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Danuta Rozpędowska-Matraszek, PhD[1]
Faculty of Economics and Administration
State Higher Vocational School in Skierniewice

Dynamic Panel Models in the Analysis of Healthcare Functioning in Groups of Similar Powiats

INTRODUCTION

Macroeconomic studies analysing healthcare sector operations by means of econometric methods have been carried out in Poland since as early as the 1990s [Suchecka, 1992; 1993; 1998]. Thanks to available technical tools of computer software and resources of statistical data, current research goes down to the level of micro analyses of units [Suchecka, 2011; 2014]. Disproportions in the level of socio-economic development of regions have contributed to the increasing importance of the cohesion policy in Poland, especially after the accession to the EU. From the point of view of regional development, it is vital to maintain spatial cohesion in healthcare. Thanks to a great number of connections with its environment, every territorial unit is an open system, thus susceptible to external influences. Therefore, taxonomic as well as statistical and econometric methods will be used to check whether the spatial distribution of powiats in Poland demonstrated a similar impact on healthcare functioning in the years 2003–2011. The methods include, in particular, agglomerative clustering methods and spatial econometrics models estimated based on panel data.

FACTORS AFFECTING POWIATS' DEVELOPMENT IN TERMS OF HEALTHCARE

One of characteristics of a region is the size of its population, which may result in varying demand for healthcare services. However, expectations inhabitants have about healthcare are the same in all regions, despite considerably differ-

[1] Adres korespondencyjny: Faculty of Economics and Administration, State Higher Vocational School in Skierniewice, ul. Batorego 64c, 96-100 Skierniewice, e-mail: daroma@uni.lodz.pl.

ent population sizes in powiats. Socio-economic development factors of social nature include health protection, social welfare and social security. At this point, technical and organizational factors should also be mentioned such as progress in medical technology, scientific and technical as well as work organization and production progress. In market economy, entities providing healthcare services are treated similarly to production facilities which operate with a view of profit. Factors affecting powiats' development stimulate the development of the system of regions which, along with economic goods, produces and consumes non-economic ones. In regions, there are not only entities and individuals operating with a view of profit but also social institutions and organisations driven by social motives. Such organisations include the healthcare system, which needs to be properly financed and managed. The share of expenditures on healthcare in total budgetary expenditures of powiats in Poland ranged from 4.5% to 6.3% in the years 2003–2013. It can be assumed that they constituted a constant expense above 5%, while expenditures on social welfare accounted, on average, for about 18%.

The proper management of independent public healthcare facilities leads to an appropriate structure of human resources (in particular, employment of physicians) and material resources (hospitals, outpatient clinics, full-time public welfare facilities). Their efficient use at the level of an individual entity improves the condition of healthcare at the regional level. A modern healthcare system includes, first of all, effective medical technologies and sufficiently low risk of death so that it is justified to conclude that the health condition is improved. All the above is connected with sufficient funds necessary to finance modern methods of treatment. Pursuant to the law applicable in Poland, citizens are ensured universal and equal access to healthcare. However, limited financial resources cause disruptions in expected increasing demand for healthcare services. The key issue for healthcare managers is to ensure the good health condition of the population. It is becoming crucial to manage resources in a rational way, i.e. in such a way so that healthcare meets expectations of both citizens and managers. The regional policy serves to remove regional disproportions, i.e. economic and social differences, which may be facilitated by already available tools of quantitative analysis.

TAXONOMIC ANALYSIS – CLUSTERING OF SIMILAR POWIATS

The tool most commonly used for grouping and classifying data in economic studies is numerical taxonomy. Taxonomy methods allow to both rank a set of objects and divide that into disjoint subsets. Within subsets, groups, classes and clusters can be identified containing elements similar to one another in terms of a selected aggregate characteristic and, at the same time, different from elements of other subsets. Due to the level of the study on the efficiency of healthcare, as a result of the complexity of the phenomenon, it is impossible to describe that using only one variable. Therefore, methods are sought that are more useful in spatial studies to compare and group spatial units, being powiats in this case. The taxonomic method of Z. Hellwig's development measure was applied in the linear ordering of powiats [Hellwig, 1968; 1994]. For that purpose, the study used a taxonomic measure of development standardized in a range [0, 1], enabling to both hierarchize (rank) the studied objects and classify them into certain disjoint subsets [Walesiak, 2011, s. 44].

To that end, a list was created of the so called potential diagnostic vari-ables taking into account the statistical properties of selected traits. The studied multi--trait object is the functioning of the healthcare system in powiats in the years 2003–2011, characterized by a list of variables at the disposal, which may describe the powiats in the studied respect. They are as follows:

- Y – physicians (per 1000 of the population),
- X_1 – dentists (per 1000 of the population),
- X_2 – nurses (per 1000 of the population),
- X_3 – midwives (per 1000 of the population),
- X_4 – hospital beds (per 1000 of the population),
- X_5 – healthcare facilities (per 1000 of the population),
- X_6 – number of places at care and treatment facilities (per 1000 of the population),
- X_7 – places at day nurseries and nursery departments (per 1000 of the population),
- X_8 – total number of consultations provided within public healthcare – general practitioner and family physician consultations (per 1000 of the population),
- X_9 – pharmacies (per 1000 of the population),
- X_{10} – infant mortality (per 1000 live births),
- X_{11} – total deaths from cardiovascular diseases (per 1000 of the population),
- X_{12} – total deaths from cancer (per 1000 of the population),
- X_{13} – hazards connected with working environment in person-hazards (per 1000 of the population),
- X_{14} – powiats' budgetary expenditures on healthcare (in thousands zlotys *per capita*),
- X_{15} – average gross monthly salary in a powiat as compared to the minimum salary in Poland (in %).

An analysis of measures describing the series and its structure for a list of variables for urban powiats in 2011 allows us to infer that about 3.5 physicians per 1000 of the population, on average, were employed, in public healthcare. The lowest number of physicians per 1000 of the population was employed in Świętochłowice (1.3), whereas the highest – in Lublin (6.5), Rzeszów and Zamość (6.1). In half of voivodships no more than about 3.3 physicians per 1000 of the population were employed in public healthcare in towns, while a half of the observations fell between 2.73 and 4.2 physicians per 1000 of the population. The standard deviation was 1.2 physicians per 1000 of the population. That indicates moderate variability of the series, which is confirmed by the coefficient of variation at 34.5%. In towns, the difference between the total number of consultations provided within public healthcare (general practitioner and family physician consultations) *per capita* was 4.15 (table 1).

Table 1. Analysis of cross-sectional series for urban powiats in 2011

Statistical measure	Y	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}
Average	3.49	0.52	7.77	0.92	7.55	0.57	2.62	1.66	4.51	0.38	4.98	4.02	1.35	14.83	0.07	2.49
Median (Me)	3.28	0.43	7.43	0.88	7.43	0.57	2.43	1.37	4.49	0.37	4.80	3.87	1.19	10.44	0.06	2.38
Variance	1.45	0.07	6.34	0.16	5.56	0.02	1.89	1.14	0.60	0.01	5.98	0.79	0.70	258.3	0.00	0.19
Standard deviation	1.20	0.27	2.52	0.41	2.36	0.16	1.38	1.07	0.77	0.09	2.45	0.89	0.84	16.07	0.05	0.44
x_{min}	1.31	0.15	3.19	0.10	2.91	0.29	0.00	0.00	2.69	0.16	0.00	2.23	0.08	1.76	0.02	1.86
x_{max}	6.50	1.30	15.82	2.58	14.83	0.94	7.20	4.73	6.84	0.63	11.60	5.98	3.58	117.6	0.26	4.56
Q1	2.73	0.32	6.64	0.61	6.24	0.44	1.67	1.00	4.10	0.33	3.20	3.41	0.68	6.70	0.04	2.23
Q3	4.20	0.68	8.85	1.11	9.23	0.66	3.23	2.29	4.92	0.43	6.40	4.58	1.97	18.24	0.08	2.60
Coefficient of variation	0.34	0.53	0.32	0.44	0.31	0.28	0.52	0.64	0.17	0.24	0.49	0.22	0.62	1.08	0.64	0.18
Range	5.19	1.15	12.63	2.48	11.91	0.66	7.20	4.73	4.15	0.47	11.60	3.75	3.50	115.8	0.25	2.70
Q3-Q1	1.47	0.36	2.21	0.50	2.99	0.22	1.57	1.29	0.82	0.10	3.20	1.17	1.29	11.53	0.04	0.37

Source: own work.

The development pattern method was used to study the health care situation separately for 314 rural powiats and 65 urban powiats in 2003 and 2011. The aim was to compare the impact of Poland's accession to the EU through a considerable inflow of funds and movement of labour force as well as the influence of reorganization and restructuring of employment carried out in healthcare. The measure is a synthetic value being the resultant of all variables describing objects of the studied group. In 2011, as compared to 2003, 108 of the studied 314 rural powiats showed an increase in the development measure. In 2011, 53 rural powiats were within the lowest range of the development measure (up to 0.15); as many as 148 powiats were in the range of 0.16 to 0.2 of the development measure. A little higher on the path of development, in the range of 0.21 to 0.25, were 101 powiats. The following powiats: Bełchatowski, Górowski, Parczewski, Lubański, Lubiński, Krośnieński, Węgorzewski, Milicki and Łęczyński, reached the level of 0.26 to 0.3 of the development measure, whereas the Poddębicki powiat obtained 0.31. It was only the Bielski powiat in the Śląskie voivodship (0.35) and the Świdnicki powiat (0.36) that displayed the highest level of the development measure, fig. 1.

The situation of healthcare development in 2011 was much better in urban powiats. The development measure was higher in 2011 than in 2003 in 38 towns. The development measure calculated for 27 towns with powiat rights ranged from

0.26 to 0.3. The development measure at 0.4 suggests that towns of Kielce, Przemyśl and Rzeszów entered a good development path, while Katowice (0.42) and Krosno (0.46) were characterized by the highest healthcare development measure, fig. 2.

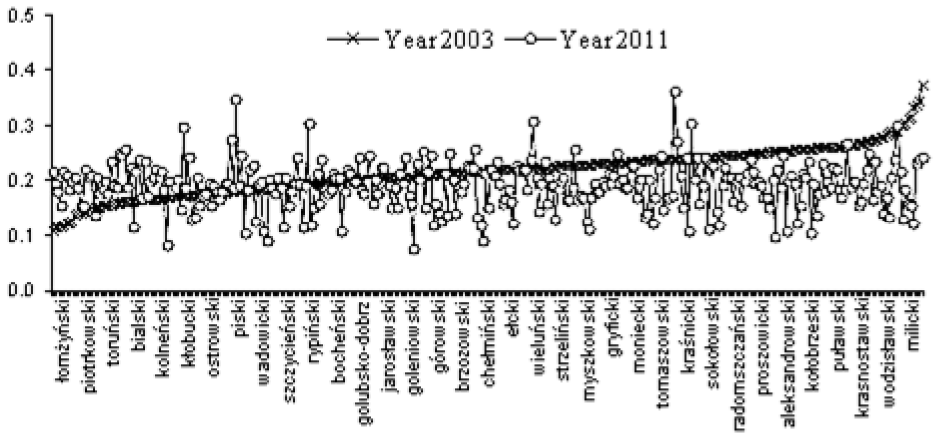

Figure 1. Development measure – healthcare in rural powiats in 2003 and 2011

Source: own work.

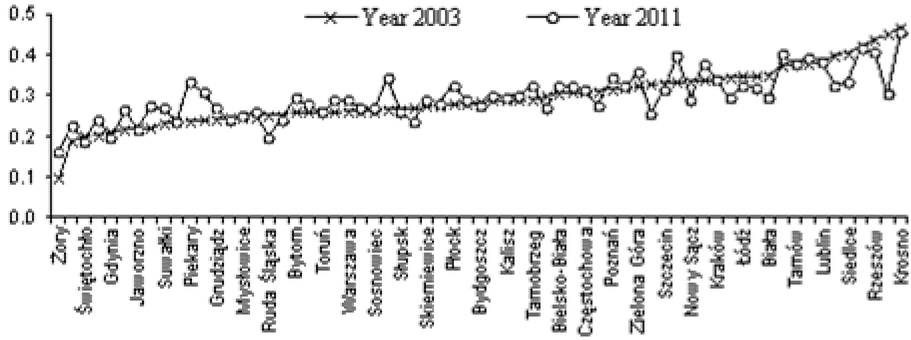

Figure 2. Development measure – healthcare in towns in 2003 and 2011

Source: own work.

The applied taxonomic analysis allowed the classification and identifi-cation of groups of powiats similar with respect to the selected variables (for rural and urban powiats separately). The estimation of distance be-tween clusters used an analysis of variance approach. Ward's agglomerative method was applied in the SPSS program. The method aims to minimize the sum of squares of deviations of any two clusters which may form at any stage. The method is considered very effective, although it creates small clusters. Clustering results in the graphic form of a hierarchical tree plot (dendrogram) for 2003 and 2011 indicated similar powiats linked together in clusters for rural powiats and urban powiats, characterized by the similar functioning of healthcare, which was shown in the form of maps. The grouping of data taking into account their healthcare resources development levels, enabled the identification of ten principal groups of rural powiats and six groups of urban powiats in 2011. The study presents only the clustering for 2011, with clustering diagrams for 314 rural and 65 ur-banpowiats. (fig. 3 and 4).

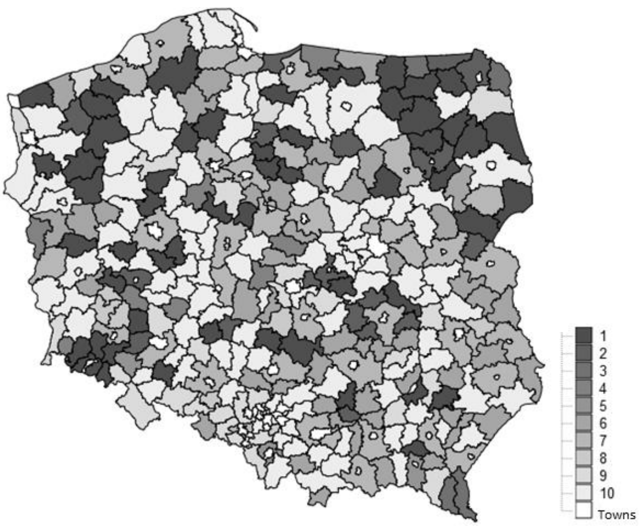

Figure 3. Clustering of rural powiats in 2011

Source: own work in the Quantum GIS Program.

In 2011 there were 54 rural powiats clustered in group 1, only 18 powiats in group 2, 4 powiats in group 3 (Bieszczadzki, Leski, Sejneński and Węgorzewski), 8 powiats in group 4 (Braniewski, Górowski, Kutnowski, Lubański, Milicki, Poddębicki, Słubicki and Żniński), and only 3 powiats in group 5 (Bielski, Krośnieński and Świdnicki). A small group – Group 8 formed a cluster of 7 powiats (Bełchatowski, Bieruńsko-Lędziński, Głogowski, Krapkowicki, Lubiński, Łęczyński and Polkowicki). Bigger clusters formed groups 6 (48 powiats), 9 (28 powiats) and the biggest group 10 clustered 105 powiats.

As for urban powiats, group 1 clustered 23 powiats, groups 2 and 4 included 11 powiats each, and group 3 contained only 3 powiats (Krosno, Zamość and Rzeszów). Group 5 clustered 16 powiats, whereas Jastrzębie-Zdrój formed a separate cluster (while in 2003 the town formed a cluster together with Dąbrowa Górnicza, Jaworzno, Gliwice, Ruda Śląska and Gdynia) – fig. 4. The analysis of the composition of specific clusters of rural powiats indicated slight interpenetration of spatial objects. Spatial diversification was much stronger than dynamic one.

Figure 4. Clustering of urban powiats in 2011

Source: own work in the Quantum GIS Program.

That resulted from the fact that a tendency of the same powiats to link together in the two analysed years was observed in specific clusters. Current research into the spatial diversification of development and pace of changes of various phenomena encourages one to apply analyses which allow for the reflection of the strength of links between regions. The clustering of similar powiats will enable us to determine diversification through the use of a dynamic panel model to estimate model parameters.

DYNAMIC PANEL MODEL

The division into groups of similar powiats based on 2011 data was as-sumed in creating panel models. That resulted from an intention to take into account the most recent trends concerning variables as factors reflecting the healthcare condition. The models were estimated based on 2003–2011 sta-tistical data separately for 314 rural powiats clustered in ten groups and 65 urban powiats clustered in six groups. The data were panel data, combining cross-sectional and temporal dimensions and characterized by a specific number of objects N in relation to the number of periods T. Using such data requires the employment of appropriate estimation methods.

The presented study used the Generalized Method of Moments – GMM. Thanks to that method, described by Stephen Bond [Bond, 2002] and in publications of Polish authors Antczak, Suchecki [Antczak, 2012, s. 109–126] and Dańska-Borsiak [Dańska-Borsiak, 2011, s. 78–79], we were able to simultaneously take into account heteroscedasticity and autocorrelation as well as differentiate among and apply appropriate instrumental variables.

The number of physicians (per 1000 of the population) was modelled. The values of that variable in specific powiats in the studied period indicated differences in the levels of the variable in all the studied groups – both its initial values of 2003 and rates of growth. The employment of physicians may be treated as a simplification of human resources in a powiat, thanks to which the health condition of the region's population improves. In order to examine factors affecting the structure of physician's employment in powiats, a dynamic panel model was used:

$$y_{it} = \alpha_0 + \gamma \cdot y_{i,t-1} + \mathbf{x}_{it}^T \cdot \boldsymbol{\beta} + (\alpha_i + \varepsilon_{it}), \text{ for } i = 1, ..., N, \ t = 1, ..., T;$$

where:

$$\varepsilon_{it} \sim N(0, \ \sigma_\alpha^2), \text{ for each } i, \ t, \ \alpha_i \ \text{– group effects.}$$

If α_i are random effects, $\alpha_i \sim N(0, \ \sigma_\alpha^2)$, $\mathbf{x}_{it} = [\mathbf{x}_{kit}]_{K\mathrm{x}1}$ – vector of explanatory variables of *K* coordinates, $\boldsymbol{\beta}$ – vector of parameters (*K* x 1), identical for all *i* and *t*.

Models were estimated using the GRETL program for variables specified as levels. The application of a dynamic panel model with a selection of instruments is very useful as the program itself controls the choice of those instruments in order to eliminate group effects α_i.

In such a model, explanatory variables are replaced with appropriate instruments which form a matrix of instrumental variables. The tables contain results of the dynamic panel model for groups of powiats, i.e. information about the impact of specific variables on the employment of physicians per 1000 of the population in powiats (Tables 2 and 3).

Estimations of parameter γ in Table 2 ranged from the lowest value (0.01) in group 2 to the value of 0.14 in group 9, while a negative impact was observed in group 10.

In groups of rural powiats, all parameters proved to be significant only in the case of nurses per 1000 of the population. For group 1, clustering the poorest rural powiats, significant parameters turned out to be for nurses (per 1000 of the population), total deaths from cardiovascular disease (per 1000 of the population) and powiats' budgetary expenditures on healthcare (in thousands zlotys per ca-pita). In the model of groups 2, 6, 7 and 9, there were significant parameters for variables representing midwives (per 1000 of the population).

Table 2. Results of panel models' estimations – rural powiats

Number of powiats / observations	GMM method	y_{-1}	α_0	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}	AR(1)	AR(2)	Sargan	$\chi2$
Group 1 54 / 486 39 instr	parameter estimation	0.043	0.286		0.211									0.021			0.486		-5.377	0.4697	188.36	682.85
	estimation error	0.0378	0.0882		0.0098									0.0108			0.1778					
	(p-value)	0.258	0.001		0.000									0.053			0.006		0.0000	0.6386	0.0000	0.0000
Group 2 18 / 162 48 instr	parameter estimation	0.012	-0.53	-0.37	0.149	1.110	0.039	0.507	0.026			0.809	0.010	0.034	0.045	-0.01	-1.92		-2.819	0.5979	106.87	19031
	estimation error	0.0317	0.1549	0.2092	0.0209	0.1565	0.0121	0.2207	0.0107			0.3245	0.0039	0.0125	0.0263	0.0034	0.6378					
	(p-value)	0.704	0.001	0.076	0.000	0.000	0.001	0.021	0.014			0.013	0.010	0.007	0.084	0.005	0.003		0.0048	0.0549	0.0000	0.0000
Group 4 8 / 72 41 instr	parameter estimation	0.123	0.073		0.109				0.034				0.007	0.069		0.016			-1.993	-1.403	71.795	1068.0
	estimation error	0.0727	0.0757		0.0134				0.0106				0.0031	0.0204		0.0074						
	(p-value)	0.092	0.334		0.000				0.001				0.022	0.001		0.028			0.0463	0.1605	0.0002	0.0000
Group 6 48 / 434 46 instr	parameter estimation	0.080	0.395	0.642	0.125	-0.16	0.091	0.385	-0.01		-0.05	0.713			-0.21			0.139	-4.160	-1.493	100.81	1327.0
	estimation error	0.0436	0.2409	0.1795	0.0170	0.0854	0.0118	0.1443	0.0061		0.0192	0.2420			0.0153			0.0694				
	(p-value)	0.067	0.101	0.000	0.000	0.069	0.000	0.008	0.048		0.009	0.003			0.000			0.045	0.0002	0.1354	0.0000	0.0000
Group 7 39 / 351 46 instr	parameter estimation	0.044	-0.40	0.284	0.171	0.525	0.078			0.166	-0.03	0.763				0.003	-0.66	0.211	-4.295	-1.658	137.63	1768.8
	estimation error	0.0266	0.0942	0.1172	0.0156	0.0942	0.0151			0.0324	0.0155	0.2196				0.0021	0.1885	0.0427				
	(p-value)	0.098	0.000	0.015	0.000	0.000	0.000			0.000	0.033	0.001				0.103	0.000	0.000	0.0000	0.0973	0.0005	0.0000
Group 9 28 / 252 46 instr	parameter estimation	0.138	1.040	0.876	0.046	0.114	-0.64	-0.06	-0.10	0.138		1.630		-0.06	-0.20		-0.59		-4.245	-1.507	33.168	746.07
	estimation error	0.0651	0.2755	0.1642	0.0182	0.0104	0.1831	0.0119	0.0361	0.0651		0.3310		0.0277	0.0401		0.3080					
	(p-value)	0.034	0.000	0.000	0.012	0.000	0.000	0.000	0.006	0.034		0.000		0.028	0.000		0.057		0.0000	0.1319	0.5082	0.0000
Group 10 105/ 945 46 instr	parameter estimation	-0.047	-0.34	0.678	0.187		0.041		0.009		0.020	0.306		0.016	-0.11	-0.003		0.288	-6.421	-1.072	123.68	1142.9
	estimation error	0.0295	0.1461	0.0711	0.0104		0.0070		0.0042		0.0111	0.1701		0.0089	0.0186	0.0014		0.0344				
	(p-value)	0.114	0.020	0.000	0.000		0.000		0.026		0.071	0.072		0.068	0.000	0.015		0.000	0.0000	0.2837	0.0000	0.0000

Source: own work based on GRETL calculations.

Table 3. Results of panel models' estimations – urban powiats

Number of powiats / observations	GMM method	y_{-1}	α_0	X_1	X_2	X_3	X_4	X_5	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}	AR(1)	AR(2)	Sargan	χ2
Group 1 23 / 207 47 instr	parameter estimation	0.008	-1.33	0.611	0.270	0.539	0.048	0.483	0.182		-1.70		0.132	-0.23	-0.01		0.526	-3.065	-1.746	49.0848	894.367
	estimation error	0.0480	0.3517	0.1270	0.0365	0.1455	0.0304	0.2517	0.0458		0.5542		0.0420	0.0388	0.0054		0.0878				
	(p-value)	0.873	0.000	0.000	0.000	0.000	0.115	0.055	0.000		0.002		0.002	0.000	0.069		0.000	0.0022	0.0808	0.0454	0.0000
Group 2 11 / 99 44 instr	parameter estimation	-0.10	3.581	1.410	0.443			-0.98		0.255	-2.30			-0.99	-0.003		-0.82	-1.772	-1.3794	43.2837	2484.3
	estimation error	0.0673	1.0783	0.2171	0.0342			0.5118		0.1470	0.8760			0.0852	0.0018		0.1447				
	(p-value)	0.140	0.001	0.000	0.000			0.055		0.083	0.009			0.000	0.096		0.000	0.0764	0.1678	0.1321	0.0000
Group 4 11 / 99 45 instr	parameter estimation	-0.20	5.012	-0.76	0.221		-0.09		-0.10	0.170	-2.31			-0.61	-0.02	0.358		-2.488	0.40401	21.2338	4459.14
	estimation error	0.0824	0.5239	0.1965	0.0394		0.0518		0.0616	0.0410	0.6603			0.0796	0.0057	0.1434					
	(p-value)	0.014	0.000	0.000	0.000		0.078		0.100	0.000	0.000			0.000	0.002	0.013		0.0129	0.0682	0.0959	0.0000
Group 5 16 / 144 45 instr	parameter estimation	-0.01	-2.18	1.595	0.098	0.779	0.085		0.197	0.131		0.020	-0.14				0.888	-2.886	2.2104	64.6511	4140.57
	estimation error	0.0479	0.2508	0.4214	0.0412	0.3401	0.0302		0.0807	0.0461		0.0114	0.0599				0.1030				
	(p-value)	0.816	0.000	0.000	0.017	0.022	0.005		0.015	0.004		0.084	0.018				0.000	0.0039	0.0271	0.0012	0.0000

Źródło: own work based on GRETL calculations.

Only in groups 7 and 9, the number of places at day nurseries and nursery departments (per 1000 of the population) proved to be significant. Infant mortality (per 1000 live births) appeared to be significant solely in groups 2 and 4. The total number of consultations provided within public healthcare – general practitioner and family physician consultations (per 1000 of the population) and average gross monthly salary in a powiat as compared to the minimum salary in Poland (in %) proved to be significant in groups 6, 7 and 10. Availability of hospital beds (per 1000 of the population) appeared to be of importance; it was significant in groups 2, 6, 7 and 9. Deaths from civilization diseases (cardiovascular diseases) were significant except for groups 6 and 7, whereas deaths (from cancer) – apart from groups 1, 4 and 7. Hazards connected with working environment in person--hazards (per 1000 of the population) turned out to be non-significant for groups 1, 6 and 9.

In fable 2, under estimations of parameters, parameter estimation errors are provided, determined based on robust estimators of variance of the random component. Based on Arleano-Bond's test, empirical values of the autocorrelation test, AR(1) and AR(2) respectively, i.e. *p* values for H_0: first (second)-order autocorrelation did not occur. Unmeasurable factors specific to groups of powiats differed between rural and urban powiats. The diversification of effects occurring in urban powiats probably resulted from transformation in the powiats and overlapping changes in recent years as well as healthcare restructurization that had been carried out. In models of groups 3, 5 and 8 for rural powiats, due to small numbers of objects (4, 3 and 7 respectively), variance of individual effects was significantly higher than variance of the random component. That bias resulted from the fact that delayed values of variables are weak instruments for first difference equations.

Estimated models for urban powiats in groups 1, 2, 4 and 5 were appropriate; they displayed correct results of statistical tests (no second-order autocorrelation). Model estimation for group 3: there was AR(2) autocorrelation; due to the small number of objects, variance of individual effects was significantly higher than variance of the random component. That bias resulted from the fact that delayed values of variables are weak instruments for equations. Sargan's test based on empirical values indicated that p values for H_0: superidentifying conditions were correct so instruments were appropriate. Wald's test allows to assess significance of the impact of the whole set of exogenous variables on the endogenous variable in the panel.

In models for groups of urban powiats, parameters for variables concerning dentists and nurses (per 1000 of the population) proved to be significant, whereas the number of pharmacies (per 1000 of the population), total deaths from cancer (per 1000 of the population) and hazards connected with working environment in person-hazards (per 1000 of the population) turned out to be non-significant solely in group 5.

The number of midwives (per 1000 of the population) and total deaths from cardiovascular diseases (per 1000 of the population) were significant only in groups 1 and 5. A significant parameter at the variable of infant mortality (per one thousand live births) – only for group 5. Powiats' budgetary expenditures on healthcare (in thousands zlotys *per capita*) were significant only in group 4 but average gross monthly salary in a powiat compared to the minimum salary in Poland (in %) did not significantly affect the employment of physicians per 1000 of the population.

The total number of consultations provided within public healthcare – general practitioner and family physician consultations (per 1000 of the population), infant mortality (per 1000 of live births) and powiats' budgetary expenditures on healthcare (in thousands zlotys *per capita*) did not significantly affect the employment of physicians only in group 1 (Bielsko-Biała, Bydgoszcz, Bytom, Chorzów, Częstochowa, Elbląg, Gorzów Wielkopolski, Grudziądz, Jelenia Góra, Kalisz, Koszalin, Legnica, Piekary Śląskie, Płock, Poznań, Przemyśl, Radom, Słupsk, Sosnowiec, Suwałki, Tarnobrzeg, Toruń and Włocławek). Only the X_6 variable – number of places at care and treatment facilities (per 1000 of the population) – turned out to be non-significant among all the studied clusters of urban powiats.

CONCLUSION

In models describing numbers of physicians (per 1000 of the popula-tion) in all groups of powiats urban and rural, sets of explanatory variables turned out to be slightly different. The variables were selected from a pool of all variables considered in the specification, which served to assess the healthcare situation of the regions.

The presented study described the functioning of healthcare in powiats of Poland. The development pattern method was employed to assess the resources and infrastructure of the healthcare system in powiats.

The clustering of similar powiats in Poland was carried out using the cluster analysis method. Ten principal groups of rural powiats and six groups of urban powiats were identified for 2011 data. The clusters served to create panel models which allowed the determination of the impact of specific variables on the employment of physicians in powiats.

The application of dynamic panel models enabled the author to check whether powiats in Poland were characterized by the same efficiency of operations in respect of healthcare. That allowed the drawing of conclu-sions about whether potential patients using healthcare services in powiats might expect identical conditions of access to healthcare in Poland.

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Summary

The econometric analyss identifies factors which characterise the specificity of the poviats in a relevant way and influence on the human resources (working doctors) in the groups of poviats under study. Mention was made of factors, which affect the level of employment of doctors' in poviats, although the strength of their impact was different.

In Poland, the dissimilarity between poviats is a result of processes taking place in particular ar-eas of country and translate into a permanent lack of coherence, clearly seen in healthcare, despite of expectations of uniformity. The quality of the services provided by the public facilities and increasing role of social capital become an essential component and a source of competitive advantage of each region.

Keywords: regional analysis, health economics, taxonomic analysis, dynamic panel model

Dynamiczne modele panelowe w analizie funkcjonowania opieki zdrowotnej w grupach powiatów podobnych

Streszczenie

Zastosowana analiza statystyczno-ekonometryczna pozwoliła wskazać czynniki, które charakteryzują specyfikę powiatów w zakresie opieki zdrowotnej i wpływają na kapitał ludzki (pracujący lekarze) w badanych grupach powiatów. Wskazano czynniki wspólne, które wpływają na zatrudnienie lekarzy w powiatach, choć siła ich wpływu okazała się różna.

Zróżnicowania regionalne w powiatach w Polsce są efektem procesów, jakie zachodziły na poszczególnych obszarach Polski i przekładają się na ciągły brak spójności, co wyraźnie uwidacznia się w opiece zdrowotnej, pomimo oczekiwań jednorodności. Wykorzystanie dynamicznych modeli panelowych pozwoliło na wyodrębnienie w składniku losowym dwóch składowych, dzięki czemu możliwe było wskazanie czynników, które w istotny sposób wpływają na dostęp do opieki zdrowotnej w grupach powiatów oraz umożliwią określić siłę tego wpływu na wzrastającą rolę zatrudnionych lekarzy, jako istotnego składnika i źródła przewagi konkurencyjności regionu.

Słowa kluczowe: analiza regionalna, ekonomika zdrowia, analiza taksonomiczna, dynamiczny model panelowy

JEL: R13, I15, C38, C33