

FUNCTIONAL STRUCTURE OF POLISH REGIONS IN THE PERIOD 2004-2013 – MEASUREMENT VIA HHI INDEX, FLORENCE’S COEFFICIENT OF LOCALIZATION AND CLUSTER ANALYSIS

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ABSTRACT

The article addresses the measurement and identification problems covering particular social and economic areas (referred to as functions) in the regions of the country, based on the employment structure analysis and assessment by the sectors of the economy. The Herfindahl-Hirschman index was applied to measure sectoral concentration and Florence’s coefficient of localization to determine regional functional specialization. Finally, cluster analysis was conducted to produce the functional typology of regions.

Key words: regional economy, dominating functions, functional specialization, typology of regions.

1. Introduction

Economic base theory remains one of the most popular concepts explaining local and regional development (see Sokołowski, 2006, pp. 33-35; Markowski, 2008; Korenik and Zakrzewska-Półtorak, 2011, pp. 23-35). The socio-economic structure of each area is determined by a system which is both complex and complicated, and which covers social and economic fields of population activity influenced by past and present management status and natural conditions. These fields are referred to as functions of particular territorial units or settlement systems in different spatial scale.

Economic base theory allows for identifying two groups of functions, i.e. exogenous (directed outside a particular territorial unit) and endogenous (related to meeting the needs of the community of this unit). Therefore, it facilitates the identification of those functions which determine the development of particular

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locations, cities or regions, since its basic assumption is to support the above-mentioned development by export-oriented (exogenous) activities. Hence, external demand for goods or services produced in a given territorial unit area (e.g. a region) is considered the most important incentive of its economic growth.

Both measurement and identification of functions are generally performed based on the employment structure analysis and assessment in accordance with local and regional economy fields (see Obrębalski, 1989, pp. 25-29). An economic base of a territorial unit is reflected by the quantitative proportions of employment in particular activity areas. Its precise and direct measurement remains, however, a complicated and laborious task. It would have to involve a detailed analysis of goods and services sales in terms of their volume and direction with reference to each entity running a business in the area of the studied territorial unit. Therefore, both in theory and practice, the identification and measurement of the economic base is commonly performed using indirect methods. One of them is the method called by R.B. Andrews the macrocosmic method (see Dziewoński, 1971, p. 49). It consists in the identification of the economic base size by comparing the employment structure in the analysed territorial unit against the general employment structure in a larger scale unit, e.g. a country. This method commonly applies two measures, namely Florence's local specialization coefficient (localization quotient) and Hoyt's employment surplus coefficient (Jerczyński, 1973, p. 38). This method is extensively applied, for instance, in functional specialization (see Dacko, 2009, pp. 25-34; Karmowska, 2011, pp. 85-93; Gwosdz, 2012, pp. 21-23) and in the economic base differentiation research (see Sokołowski, 2008, pp. 254-257).

In practice, numerous studies have been conducted regarding the coefficient of localization application to measure the functional specialization level of each region in a country. The specialization index was, among others, applied in the study (Angulo, Mur and Trivez, 2014) to separate sectors in which Spanish regions were specializing in 2010. The study covered 6 sectors of the economy and 47 regions (NUTS-3). The specialization analysis of 13 Greek regions (NUTS-2) in the system of three sectors of the economy in 2007 was performed in the study by (Christofakis and Gkouzos, 2013).

The cognitive and practical purpose of the this paper is to discuss the level and scope of the differentiation between functions with reference to particular regions (NUTS-2 – voivodships). The study of sectoral concentration, specialization and typology of Polish regions in the period 2004-2013 with application of the research method covering the combined application of cluster analysis and Herfindahl-Hirschman index is a pioneering one on Polish market. Identification and measurement of the functional structures of Polish regions in terms of the dynamics is important primarily because of its scope and direction of the socio-economic transformation, as well as the apparent dearth of current research and information in this regard. The results of the study will extend the information base for monitoring national regional policy and developmental policies of individual regions.

2. Sectoral structure of Polish economy

The research covering functional concentration and specialization of Polish regions will be conducted by sectors for the years 2004 and 2013. Due to the fact that Polish Classification of Activities (PCA) was changed in the period under analysis, Table 1 presents Polish economy sectoral structure in accordance with 2004 PCA and 2007 PCA.

Table 1. Polish economy sectoral structure in accordance with 2004 PCA and 2007 PCA

| Sectors | 2013 | | 2004 | | |
|---|-----------------|---|-----------------|--|---|
| | Sections / name | | Sections / name | | |
| S_1. Agriculture | A | Agriculture, hunting, forestry and fishing | A | Agriculture, hunting and forestry | |
| | B | | Fishing | | |
| S_2. Industry and construction | B | Mining and quarrying | C | Mining and quarrying | |
| | C | Manufacturing | D | Manufacturing | |
| | D | Electricity, gas, steam and air conditioning supply | E | Electricity, gas and water supply | |
| | E | | | | Water supply; sewerage, waste management and remediation activities |
| | F | Construction | F | Construction | |
| Market services (S_3 and S_4) | | | | | |
| S_3. Logistic support of the population and companies | G | Trade; repair of motor vehicles | G | Trade and repair | |
| | H | Transportation and storage | I | Transport, storage and communication | |
| | J | | | | Information and communication |
| | I | Accommodation and catering | H | Hotels and restaurants | |
| S_4. Entrepreneurship development support | K | Financial and insurance activities | J | Financial intermediation | |
| | L | Real estate, renting and business activities | K | Real estate, renting and business activities | |
| | M | | | | Professional, scientific and technical activities |
| | N | | | | Administrative and support service activities |

Table 1. Polish economy sectoral structure in accordance with 2004 PCA and 2007 PCA (cont.)

| Sectors | 2013 | | 2004 | |
|--------------------------|-----------------|---|-----------------|---|
| | Sections / name | | Sections / name | |
| S_5. Non-market services | O | Public administration and defence; compulsory social security | L | Public administration and defence; compulsory social security |
| | P | Education | M | Education |
| | Q | Human health and social work activities | N | Health and social work |
| | R | Arts, entertainment and recreation | O | Other community, social and personal service activities |
| | S | Other service activities | | |
| | T | Activities of households as employers and products-producing activities of households for own use | P | Private household with employed persons |
| | U | Extra-territorial organizations and bodies | Q | Extra-territorial organizations and bodies |

Source: for 2013 – Regulation by the Council of Ministers regarding Polish Classification of Activities (PCA) (Journal of Laws from 2007 no. 251, item 1885 and from 2009 no. 59, item 489). For 2004 – Regulation by the Council of Ministers regarding Polish Classification of Activities (PCA) (Journal of Laws from 2004 no. 33, item 289).

PCA sections are grouped in 5 sectors: agriculture, industry and construction, logistic support of the population and companies, entrepreneurship development support and non-market services. The basis for determining market services of two separate sectors in the system was the similarity of types and scope of activities (see Obrębałski, 2012, p. 116).

3. Research methodology for functional structures of regions

The article presents the conducted research covering functional structures of regions referring to the following problems:

- determining the dominant functions of regions,
- identifying the functional specialization of regions,
- conducting the functional typology of regions.

In order to define the dominant functions of regions the percentage of the share employment by sectors of the economy was calculated. Herfindahl-

Hirschman index was applied to measure sectoral concentration (dominance) of regions (Herfindahl, 1950; Hirschman, 1964):

$$HHI_i = \sum_{j=1}^m b_j^2, \quad (1)$$

where: $i = 0, 1, \dots, n$ – object number (0 refers to a country whereas $1, \dots, n = 16$ refers to the number of regions)

$$b_j = \frac{Z_{ij}}{\sum_{j=1}^m Z_{ij}} \cdot 100\% \text{ – for regions,}$$

$$b_j = \frac{Z_{\cdot j}}{\sum_{j=1}^m Z_{\cdot j}} \cdot 100\% \text{ – for a country,}$$

$j = 1, \dots, m = 5$ – the number of the sector of the economy.

Herfindahl-Hirschman Index (*HHI*) is the most well-known measure of specialization and concentration constructed on the basis of structural data in economics (Calkins, 1983). In Polish literature specialization and concentration indices (with *HHI* index) are presented, among others, in the studies by Szyrmer (1975) and Kukuła (1976).

HHI_i index represented by (1) takes values form $\left[\frac{10,000}{m}; 10,000 \right]$ interval.

In the case of five sectors of the economy the index takes values from $[2,000; 10,000]$ interval. The higher the values from the bottom limit the higher the sectoral concentration in a particular region.

The coefficient of localization (also referred to as specialization ratio) introduced by P. Florence (Florence, 1939; Florence, 1944, p. 96), as presented below, was applied to identify and measure the specialized functions of regions:

$$S_{ij} = \frac{Z_{ij} / \sum_{j=1}^m Z_{ij}}{Z_{\cdot j} / \sum_{j=1}^m Z_{\cdot j}}, \quad (2)$$

where: S_{ij} – specialization coefficient of i -th territorial unit (region) in j -th sector of the economy,

Z_{ij} – employment in j -th sector in i -th territorial unit (region),

$Z_{\cdot j}$ – employment in j -th sector of the economy in a country,

$i = 1, \dots, n = 16$ – the number of the region.

In Polish literature it is presented, among others, in the studies by (Jerczyński, 1971, p. 126; Kostrubiec, 1972, p. 25; Runge, 2007).

Florence's coefficient of localization measures the share of employment ratio in j -th region sector against the share of employment in j -th sector of a country. Values higher than one indicate greater share of employment in a region than in a

country for a given sector. It means that a region specializes in a particular sector of the economy.

Cluster analysis was applied to conduct the functional typology of regions (see Walesiak, 2008; Walesiak, 2009). In order to identify the classes of similar regions, in terms of Florence's coefficient of localization values in 2004 and then in 2013, the following research procedure was applied:

- GDM1 distance was used for metric data to determine the distance matrix between regions in each year (see Walesiak, 2011, p. 39);
- hierarchical agglomeration method of the furthest neighbour was applied to divide 16 regions into relatively homogenous clusters. The results of cluster analysis were graphically presented by means of a dendrogram;
- Caliński-Harabasz index for quality assessment of classification results was adopted to determine the number of clusters into which the analysed 16 regions in 2004 and 2013 should be divided (see Walesiak, 2011, p. 61). Moreover, the identified divisions of the regions should remain stable. Replication analysis using *replication.Mod* function of *clusterSim* package was applied for the assessment of stability of the results of cluster analysis (see Walesiak and Dudek, 2015):
- adjusted Rand index was used to calculate agreement between two partitions of 16 regions for the years 2004 and 2013 (Hubert and Arabie, 1985),
- the profiles of the identified typological clusters were specified and the changes characteristic for the period 2004-2013 were assessed.

4. Dominant functions of regions

Each region is characterized by social, economic and spatial diversity. Table 2 presents information about functional diversification of regions in the years 2004 and 2013, identified based on employment structure by sectors.

In the period 2004-2013 the following multidirectional changes occurred in the employment sectoral structure in the national economy:

- the importance of the agricultural sector decreased (the share of employment in this sector field was reduced from 17.29% to 17.11% of the total employment in the national economy),
- the decreasing trend was also observed in the industry and construction sector (the share if this sector in the employment structure was reduced from 28.28% to 26.33%),
- the importance of logistics service for population and companies increased (its share went up from 23.53% to 24.34% of the total employment),
- the importance of the entrepreneurship development support sector went down (the share of employment in this sector decreased from 9.66% to 7.94%),
- the non-market services sector increased (the share of employment in this sector field went up from 21.25% to 24.27%).

Having analysed Herfindahl-Hirschman index values one should conclude that in the analysed period a slight increase in sectoral concentration in Poland was observed (*HHI* value increased from 2197 up to 2231).

Both in the entire country and in every of its regions the significant importance of the service-oriented activity identified according to fields is recognized (S_3, S_4 and S_5). In 2013, 56.6% of total employment was in the service sector. Among the service-oriented fields of population occupational activity the major role was played by commercial operations (15.3%), education, health care and social aid activity types.

The data referring to particular regions also confirm the dominating role of the broadly understood role of the service sector. In 2013 the highest level of the discussed dominance referred to the following regions: Mazowieckie (almost 68% of total employment), Zachodniopomorskie (63.6%), Pomorskie (62.8%) and Dolnośląskie (60.8%). On the other hand, the lowest level of dominance of the service function refers to such regions as: Podkarpackie (43.0%), Lubelskie (44.3%) and Świętokrzyskie (44.9%).

In relation to entities conducting activities in the fields covering logistics service of population and companies, the following regions were characterized by the highest share of employment in 2013: Mazowieckie (over 29.2% of total employment), Zachodniopomorskie (over 27.7%) and Pomorskie (almost 27.5%), whereas the lowest one – Podkarpackie (only 17.5%) and Lubelskie (17.7%).

On the other hand, entrepreneurship development support played a more significant role in the regional labour market structure of the following regions: Mazowieckie (almost 14% of total employment), while a relatively smaller one referred to Podkarpackie (less than 4%) and Świętokrzyskie regions (slightly more than 4%).

Table 2. Employment structure as well as concentration and specialization coefficients by Polish sectors and regions in the years 2004 and 2013

| Specification | Total | S_1 | S_2 | S_3 | S_4 | S_5 | <i>HHI</i> | |
|--------------------|----------|---------|---------|---------|---------|---------|------------|------|
| 2004 | | | | | | | | |
| P O L A N D | 12413284 | 2145668 | 3509917 | 2920913 | 1198803 | 2637983 | | |
| | % | 100 | 17.29 | 28.28 | 23.53 | 9.66 | 21.25 | 2197 |
| Dolnośląskie | 875865 | 75070 | 280775 | 221000 | 95851 | 203169 | | |
| | % | 100 | 8.57 | 32.06 | 25.23 | 10.94 | 23.20 | 2396 |
| | <i>S</i> | | 0.4959 | 1.1337 | 1.0723 | 1.1332 | 1.0915 | |
| Kujawsko-Pomorskie | 640041 | 118161 | 189486 | 141792 | 52780 | 137822 | | |
| | % | 100 | 18.46 | 29.61 | 22.15 | 8.25 | 21.53 | 2240 |
| | <i>S</i> | | 1.0680 | 1.0470 | 0.9415 | 0.8539 | 1.0133 | |
| Lubelskie | 724950 | 278582 | 131564 | 125631 | 38092 | 151081 | | |
| | % | 100 | 38.43 | 18.15 | 17.33 | 5.25 | 20.84 | 2568 |
| | <i>S</i> | | 2.2232 | 0.6418 | 0.7365 | 0.5441 | 0.9807 | |
| Lubuskie | 282474 | 27580 | 87674 | 72063 | 25675 | 69482 | | |
| | % | 100 | 9.76 | 31.04 | 25.51 | 9.09 | 24.60 | 2397 |
| | <i>S</i> | | 0.5649 | 1.0977 | 1.0842 | 0.9412 | 1.1575 | |

Table 2. Employment structure as well as concentration and specialization coefficients by Polish sectors and regions in the years 2004 and 2013 (cont.)

| Specification | Total | S_1 | S_2 | S_3 | S_4 | S_5 | HHI |
|---------------------|----------|---------|---------|---------|---------|---------|------|
| 2004 | | | | | | | |
| Łódzkie | 887833 | 192391 | 261680 | 187647 | 72295 | 173820 | 2235 |
| % | 100 | 21.67 | 29.47 | 21.14 | 8.14 | 19.58 | |
| S | | 1.2537 | 1.0424 | 0.8982 | 0.8432 | 0.9213 | |
| Małopolskie | 1011715 | 184121 | 271209 | 237231 | 92258 | 226896 | 2186 |
| % | 100 | 18.20 | 26.81 | 23.45 | 9.12 | 22.43 | |
| S | | 1.0529 | 0.9481 | 0.9965 | 0.9442 | 1.0553 | |
| Mazowieckie | 2024968 | 320826 | 449008 | 534272 | 303658 | 417204 | 2088 |
| % | 100 | 15.84 | 22.17 | 26.38 | 15.00 | 20.60 | |
| S | | 0.9166 | 0.7842 | 1.1213 | 1.5528 | 0.9695 | |
| Opolskie | 290772 | 50403 | 87799 | 63649 | 22366 | 66555 | 2274 |
| % | 100 | 17.33 | 30.20 | 21.89 | 7.69 | 22.89 | |
| S | | 1.0028 | 1.0679 | 0.9303 | 0.7965 | 1.0771 | |
| Podkarpackie | 635569 | 158887 | 179289 | 121908 | 40238 | 135247 | 2282 |
| % | 100 | 25.00 | 28.21 | 19.18 | 6.33 | 21.28 | |
| S | | 1.4463 | 0.9977 | 0.8152 | 0.6556 | 1.0013 | |
| Podlaskie | 388691 | 139540 | 74070 | 71839 | 23667 | 79575 | 2450 |
| % | 100 | 35.90 | 19.06 | 18.48 | 6.09 | 20.47 | |
| S | | 2.0769 | 0.6740 | 0.7855 | 0.6305 | 0.9634 | |
| Pomorskie | 656222 | 62582 | 196192 | 176256 | 71111 | 150081 | 2347 |
| % | 100 | 9.54 | 29.90 | 26.86 | 10.84 | 22.87 | |
| S | | 0.5517 | 1.0574 | 1.1415 | 1.1221 | 1.0762 | |
| Śląskie | 1491783 | 71369 | 565094 | 387078 | 148891 | 319351 | 2689 |
| % | 100 | 4.78 | 37.88 | 25.95 | 9.98 | 21.41 | |
| S | | 0.2768 | 1.3397 | 1.1027 | 1.0335 | 1.0073 | |
| Świętokrzyskie | 429552 | 144126 | 95412 | 82407 | 25008 | 82599 | 2391 |
| % | 100 | 33.55 | 22.21 | 19.18 | 5.82 | 19.23 | |
| S | | 1.9411 | 0.7856 | 0.8153 | 0.6028 | 0.9048 | |
| Warmińsko-Mazurskie | 386626 | 67343 | 110384 | 86668 | 29821 | 92410 | 2252 |
| % | 100 | 17.42 | 28.55 | 22.42 | 7.71 | 23.90 | |
| S | | 1.0077 | 1.0097 | 0.9527 | 0.7987 | 1.1247 | |
| Wielkopolskie | 1209924 | 210057 | 398498 | 274746 | 110424 | 216199 | 2304 |
| % | 100 | 17.36 | 32.94 | 22.71 | 9.13 | 17.87 | |
| S | | 1.0044 | 1.1648 | 0.9650 | 0.9450 | 0.8408 | |
| Zachodniopomorskie | 476299 | 44630 | 131783 | 136726 | 46668 | 116492 | 2372 |
| % | 100 | 9.37 | 27.67 | 28.71 | 9.80 | 24.46 | |
| S | | 0.5421 | 0.9785 | 1.2199 | 1.0146 | 1.1509 | |
| 2013 | | | | | | | |
| P O L A N D | 13919826 | 2382129 | 3665103 | 3388065 | 1105776 | 3378753 | 2231 |
| % | 100 | 17.11 | 26.33 | 24.34 | 7.94 | 24.27 | |
| Dolnośląskie | 1018172 | 88433 | 310822 | 256211 | 89768 | 272938 | 2437 |
| % | 100 | 8.69 | 30.53 | 25.16 | 8.82 | 26.81 | |
| S | | 0.5075 | 1.1594 | 1.0339 | 1.1099 | 1.1044 | |
| Kujawsko-Pomorskie | 676971 | 107287 | 195271 | 157955 | 46312 | 170146 | 2306 |
| % | 100 | 15.85 | 28.84 | 23.33 | 6.84 | 25.13 | |
| S | | 0.9261 | 1.0955 | 0.9586 | 0.8612 | 1.0354 | |

Table 2. Employment structure as well as concentration and specialization coefficients by Polish sectors and regions in the years 2004 and 2013 (cont.)

| Specification | Total | S_1 | S_2 | S_3 | S_4 | S_5 | HHI |
|---------------------|---------|--------|--------|--------|--------|--------|------|
| 2013 | | | | | | | |
| Lubelskie | 799820 | 307911 | 137488 | 141646 | 36980 | 175795 | |
| % | 100 | 38.50 | 17.19 | 17.71 | 4.62 | 21.98 | 2596 |
| S | | 2.2496 | 0.6529 | 0.7276 | 0.5820 | 0.9055 | |
| Lubuskie | 320293 | 36780 | 99339 | 81211 | 18871 | 84092 | |
| % | 100 | 11.48 | 31.02 | 25.36 | 5.89 | 26.25 | 2461 |
| S | | 0.6710 | 1.1779 | 1.0417 | 0.7417 | 1.0816 | |
| Łódzkie | 925303 | 179190 | 253262 | 212338 | 60387 | 220126 | |
| % | 100 | 19.37 | 27.37 | 22.95 | 6.53 | 23.79 | 2259 |
| S | | 1.1316 | 1.0395 | 0.9428 | 0.8215 | 0.9801 | |
| Małopolskie | 1259992 | 272715 | 295212 | 302983 | 95830 | 293252 | |
| % | 100 | 21.64 | 23.43 | 24.05 | 7.61 | 23.27 | 2195 |
| S | | 1.2648 | 0.8898 | 0.9879 | 0.9574 | 0.9588 | |
| Mazowieckie | 2274610 | 301358 | 429915 | 664813 | 317861 | 560663 | |
| % | 100 | 13.25 | 18.90 | 29.23 | 13.97 | 24.65 | 2190 |
| S | | 0.7742 | 0.7178 | 1.2008 | 1.7591 | 1.0155 | |
| Opolskie | 311442 | 50536 | 96450 | 64968 | 17597 | 81891 | |
| % | 100 | 16.23 | 30.97 | 20.86 | 5.65 | 26.29 | 2381 |
| S | | 0.9482 | 1.1762 | 0.8570 | 0.7113 | 1.0833 | |
| Podkarpackie | 792771 | 259686 | 192221 | 138789 | 31316 | 170759 | |
| % | 100 | 32.76 | 24.25 | 17.51 | 3.95 | 21.54 | 2447 |
| S | | 1.9141 | 0.9209 | 0.7193 | 0.4973 | 0.8874 | |
| Podlaskie | 400090 | 126790 | 78881 | 78580 | 19396 | 96443 | |
| % | 100 | 31.69 | 19.72 | 19.64 | 4.85 | 24.11 | 2383 |
| S | | 1.8518 | 0.7488 | 0.8069 | 0.6103 | 0.9931 | |
| Pomorskie | 753429 | 66394 | 213948 | 207036 | 68362 | 197689 | |
| % | 100 | 8.81 | 28.40 | 27.48 | 9.07 | 26.24 | 2410 |
| S | | 0.5149 | 1.0785 | 1.1290 | 1.1422 | 1.0810 | |
| Śląskie | 1638657 | 101963 | 586968 | 419282 | 129360 | 401084 | |
| % | 100 | 6.22 | 35.82 | 25.59 | 7.89 | 24.48 | 2638 |
| S | | 0.3636 | 1.3604 | 1.0512 | 0.9938 | 1.0084 | |
| Świętokrzyskie | 453970 | 149635 | 100598 | 84001 | 18424 | 101312 | |
| % | 100 | 32.96 | 22.16 | 18.50 | 4.06 | 22.32 | 2434 |
| S | | 1.9261 | 0.8416 | 0.7602 | 0.5109 | 0.9194 | |
| Warmińsko-Mazurskie | 419637 | 70022 | 118921 | 89792 | 24269 | 116633 | |
| % | 100 | 16.69 | 28.34 | 21.40 | 5.78 | 27.79 | 2345 |
| S | | 0.9751 | 1.0763 | 0.8791 | 0.7280 | 1.1451 | |
| Wielkopolskie | 1367192 | 213618 | 420864 | 347679 | 94414 | 290617 | |
| % | 100 | 15.62 | 30.78 | 25.43 | 6.91 | 21.26 | 2338 |
| S | | 0.9130 | 1.1691 | 1.0448 | 0.8693 | 0.8757 | |
| Zachodniopomorskie | 507477 | 49811 | 134943 | 140781 | 36629 | 145313 | |
| % | 100 | 9.82 | 26.59 | 27.74 | 7.22 | 28.63 | 2445 |
| S | | 0.5736 | 1.0099 | 1.1398 | 0.9086 | 1.1797 | |

S – Florence's coefficient of localization presented as (2).

Source: authors' compilation based on: *Pracujący w gospodarce narodowej w 2013 r.* [Employment in national economy in 2013] Central Statistical Office, Warsaw 2014, pp. 40-47; *Pracujący w gospodarce narodowej w 2004 r.* [Employment in national economy in 2004] Central Statistical Office, Warsaw 2005, pp. 34-39.

The fields of non-market services were characterized by their relatively high importance in the employment structure in two regions: Zachodniopomorskie (over 28.6% of total employment) and Warmińsko-Mazurskie (almost 27.8%).

Industry and construction played a significant role in the following regions: Śląskie (over 35.8% of total employment), Lubuskie and Opolskie (31.0% each), Wielkopolskie (30.8%) and Dolnośląskie (30.5%).

Agricultural function is recognized as crucial in regional economy of Lubuskie (38.5% of total employment), Świętokrzyskie (almost 33%), Podkarpackie (32.8%) and Podlaskie (nearly 31.7%).

Following the analysis of Herfindahl-Hirschman index values it should be observed that:

- the highest *HHI* values were recorded for Śląskie region (industry and construction dominate) and Lubuskie region (agricultural function remains the dominant one), whereas the lowest value was true for Mazowieckie region,
- in the analysed period the majority of regions were characterized by higher level of sectoral concentration. In the case of Podlaskie and Śląskie regions only the decrease in *HHI* index values was observed.

5. Functional specialization of regions

The rank of particular regions, in a broader spatial system (e.g. a country), is determined by the so-called specialized functions. The functions are represented by the social and economic activity sectors, the importance of which in the analysed territorial unit is larger than the one typical for its environment.

Specialization levels of *i*-th territorial unit (region) in *j*-th economic sector are defined in the article as follows:

| | |
|-------------------------|--|
| $S_{ij} \leq 1$ | no specialization (endogenous function), |
| $1 < S_{ij} \leq 1.2$ | very low level of specialization, |
| $1.2 < S_{ij} \leq 1.5$ | low level of specialization, |
| $1.5 < S_{ij} \leq 2.0$ | medium level of specialization, |
| $S_{ij} > 2.0$ | high level of specialization. |

The levels of functional specialization characteristic for particular regions in the country in the years 2004 and 2013 are presented in Table 3.

Table 3. Functional specialization of regions in 2004 and 2013

| Sectors of the economy | | Functional specialization level in regions | | |
|--|------|--|---|--------------------------|
| | | high | medium | low |
| S_1. Agriculture | 2004 | Lubelskie, Podlaskie | Świętokrzyskie | Podkarpackie, Łódzkie |
| | 2013 | Lubelskie | Świętokrzyskie, Podkarpackie, Podlaskie | Małopolskie |
| S_2. Industry and construction | 2004 | – | – | Śląskie |
| | 2013 | – | – | Śląskie |
| S_3. Logistic support of the population and companies | 2004 | – | – | Zachodnio- pomorskie |
| | 2013 | – | – | Mazowieckie |
| S_4. Entrepreneurship development support | 2004 | – | Mazowieckie | – |
| | 2013 | – | Mazowieckie | – |
| S_5. Non-market services | 2004 | – | – | – |
| | 2013 | – | – | – |

Source: authors' compilation.

The analysed economic activity sectors are characterized by the diversified specialization level in the regions of the country.

In 2013 the agricultural sector determined a high functional specialization of Lubelskie region. In 2004 this specialization level in these fields was also recorded in Podlaskie region.

The number of regions characterized by a medium specialization level in the agricultural sector fields saw an increase. In 2004 this level was recorded in Świętokrzyskie region only, while in 2013 this group covered also Podkarpackie and Podlaskie regions. On the other hand, a low level of functional specialization in agriculture in 2013 referred to Małopolskie, whereas in 2004 this group included Podkarpackie and Łódzkie regions.

With reference to functional specialization in the fields of industry and construction the only region with a low specialization level was Śląskie region.

In relation to logistics service of population and companies Mazowieckie region showed a low level of functional specialization. Moreover, Mazowieckie region also showed a medium specialization level in the fields of entrepreneurship development support.

As far as the non-market services are concerned none of the regions under analysis revealed any specialization. It is substantively justified since the non-market services sector remains crucial in reflecting spatial distribution of population since it primarily covers the infrastructure fields focused on meeting the widely felt social needs by local and regional communities in each of the regions (e.g. in terms of education, health care, social aid, culture and recreation).

The sectoral perspective provides the general dimension of the functional structure and specialization in particular regions. However, a more detailed analysis of PCA sections system allows for presenting the field-oriented specialization and therefore:

- a high specialization level was recorded in the following regions: Lubelskie (section A: agriculture, forestry, hunting and fishing – $S_{ij} = 2.2496$) and Mazowieckie (section J: information and communication – $S_{ij} = 2.0749$),
- a medium specialization level referred to such regions as: Dolnośląskie (section N: administrative and support service activities – $S_{ij} = 1.5507$), Mazowieckie (section K: financial and insurance activities – $S_{ij} = 1.8539$; section M: professional, scientific and technical activities – $S_{ij} = 1.8014$), Podkarpackie (section A: agriculture, forestry, hunting and fishing – $S_{ij} = 1.9141$), Podlaskie (section A – $S_{ij} = 1.8518$), Świętokrzyskie (Section A – $S_{ij} = 1.9261$) and Zachodniopomorskie (section I: accommodation and catering – $S_{ij} = 1.7828$).

A clear functional specialization was observed not only in the agricultural sector fields, but also in some fields of market services. It mainly referred to Mazowieckie and Dolnośląskie regions, whereas tourism was recorded as a medium specialization level in Zachodniopomorskie region. It is facilitated not only by attractive natural conditions, but also by extensive tourism-oriented investments used in both summer and winter seasons. A relatively low level of this specialization refers to the following regions: Małopolskie, Pomorskie, Dolnośląskie, Mazowieckie, Warmińsko-Mazurskie and Śląskie.

6. Functional typology of regions

Cluster analysis was applied in conducting the functional typology of regions. Based on the data presented in Table 2 and following the procedure described in point 3 the clusters of regions similar in terms of Florence's coefficient of localization were determined for the years 2004 and 2013. The results of cluster analysis are presented in Table 4.

Table 4. Functional typology of regions in terms of Florence’s coefficients of localization values in the years 2004 and 2013

| Specification | 2004 | 2013 |
|--|--|--|
| The results of the division of a set of regions into clusters by applying the furthest neighbour method | | |
| Cluster 1 | (1) Dolnośląskie; (4) Lubuskie; (11) Pomorskie; (12) Śląskie; (16) Zachodniopomorskie | (1) Dolnośląskie; (4) Lubuskie; (11) Pomorskie; (12) Śląskie; (16) Zachodniopomorskie |
| Cluster 2 | (2) Kujawsko-Pomorskie; (6) Małopolskie; (8) Opolskie; (14) Warmińsko-Mazurskie; (15) Wielkopolskie | (2) Kujawsko-Pomorskie; (5) Łódzkie; (6) Małopolskie; (8) Opolskie; (14) Warmińsko-Mazurskie; (15) Wielkopolskie |
| Cluster 3 | (3) Lubelskie; (10) Podlaskie; (13) Świętokrzyskie | (3) Lubelskie; (9) Podkarpackie; (10) Podlaskie; (13) Świętokrzyskie |
| Cluster 4 | (5) Łódzkie; (9) Podkarpackie | (7) Mazowieckie |
| Cluster 5 | (7) Mazowieckie | — |
| Dendrogram | | |
| Graphic interpretation of G1 Caliński-Harabasz index. Criterion of u clusters number selection: $\hat{u} = \underset{u}{\operatorname{argmax}}\{G1(u)\}$ | | |
| Results of replication analysis | 0.5212 | 0.6513 |
| Agreement between two partitions | 0.7887 | |

Source: authors’ compilation using R (R Development Core Team, 2015).

The maximum value of Caliński-Harabasz index was obtained following the division into 5 classes (for 2004) and the division into 4 classes (for 2013). Replication analysis was conducted to assess the stability of the obtained cluster division into classes. The purpose of replication analysis is the stability assessment of the conducted classification covering the set of objects. The stability assessment was performed based on the adjusted Rand index value from $[-\infty; 1]$ interval. The values obtained as a result of replication analysis for the year 2004 and 2013 confirmed a relatively stable division of regions into classes.

In order to facilitate the obtained results the interpretation medians from Florence's coefficient were specified for each class regarding 5 sectors of the economy:

[1] Medians (2004)

| | [.1] | [.2] | [.3] | [.4] | [.5] |
|------|---------------|---------|---------------|---------------|--------|
| [1.] | 0.5421 | 1.09770 | 1.1027 | 1.0335 | 1.0915 |
| [2.] | 1.0077 | 1.04700 | 0.9527 | 0.8539 | 1.0553 |
| [3.] | 2.0769 | 0.67400 | 0.7855 | 0.6028 | 0.9634 |
| [4.] | 1.3500 | 1.02005 | 0.8567 | 0.7494 | 0.9613 |
| [5.] | 0.9166 | 0.78420 | 1.1213 | 1.5528 | 0.9695 |

[1] Medians (2013)

| | [.1] | [.2] | [.3] | [.4] | [.5] |
|------|----------------|---------------|---------------|----------------|---------|
| [1.] | 0.51490 | 1.1594 | 1.0512 | 0.99380 | 1.08160 |
| [2.] | 0.96165 | 1.0859 | 0.9507 | 0.84135 | 1.00775 |
| [3.] | 1.92010 | 0.7952 | 0.7439 | 0.54645 | 0.91245 |
| [4.] | 0.77420 | 0.7178 | 1.2008 | 1.75910 | 1.01550 |

The specialization ratios over 1.10 were marked in bold.

0.7887 value of adjusted Rand index confirms high consistency of the obtained divisions of regional clusters into classes in the years 2004 and 2013. In the analysed period class 4 regions from 2004 moved to class 2 (Łódzkie region) and class 3 (Podkarpackie region). Łódzkie region recorded a significant reduction in specialization level with reference to S_1 sector (agriculture), whereas Podkarpackie region an extensive strengthening of specialization in this area.

Based on the obtained results the following conclusions can be put forward:

- class 3 regions (both in 2004 and in 2013) shows a clear specialization in S_1 sector (agriculture);
- one-element class covering Mazowieckie region (class 5 in 2004 and class 4 in 2013) specializes primarily in S_4 sector (entrepreneurship development support) and highly in S_3 sector (logistic support of the population and companies); in the analysed period the specialization ratio values increased significantly;
- in the case of class 2 regions (both in 2004 and in 2013) the absence of sectoral specialization was observed;
- for class 1 regions a low level of specialization was recorded in S_3 sector in 2004 and in S_2 sector in 2013.

Therefore, having conducted the typology of regions by sectoral specialization level and scope in 2013 the following regions can be determined:

- industry and service-oriented regions (class I: Dolnośląskie, Lubuskie, Pomorskie, Śląskie, Zachodniopomorskie);
- non-specialized regions (class II: Kujawsko-Pomorskie, Łódzkie, Małopolskie, Opolskie, Warmińsko-Mazurskie, Wielkopolskie);
- agricultural regions (class III: Lubelskie, Podkarpackie, Podlaskie, Świętokrzyskie);
- capital region (class IV: Mazowieckie) characterized by market services specialization; this region's individuality in the presented typology results from the developed central service-oriented functions in Warsaw, provided not only for its regional environment (see Obrębalski, 2014, p. 121).

The presented typology confirms limited composition variance of the analysed regional groups by sectoral specialization in the period under analysis. It does not, however, mean that in terms of particular social and economic activity areas within the framework of the identified sectors a relative stability of specialization level was also observed. Functional specialization factors result from many diversified local and regional determinants of demographic and social, natural and cultural, economic, institutional and spatial nature.

7. Final remarks and policy implications

In general, particular regions show a significant polyfunctionality, although each of them is characterized by a dominant function. In every region of the country it takes the form of a service function diversified by fields, but in many regions the significant role is also played by an industrial and agricultural function. The studied regions, however, show distinct functional specialization (in terms of field and level). It is at a high level in the agricultural sector for Lubelskie region only. Apart from agriculture, a medium specialization level is recorded also in the entrepreneurship development support sector, whereas a low

level – in industry and construction sectors as well as logistics service of population and companies.

Mazowieckie region, with the dominant Warsaw, is characterized by a high specialization in market services. This region was identified as a result of the conducted typology as one of functional specialization types. This typology also allowed for separating the group of agricultural, industry and service-oriented and also non-specialized regions.

It should be observed, however, that despite many common typological characteristics, each region has individual and diversified potential, regional identity and the level of economic competitiveness. In the context of the national strategy of regional development this will concern the future development of the individual regions and the country (see *Krajowa strategia ...*, 2010).

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