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THE REGIONAL DEVELOPMENT OF POLAND IN 2005–2013 – THE MAIN TENDENCIES

A b s t r a c t. The regional development of Poland is presented from a different point of view. One is connected with the GDP growth paths, characterizing each of the regions of Poland and their differentiation. Another deals with the gap of *per capita* GDP between regions and characteristic features of the regional development, especially if one can observe the convergence or divergence processes. According to the theory that GDP is not only one category sufficient to represent regional development, some selected variables are examined from the convergent point of view. The new method of convergence analysis is presented in this paper. The method is based on the information theory and entropy. The distributions by regions of selected variables representing the different socio-economic phenomena are compared with the distribution of basic variables, treated as a pattern, and the proposed similarity measures are estimated. The analysis of the changes in the similarity measures over time is the basis of concluding whether the convergence of regional development has been observed. The proposed method gives us more useful results, as it takes into account many aspects of socio-economic sphere. The empirical analysis for Poland contains the period of 2005–2013. The trend models for regional *per capita* GDP were estimated, also for similarity measures of the selected variables. The conclusions based on the results of empirical analysis are the final part of this article.

K e y w o r d s: regional development. GDP and other indicators. Convergence analysis. Entropy. Similarity measures.

J E L Classification: G15, Q47.

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Introduction

One of the crucial targets of the regional policy of The European Union is diminishing disparities between the regions of Europe. The greatest differences are observed not only between the old and new members of the EU, but also inside each particular country. Poland is an example of such a country, where the gap between the GDP per capita of the richest region (mazowieckie voivodeship) and the poorest (voivodeships: lubelskie and podkarpackie) is large – over double in 2012.

Absorption of EU funds by Polish voivodeships is thought to be the main source of the reduction of disparities between them, and it is thus very important to find out if the absorption indeed has influence on the convergence of regional development. Usually, the concept of convergence concerns income disparities, measured by per capita GDP, with the analysis of convergence being provided by testing of β and σ hypotheses. The β-convergence means that a negative relation exists between the initial level of per capita GDP and its growth rate, and indicates that this relation is the main factor in diminishing differences across the regions (see Barro, 1991; Barro and Sala-i-Martin, 1997). The σ-convergence is the statistical analysis of the changes in GDP per capita variations between countries, over time. The β-convergence is the necessary, but not sufficient condition of σ-convergence. When β-convergence does not exist, it means that a divergence or a so called negative convergence, occurred.

In the recent years more studies have been devoted to the problems of unconditional or conditional convergence (club – convergence), TPF[1] convergence, human capital convergence and applying the spatial econometrics. The important overview of these theories is presented in the paper of Nazrul Islam (2003).

This paper discusses whether the per capita GDP is a sufficient indicator of regional development, and includes an analysis of convergence on the basis of information theory, which enables its deeper and holistic treatment.

Statistical data for the voivoideships of Poland on the NUTS 2 level (voivodeships i.e. provinces) are used for the applied analysis. These data include many variables, representing different areas of economic and social spheres and cover 2005–2013 time period.

[1] TPF – total factor productivity.

1. GDP OR MULTIDIMENSIONAL ANALYSIS?

Recently, we can observe discussions among economists (for example Joseph Stiglitz, 2006) concerning whether per capita GDP is a proper indicator of economic growth and well-being of nations[2]. The main source of such doubts are: – dependence of GDP value on the degree of cooperation inside each economy; – relation of prices, different in each country and problems with elimination of the differences by PPS[3]; – neglecting the quality of environment, usually negatively correlated with GDP level; – and the necessity of taking into account some social indicators which are important for the process of economic growth. As mentioned above, the convergence of regional growth also tends to extend the analysis towards the TPF convergence or human capital convergence.

On the other hand, results of the multidimensional analysis[4] depend on the method of analysis and the choice of the set of indicators. So, if we are able to agree on a reasonable set of indicators and use the same method of analysis, the results will be comparable. The selected set of indicators should cover the economic, social, infrastructure, and environmental variables, which makes the results more appropriate for measurement of well-balanced growth.

2. LINEAR TREND MODELS OF GDP FOR VOIVODESHIPS AND POLAND

The estimated linear trend models for GDP per capita for all voivodeships and Poland are the basis for the analysis if the absorption of the EU funds had any effect on diminishing the disparities between them. GDP per capita data covers the years 2005–2013, which is the period of considerable absorption of the EU funds. The results of the trend models estimation are presented in Table 1. Below the estimated values of the parameters – in the parenthesis – Student t-Statistics are presented.

As can be seen, all the estimated parameters significantly differ from zero, and the coefficients of determinations R^2 are very high. Some selected trends are presented on the graphs 1–4. The trend coefficients which represent yearly GDP increment per capita differ substantially among regions, from 1470.98 PLN for warmińsko- mazurskie voivodeship to 3775.47 PLN

[2] Nota bene, president Sarkozy has asked Joseph Stiglitz and Amartya Sen to propose the alternative indicator taking into account welfare, social inequalities and environment.

[3] PPS – purchase power standards.

[4] The multidimensional analysis is very popular in Poland and some new methods were proposed by Hellwig (1968) and Strahl (1978).

for mazowieckie voivodeship. For Poland, it is 2353.2 PLN. Every year, a growth by less than 2000 PLN is observed for 9 regions including kujawsko-pomorskie, lubelskie, lubuskie, opolskie, podkarpackie, podlaskie, świętokrzyskie, warmińsko-mazurskie and zachodnio-pomorskie.

Table 1. Linear trend models of GDP for voivodeships and Poland

Voivodeship	Linear trends of GDP (2005–2013)		
	Constant	Coefficients	R^2
Dolnośląskie	21099.25 (42.56)*	2973.62 (33.76)	0.993
Kujawsko—pomorskie	19832.44 (52.84)	1624.0 (24.35)	0.987
Lubelskie	14469.6 (34.68)	1645.0 (22.19)	0.984
Lubuskie	20007.78 (90.53)	1670.4 (42.53)	0.996
Łódzkie	19667.83 (59.06)	2163.57 (59.18)	0.994
Małopolskie	18070.72 (50.55)	2116.37 (33.32)	0.993
Mazowieckie	33322.0 (75.75)	3775.47 (48.30)	0.997
Opolskie	18236.17 (33.72)	1794.1 (18.67)	0.978
Podkarpackie	14657.22 (44.69)	1629.0 (27.95)	0.990
Podlaskie	16181.47 (56.56)	1592.42 (31.32)	0.996
Pomorskie	21147.75 (73.87)	2166.45 (42.59)	0.996
Śląskie	23708.25 (41.10)	2344.48 (22.87)	0.985
Świętokrzyskie	16649.56 30.25)	1732.27 (17.71)	0.975
Warmińsko-mazurskie	16964.75 (75.29)	1470.98 (36.74)	0.994
Wielkopolskie	22873.33 (68.20)	2392.39 (40.14)	0.995
Zachodnio-pomorskie	20778.25 (55.25)	1640.35 (24.55)	0.987
Polska	20812.14 (24.15)	2353.22 (15.36)	0.967

Note: in parentheses are t-Student statistics.

The yearly growth level close to the growth in mazowieckie voivodeship is observed for dolnośląskie (2937 PLN).

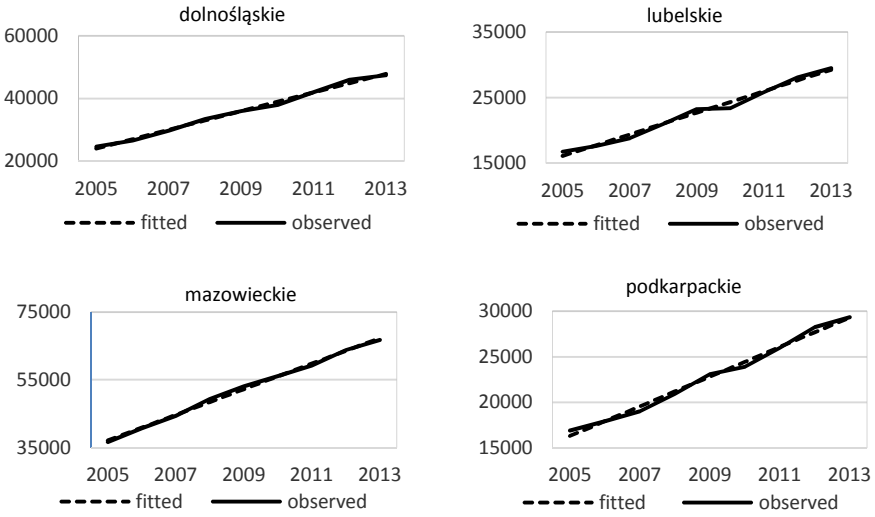

Figure 1. Fitted values of linear trend model for GDP per capita in chosen voivodeships

A better way of presentation seems to be displaying linear trend models together with the trend of the most developed mazowieckie voivodeship, which makes it easier to compare the GDP levels and trend coefficients for that pair of regions.

It is seen in Figure 2 that the gap between mazowieckie and kujawsko-pomorskie is larger than the gap between mazowieckie and dolonośląskie, and this gap is growing in time. Such situation is typical for all less developed regions characterized by low *per capita* GDP.

A large and growing gap between per capita GDP can be observed for lubelskie voivodeship, and not so large gap for łódzkie voivodeship, yet also growing in time.

The gap between the growth of podlaskie and mazowieckie voivodeships is greater than the gap between the growth of małopolskie and mazowieckie (Figure 2).

Świętokrzyskie and warmińsko-mazurskie voivodeships belong to the less developed regions, and the gap between the growth of mazowieckie and their growth is large and growing in time (see Figures 2 and 3).

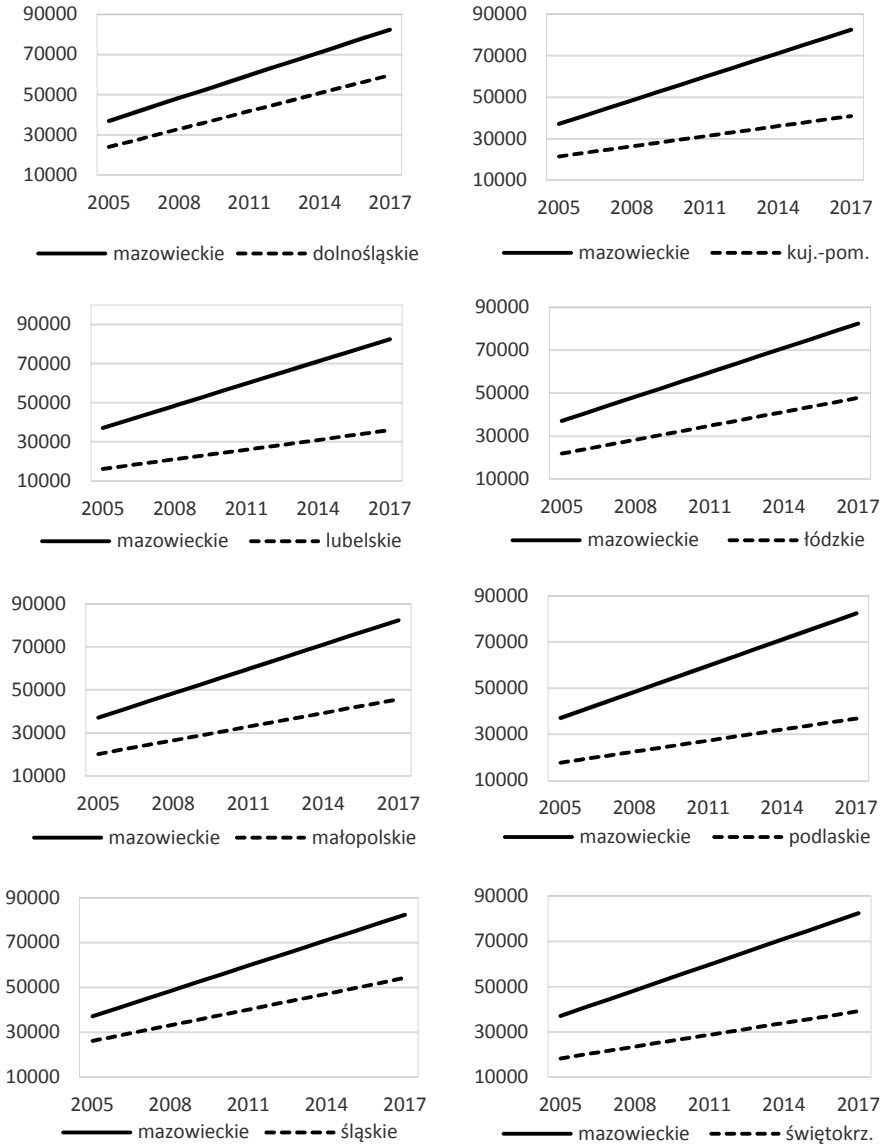

Figure 2. The gap between fitted values of linear trend for GDP per capita in mazowieckie and eight selected voivodeships

The set of more developed regions, such as dolnośląskie, łódzkie, pomorskie, śląskie and wielkopolskie voivodeships, is characterized by not

so large discrepancy between annual growth of GDP per capita in comparison with mazowieckie voivodeship, however the GDP levels per capita in those regions are significantly smaller than in mazowieckie voivideship (in 2012 the differences were about 20,000 PLN). It indicates that the process of divergence is observed for GDP per capita category between the regions and the process of divergence is stronger for less developed regions.

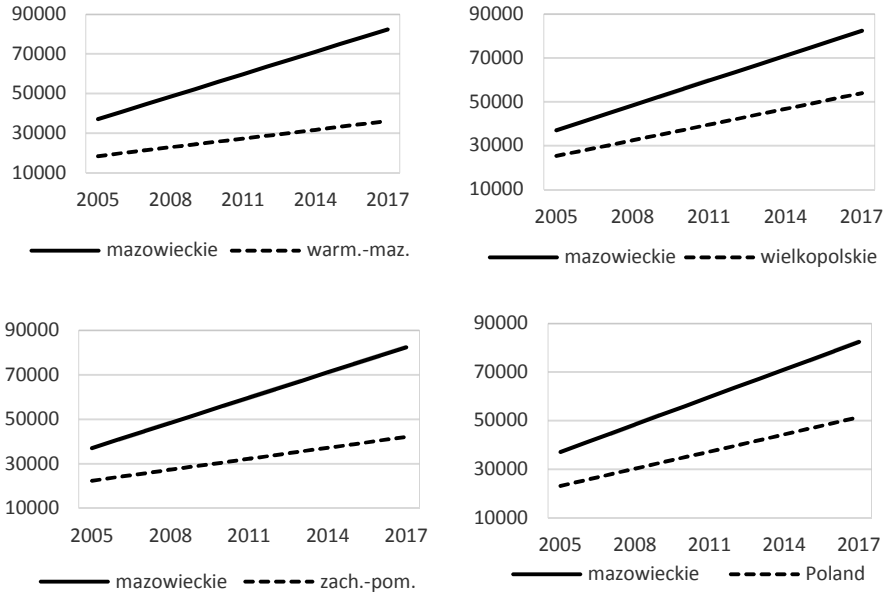

Figure 3. The gap between fitted values of linear trend for GDP per capita in mazowieckie and three selected voivodeships and Poland

3. SIMILARITY MEASURES AND THEIRS TRENDS

Assuming that *per capita* GDP category is not sufficient to represent the regional development, it is worth examining in more detail if the regional development of Poland is characterized by the convergence or the divergence process. Such analysis may be based on the trends of similarity measures.

The similarity measure proposed by the author (Kudrycka, 1984), which is a transformed form of the information inaccuracy measure, allows to determine the similarity between the distributions of two sets of variables, and may be used in the regional development analysis. The information inaccuracy $I(Y:X)$ (see Theil, 1966) was used to compare the distributions of two variables:

$$I(Y:X) = \sum_{i=1}^{n} y_i log \frac{y_i}{x_i}, \quad (1)$$

where: x_i is the frequency distribution of one variable in region "*i*" ,
y_i is the frequency distribution of another variable in region "*i*"
$\sum_{i=1}^{n} x_i = 1; \quad \sum_{i=1}^{n} y_i = 1; \quad i = 1, \dots, n.$

The information inaccuracy $I(Y:X)$ is equal to zero, when the appropriate frequencies of two distributions are equal, $y_i = x_i$ for all $i = 1, \dots, n.$

It is not possible to determine the maximum value $I(Y:X)$ because the value of the expression $y_i log \frac{y_i}{x_i} \to \infty$ (tends to infinity), whereas for fixed y_i $x_i \to 0$ (tends to zero).We can avoid that problem and normalized information inaccuracy in the following way:

$$P(Y:X) = \frac{1}{1+I(Y:X)} \quad (2)$$

where $P(Y:X)$ is the similarity measure[5].

In case $y_i = x_i$ for all $i = 1, \dots, n$ the similarity measure $P(Y:X) = 1$, and when $I(Y:X) \to \infty$, which means that discrepancy between frequencies of two distributions are large, the similarity measure $P(Y:X) \to 0$.

Let us assume that we are going to compare by regions the frequency distribution of a particular variable *Y* to the frequency distribution of another selected variable, which is treated as a pattern, and estimate the similarity measures for a given period. The pattern variable should be the same in all periods or changing insignificantly, thus we obtain the set of similarity measures, which will be the basis of concluding whether the process of convergence exists or not. If the similarity measures tend to 1 over time, the convergence process exists. Otherwise, when the similarity measures decrease over time, the divergence process is observed.

This method of convergence analysis has a number of advantages. First of all, we are able to analyze the convergence in some sectors of socio- economic phenomena, as well as for a particular variable. Secondly, it is not necessary to have access to a very long time series, as is necessary in the case of other methods, based on the growth rate of GDP. The simplicity of that method, and the fact that it lends itself to a clear interpretation are also important.

The disadvantage of this method is the necessity to determine the variables which will be used as the pattern. The simplest way to choose the pat-

[5] The similarity measure was also used by the author in the method of specification of an econometric model – determining the set of the endogenous and explanatory variables (Kudrycka, 1984).

tern is to establish the distribution of the population by regions for comparison of economic and social sphere, and the distribution of areas by regions to compare the infrastructural and environmental variables.

Table 2. Estimates of linear trend for the similarity measures

Variables	Linear trends for similarity measures		
	Constant	Coefficient	R^2
Live births	0.997 (6374.2)	-4.167^{-5} (–1.25)	0.243
University students	0.985 (1240 .6)	– 0.002 (–10.89)	0.936
Employment in R&D	0.855 (266.2)	0.002 (3.89)	0.684
Gross domestic expenditure on R&D	0.743 (235.96)	0.6^{-5} (3.38)	0.620
Bed places	0.790 (90.6)	0.003 (1.81)	0.319
Consumption of water by households	0.989 (677.5)	0.001 (2.31)	0.423
Consumption of gas by households	0.952 (819.5)	–0.001 (–2.68)	0.807
Audience in dramatic theatres and music Institutions	0.950 (152.3)	–0.005 (–4.20)	0.716
Personal computers with access to Internet	0.981 (584.9)	0.002 (7.08)	0.877
Water line distribution	0.940 (985.9)	0.001 (6.09)	0.840
Gas-line distribution system	0.716 (69.5)	0.008 (4.21)	0.717
Emission of gases from plants	0.763 (20.3)	–0.032 (–4.90)	0.774
Average values of similarity measures for human capital	0.969 (1046.3)	0.0001 (2.75)	0.520
Average values of similarity measures for economy	0.893 (178.1)	0.002 (2.34)	0.438
Average values of similarity measures for households	0.974 (463.9)	–0.001 (–2.01)	0.367
Average values of similarity measures for infrastructure	0.885 (429.2)	0.002 (5.51)	0.813
Average values of similarity measures for environment	0.816 (65.6)	–0.017 (–7.55)	0.891
Total average values of similarity	0 .908 (243.9)	–0.002 (–3.74)	0.667

Note: in parentheses are t-Student statistics.

The estimated similarity measures for some variables in the period 2005–2013 are presented in the Tables 1–3 in Appendix. Using selected

data, the linear trends of similarity measures were estimated. In the case of some variables, the linear trend, or any other form of trend, does not exist. Table 2 contains some of the results.

As we can see, the convergence process (growing values of similarity measures over time) exists for employment R&D, gross domestic expenditure on R&D, sleeping places, consumption of water by household, personal computers with Internet access, water line distribution and gas line distribution, which may be interpreted as positive process.

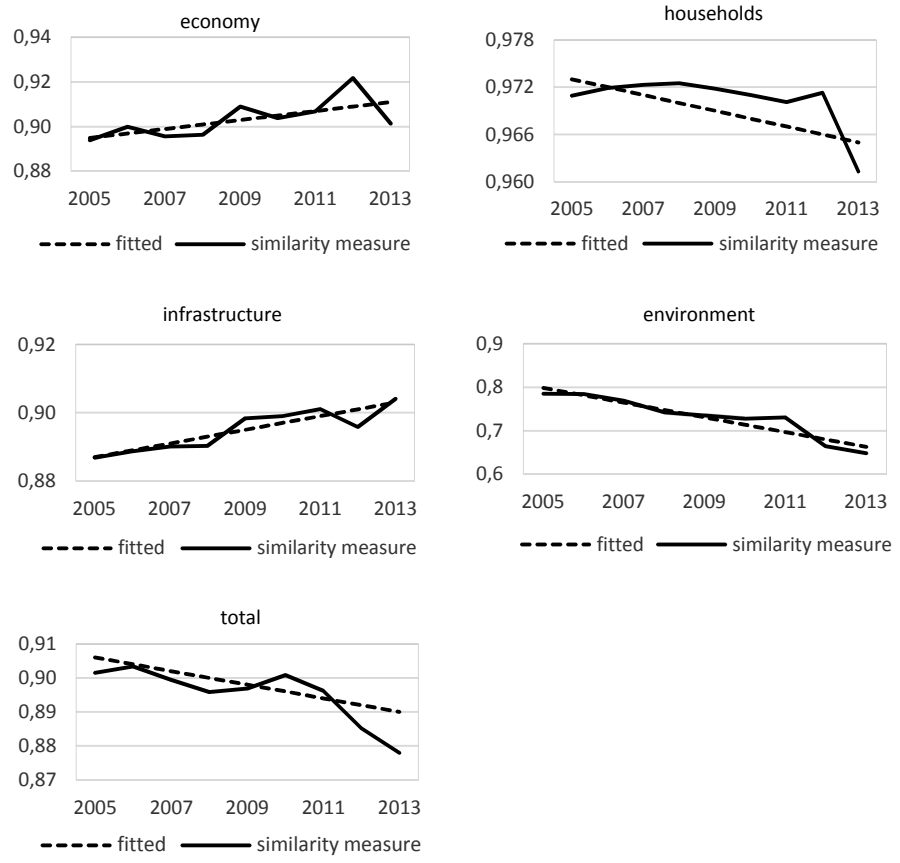

Figure 4. Fitted values of linear trend for similarity measures

The divergence process characterized the following variables: live birth, number of university students, consumption of gas by households, audience in dramatic theatres and music institutions, and emission of gases from plants.

Estimated trends for average values of similarity measures characterizing a particular sphere of activity indicate the convergence process for human capital, economy, and infrastructure, while the divergence process exists for households, environment, and a total average of all selected variables.

The trends for the average values of similarity measures are presented in Figures 4. We can see that in the case of average similarity measures for households and average for total variables, it is necessary to estimate another form of the trend – likely the log-linear one which may improve the goodness of fit.

CONCLUSIONS

Restraining the regional development convergence analysis only to the rate of GDP growth is too narrow and excessively simplified. It is important to take into account several aspects of regional development and to use appropriate research methods.

The similarity measure proposed by the Author, which is the transformed measure of inaccuracy of information, has a good background and interpretation on the basis of information theory, and may be used for comparison of distributions of variables among regions.

Changes in the similarity measures over time enable to recognize characteristics of regional development, specifically whether convergence processes exist or not.

It is worth emphasizing that the similarity measures method provides us with more useful results, as it takes into account many aspects of socio-economic sphere.

We have observed the divergence process of the regional development, taking into account *per capita* GDP based on the trend analysis of this category.

The trends of similarity measures indicate that divergence process exists also for average values of economy variables, households, environment and total average, as well as for singular variables: the number of university students, the audience in dramatic theatres and music institutions, consumption of gas by households and emission of gas by plants. It is worth stressing that absorption of the EU funds has had limited influence on the reduction of disparities between the regions of Poland.

Fortunately, the convergence processes exist in relation to some important economic and social phenomena such as: employment in R&D sector, gross domestic expenditure on R&D, households access to the Internet, and infrastructure.

The regional development analysis presented in this article may be used by central and local authorities for creating regional policy

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ROZWÓJ REGIONALNY W POLSCE W LATACH 2005–2013 – GŁÓWNE TENDENCJE

Z a r y s t r e ś c i. Artykuł przedstawia ekonometryczną analizę rozwoju regionalnego Polski w latach 2005-2013. Przedmiotem rozważań są nie tylko trendy wzrostu PKB w poszczególnych województwach i zwiększanie się w czasie różnic między poziomem PKB *per capita* w regionach słabiej i mocniej rozwiniętych, ale też możliwości bardziej kompleksowego ujęcia rozwoju regionalnego. W tym celu zaproponowano wykorzystanie zaproponowanych przez autorkę miar podobieństwa obliczonych dla wybranych zmiennych- charakteryzujących ekonomiczne i społeczne atrybuty rozwoju. Analiza zmian w czasie wartości miar podobieństwa umożliwia określenie czy występuje proces konwergencji rozwoju, czy też zjawisko dywergencji

S ł o w a k l u c z o w e. Rozwój regionalny. PKB i inne wskaźniki. Analiza kokonwergecji. Entropia i miara podobieństwa.

APPENDIX

Table 1. Similarity measures for regions – human capital and economy

N	Variables	2005	2006	2007	2008	2009	2010	2011	2012	2013
1.	Live births	0.9976	0.9975	0.9972	0.9974	0.9977	0.9976	0.9978	09980	0.9975
2.	Infant deaths	0.9945	0.9924	0.9861	0.9919	0.9899	0.9937	0.9861	0.9914	0.9955
3.	Students at general secondary schools	0.9835	0.9953	0.9949	0.9941	0.9926	0.9915	0.9916	0.9913	0.9914
4.	University students	0.9835	0.9817	0.9797	0.9777	0.9781	0.9771	0.9756	0.9723	0.9697
5.	Employed persons (thousands)	0.9943	0.9946	0.9946	0.9934	0.9940	0.9952	0.9947	0.9942	0.9945
6.	Employment in (R&D)sector	0.8542	0.8611	0.8596	0.8681	0.8642	0.8679	0.8768	0.8759	0.8679
7.	Unemployed persons (thousands)	0.9830	0.9816	0.9743	0.9638	0.9758	0.9803	0.9814	0.9846	0.9838
8.	Average value of similarity measures for human capital	0.9701	0.9721	0.9694	0.9695	0.9703	0.9719	0.9720	0.9725	0.9747
9.	GDP (mln zł)	0.9690	0.9672	0.9674	0.9694	0.9666	0.9635	0.9635	0.9732	–
10.	Enterprises investment outlays (mln zł)	0.9381	0.9378	0.9376	0.9432	0.9655	0.9390	0.9559	0.9577	0.9499
11.	Fixed assets (mln zł	0.9309	0.9350	0.9349	0.9357	0.9344	0.9314	0.9730	0.9756	0.9763
12.	Entities of the national economy registered in REGON system	0.9867	0.9866	0.9869	0.9855	0.9849	0.9850	0.9851	0.9850	0.9835
13.	Gross domestic ex-penditure on R&D(thousands zl)	0.7527	0.7583	0.7652	0.7527	0.7991	0.7861	0.7937	0.8309	0.7879
14.	Number of beds in hotels and tourist establishment (in thousands)	0.7868	0.8146	0.7817	0.7913	0.8031	0.8184	0.8182	0.8076	0.8095
15.	Average value of similarity measures for economy	0.8940	0.8999	0.8956	0.8963	0.9090	0.9038	0.9068	0.9217	0.9014

Table 2. Similarity measures for regions – households

No.	Variables	2005	2006	2007	2008	2009	2010	2011	2012	2013
1.	Nominal income in the house-holds sector (in PLN)	0.9894	0.9896	0.9897	0.9895	0.9877	0.9866	0,9928	0,9928	–
2.	Consumption of water in house-holds (in h.m^3)	0.9905	0.9998	0.9913	0.9908	0.9922	0.9922	0.9921	0,9984	0,9923
3.	Consumption of electricity In households (GWh)	0.9735	0.9733	0.9746	0.9749	0.9750	0.9749	0.9741	0,9736	0,9744
4.	Consumption of gas in house-holds (w hm^3)	0.9525	0.9500	0.9511	0.9481	0.9480	0.9465	0.9507	0,9472	0,9469
5.	Audience In dramatic thea-tres and music institution (thousnds)	0.9380	0.9345	0.9377	0.9434	0.9341	0.9285	0,9141	0,9180	0,8961
6.	Personal computers with access to Internet	0.9817	0.9842	0.9895	0.9889	0.9937	0.9971	0.9971	0,9979	0.9967
7.	Average value of similarity measures for households	0,9709	0.9719	0.9723	0.9725	0.9718	0.9710	0.9701	0,9713	0.9613

Table 3. Similarity measures for regions – infrastructure and environment

No.	Variables	2005	2006	2007	2008	2009	2010	2011	2012	2013
1.	Hard surface public roads (km)	0.9881	0.9875	0.9875	0.9858	0.9872	0.9872	0.9856	0,9870	0,9872
2.	Water-line distribution system (km)	0.9427	0.9429	0.9433	0.9432	0.9428	0.9468	0.9483	0,9491	0,9499
3.	Sewage system (km)	0.8963	0.8952	0.8938	0.8931	0.8893	0.8855	0.8901	0,8940	0,8931
4.	Gas-line distribution system (km)	0.7200	0.7293	0.7358	0.7391	0.7745	0.7767	0.7805	0,7531	0,7862
5.	Average value of similarity measures for infrastructure	0.8868	0.8887	0.8901	0.8903	0.8984	0.8990	0.9011	0,8958	0,9041
6.	Emission of air particulates pollutants from plants (thou-sands tons)	0.7911	0.7918	0.7541	0.7998	0.8024	0.7790	0.7729	0,7898	0,7831
7.	Emission of gases from plants (thou-sands tons)	0.7001	0.6955	0.6910	0.5600	0.5444	0.5454	0.5518	0,5392	0,5136
8.	Average value of similarity measures for environment	0.7858	0.7845	0.7693	0.7425	0.7351	07283	0.7311	0,6645	0,6483
9.	Total average similarity measures	0.9015	0.9034	0.8994	0.8958	0.8969	0.9008	0.8962	0,8852	0,8780