic is also important in the Czech Republic even two papers focused on regional price levels were published in *Statistika* journal in 2016. The aim of the paper is to compare both approaches from various perspectives.[2]

Keywords

Regional price levels, comparison, Czech Republic

JEL code

R10

INTRODUCTION

International comparison of economic indicators started in 1960s. In the beginning, economic indicators were transformed to the same currency (e.g. US dollar) using exchange rate. On one hand, the method is very easy, on the other hand, exchange rate does not reflect actual difference in price levels. At the best case, it describes price relations of negotiable products. Highly sophisticated approach has been developed by international institutions. The approach is based on expenditure side and covers all products in the economy including non-negotiable ones, for more details see Eurostat-OECD Methodological Manual on Purchasing Power Parities (EC, OECD, 2012). Indicators at national currencies are transformed to the artificial currency PPS (purchase power standard) using purchase power parities (PPPs) that express actual price differences.

Regional accounts may be considered as national accounts for a region. Actually, a limited set of indicators is available for many countries because of restricted data sources and severity of compilation. European standard on national accounts ESA 2010 (EC, 2013) does not requires expenditure components of GDP at regional level. Regional price levels are not officially compiled, nevertheless they have been estimated in several countries by researchers.

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2 Editor's note: another discussion paper comparing these two articles focused on regional price levels (both published in *Statistika: Statistics and Economy Journal* in 2016) will be published in the next *Statistika* issue No. 3/2017.

1 STATE OF THE ART IN THE CZECH REPUBLIC

Kramulová et al. (2016) and Kocourek et al. (2016) published papers focused on regional price levels in *Statistika* journal in 2016. This is undoubtedly a current issue desired in academic community. Both author teams declare more or less the same goal: to assess price differences among regions of the Czech Republic. It seems that research has been carried out independently as approaches are slightly different.

1.1 Methodology

Both papers offer an extensive literature review. Readers are apprised of approaches in other countries (e.g. Germany, China, UK, USA, Slovakia). Kramulová et al. (2016) provide the follow up to the previous research and describe only changes in methodology. Original methodology can be found in Čadil et al. (2014). Kocourek et al. (2016) introduce their methodology and data sources.

Generally, both author teams argue that their methodology is more or less based on the international recommendations given in Eurostat-OECD Methodological Manual on Purchasing Power Parities (hereafter Manual). However, differences compared to the Manual are not negligible and may have an impact on the results. Both approaches are focused on household expenditure only though this indicator is not officially published within regional accounts. It is obvious that the main reason is the interest in living conditions of households. Nevertheless, I see the research challenge to estimate regional price level for GDP (including other expenditure components). It would improve interregional analysis of economic performance. As mentioned, regional GDP by expenditure approach is not published by official statistics, but estimated by researchers (Sixta and Vltavská, 2016).

Both teams follow the Manual in estimating weights and aggregation methods. Weights are based regional consumption baskets estimated independently and the EKS method (Éltetö-Köves-Szulc) is applied for aggregation. A data collection is carried out for international comparison that cannot be used for regional price levels. The Czech Statistical Office conducts monthly price collection for consumer price index which is carried out in 35 districts representing about 50% districts in the Czech Republic (CZSO, 2016). It should be mentioned that prices of selected products are not surveyed by interviewers in stores but they are collected centrally i.e. no regional data are available. Moreover, data collection is designed to provide reliable results for the Czech Republic but representativeness at regional level is not ensured. This data source is used in both papers and it should be emphasized in order to acquaint the users with the limits of the results even though data were checked and processed.

As prices for some products in some regions were missing they had to be estimated. Both approaches are based on similar methods (e.g. bridging) that are recommended in the Manual. Above that, regional prices for selected products are not available at all. Kramulová et al. (2016) stated that e-commerce has become more common which leads to the decrease in regional differences. An important item for which regional prices are not available is rent which influences regional price levels significantly. Completely different approaches were applied by both teams. Kramulová et al. (2016) more or less follow the Manual (chapter 6) and use mainly stratification method. Rent of dwellings for which stratification method is not applied was estimated using model approach that is based on prices of buildings. The approach of Kocourek et al. (2016) is inspired by Melser and Hill (2007) and it is based on mortgages repayments. It should be mentioned that mortgages repayments are considered as consumption expenditure neither in national accounts nor in household budget survey. Melser and Hill (2007) published quite comprehensive article where approaches to spatial analysis are compared and discussed. They argued that payments approach is problematic (Melser and Hill, 2007, p. 28). The paper is mainly focused on practice in New Zealand. Apart from the Czech approach, CPI in New Zealand comprises also purchase and construction of dwellings (Melser and Hill, 2007, p. 83). It means that weighting scheme of CPI is based on a different concept including investments to dwellings. It may have an impact of results as the used approach measures something that is not included in the weighting scheme.

1.2 Results

Kramulová et al. (2016) published just regional price levels for NUTS 3 ('kraje') without any additional breakdown. Authors also performed comparison with the previous research and analyzed differences between regional price levels for 2007 and 2012. Revaluation of regional net disposable income of households to regional price levels was carried out. Next authors discussed comparability of results for 2007 and 2012 as several changes occurred in meantime.

Kocourek et al. (2016) presented a set of extensive results. Regional price levels are published for each district broken down by COICOP classification (12 divisions). Aggregation to NUTS 3 and NUTS 2 regions is also carried out. Authors were able to estimate directly regional price levels in regions where data collection is performed. Regional price levels in other districts were estimated using regression analysis as the similar approach was applied by Roos (2006) for German regional price levels. However, approaches are not completely the same; Roos (2006) used fewer predictors such as GDP per capita. It is obvious that these predicators cannot be applied at district level in the Czech Republic. Kocourek et al. (2016) used different predicators for each division of COICOP classification. Although statistical significance of all parameters was proved, the factual dependence may be questionable. For instance, authors identified a relation between prices of alcoholic beverages (purchased in outlets), tobacco and narcotics (COICOP 02) and number of business units operating in the field of accommodation and food services activities per 1 000 inhabitants and also number of business units operating in the field of arts, entertainment and recreation per 1 000 inhabitants.

The comparison of results is shown in Table 1. Unsurprisingly, the highest price level is observed in Hlavní město Praha according to both approaches. Kramulová et al. (2016) estimated regional price level at 122.3 whereas Kocourek et al. (2016) at 117.1. The reasoning is provided in both papers. Generally, the differences in price levels are recorded in Kramulová et al. (2016) as standard deviation is 6.8 than in Kocourek et al. (standard deviation 4.8). Except Hlavní město Praha estimated regional price levels differ less than 5 p.p.

Table 1 Comparison of results

	Regional price levels		
Region	**Kramulová et al. (2016)**	**Kocourek et al. (2016)**	**Difference (p.p.)**
Hlavní město Praha	122.3	117.1	5.2
Středočeský kraj	106.3	104.8	1.5
Jihočeský kraj	99.0	99.7	–0.7
Plzeňský kraj	100.0	100.1	–0.1
Karlovarský kraj	99.9	97.7	2.2
Ústecký kraj	96.7	97.4	–0.7
Liberecký kraj	100.5	101.4	–0.9
Královehradecký kraj	96.7	101.2	-4.5
Pardubický kraj	96.2	100.1	–3.9
Kraj Vysočina	93.1	97.7	–4.6
Jihomoravský kraj	100.6	103.0	–2.4
Olomoucký kraj	96.9	99.2	–2.3
Zlínský kraj	97.5	101.5	–4.0
Moravskoslezský kraj	97.2	98.9	–1.7

Source: Own construction, Kramulová et al. (2016), Kocourek et al. (2016)

CONCLUSION

I highly appreciate that researchers have dealt with regional price levels in the Czech Republic. I find the issue very important as it has an impact on regional indicators. Nevertheless, official statistics will probably never estimate regional price levels as source data are very limited or not available at all. Users should keep in mind that estimated regional price levels are less reliable than national price levels because of above mentioned reasons. As the methodology differs the results vary but the main findings are more or less the same. I assume that the main reason of different results is a dissimilar approach to dwelling services. Users whose attention is drawn to macroeconomic statistics would probably prefer research conducted by Kramulová et al. (2016). I see the main advantage in consistency with national accounts indicators in terms of the same principles, definitions and breakdowns. General public probably identify with the second research that offers more detailed results which enable to compare districts. Detailed regional analysis can also benefit from the detailed breakdown though reliability is lower. Nevertheless, results are dependent on selected predictors and their factual and statistical relationships to regional price levels.

References

ČADIL, J., MAZOUCH, P., MUSIL, P., KRAMULOVÁ, J. True Regional Purchasing Power: Evidence from the Czech Republic. *Post-Communist Economies*, 2014, Vol. 26, No. 2, pp. 241–256.

CZSO. *Inflation – Types, Definition, Tables* [online]. Prague: Czech Statistical Office, 2016. [cit. 1.3.2017]. < https://www.czso.cz/csu/czso/inflation_rate >.

EUROPEAN COMMISSION. *European System of Accounts (ESA 2010)*. Luxembourg: Publications Office of the European Union. 2013.

EUROPEAN COMMISSION / OECD. *Eurostat-OECD Methodological Manual on Purchasing Power Parities*. 2nd Ed. Luxembourg: Publications Office of the European Union, 2012.

KRAMULOVÁ J., MUSIL, P., ZEMAN, J., MICHLOVÁ R. Regional Price Levels in the Czech Republic – Past and Current Perspectives [online]. *Statistika: Statistics and Economy Journal*, 2016, Vol. 96, Iss. 3, pp. 22–34.

KOCOUREK A., ŠIMANOVÁ, J., ŠMÍDA J. Estimation of Regional Price Levels in the Districts of the Czech Republic [online]. *Statistika: Statistics and Economy Journal*, 2016, Vol. 96, Iss. 4, pp. 56–70.

MELSER, D. AND HILL, R. Methods for Constructing Spatial Cost of Living Indexes. *Official Statistics Research Series*, 2007, Vol. 1, pp. 1–113.

ROOS, M. W. Regional price Levels in Germany. *Applied Economics*, 2006, Vol. 38, Iss. 1, pp. 1553–1566.

SIXTA, J. AND VLTAVSKÁ, K. Regional Input-output Tables: Practical Aspects of its Compilation for the Regions of the Czech Republic. *Ekonomický časopis*, 2016, Vol. 64, Iss. 1, pp. 56–69.

Recent Publications and Events

New publications of the Czech Statistical Office

Export and Import Price Indices in the Czech Republic in 2016. Prague: CZSO, 2017.
Focus on women, on men. Prague: CZSO, 2016.
Indicators of Social and Economic Development of the Czech Republic 2000 – 4th quarter 2016. Prague: CZSO, 2017.
Vývoj ekonomiky České republiky v roce 2016. Prague: CZSO, 2017.

Conferences

The ***61st ISI World Statistics Congress*** will take place in **Marrakech, Morocco, from 16th to 21st July 2017**. More information available at: *http://www.isi2017.org*.

The ***20th International Scientific Conference Applications of Mathematics and Statistics in Economics (AMSE 2017)*** will this year be held in **Szklarska Poręba, Poland, from 30th August to 3rd September 2017**. This scientific conference is organized each year by the Faculty of Informatics and Statistics of the University of Economics in Prague (the Czech Republic), Wrocław University of Economics (Poland) and the Faculty of Economics of Matej Bel University in Banská Bystrica (Slovakia). The conference aims to acquaint its participants with the latest mathematical and statistical methods that can be used in solving theoretical and practical problems and challenges of economics. More information available at: *http://amse.ue.wroc.pl*.

The ***19th Joint Czech-German-Slovak Conference on Mathematical Methods in Economy and Industry (MMEI)*** will take place in **Jindřichův Hradec, Czech Republic, during 4–8 September 2017**. More information available at: *http://www.karlin.mff.cuni.cz*.

The ***25th Interdisciplinary Information Management Talks (IDIMT 2017)*** will be held in **Poděbrady, Czech Republic, from 6th to 8th September 2017**. More information available at: *http://www.idimt.org*.

The ***35th International Conference on Mathematical Methods in Economics (MME 2017)*** will take place in **Hradec Králové, Czech Republic, during 13–15 September 2017**. The conference is a traditional meeting of professionals from universities and businesses interested in the theory and applications of operations research and econometrics. More information available at: *http://fim2.uhk.cz/mme*.

The ***11th International Days of Statistics and Economics (MSED 2017)*** will take place in **Prague, Czech Republic, during 14–16 September 2017**, organized by the Department of Statistics and Probability and the Department of Microeconomics, University of Economics, Prague, Czech Republic, Faculty of Economics, Technical University of Košice, Slovakia, and Ton Duc Thang University, Vietnam. The aim of the conference is to present and discuss current problems of statistics, demography, economics and management and their mutual interconnection. More information available at: *https://msed.vse.cz*.

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