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Armand Kasztelan
University of Life Sciences in Lublin, Department of Economics and Agribusiness
e-mail: armand.kasztelan@up.lublin.pl
ORCID: 0000-0002-1947-9846

THE GREEN COMPETITIVENESS OF POLISH REGIONS

ZIELONA KONKURENCYJNOŚĆ POLSKICH REGIONÓW

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Summary: Nowadays, environmental factors are seen as an important element in achieving competitive advantage at micro, meso and macro levels. The paper presents an assessment of the green competitiveness of Polish regions in the years 2004 and 2018 (last available data). For the purposes of the analysis, 25 indicators of the condition and protection of the environment and also environmental pressures were selected. Research was carried out based on the taxonomic linear ordering method, which enabled multidimensional comparative analysis (MCA). The adopted method made it possible to evaluate the studied phenomenon as a whole, providing grounds for assigning the Polish regions into four groups, characterized by a similar level of green competitiveness.

Keywords: competitiveness, environment, green growth, natural capital, taxonomic methods.

Streszczenie: W dzisiejszych czasach czynniki środowiskowe są postrzegane jako ważny element w osiągnięciu przewagi konkurencyjnej na poziomie mikro, mezo i makro. W pracy przedstawiono ocenę zielonej konkurencyjności polskich regionów w latach 2004 i 2018 (ostatnie dostępne dane). Na potrzeby analizy wybrano 25 wskaźników stanu i ochrony środowiska, a także presji wywieranych na środowisko. Badania przeprowadzono w oparciu o taksonomiczną metodę uporządkowania liniowego, która umożliwiła wielowymiarową analizę porównawczą (MCA). Przyjęta metoda pozwoliła na ocenę badanego zjawiska jako całości, dając podstawy do przyporządkowania województw w Polsce do czterech grup charakteryzujących się podobnym poziomem zielonej konkurencyjności.

Słowa kluczowe: konkurencyjność, środowisko, zielony wzrost, kapitał naturalny, metody taksonomiczne.

1. Introduction

The natural environment has a doubly positive effect on social and economic processes: it supplies specific resources such as water, minerals, and components of flora and fauna that are used in the production of goods, and provides a number of services, e.g. assimilation (absorbs the anthropogenic impact to some extent and neutralizes it through natural biochemical and geological processes), recreation and tourism (Everett, Ishwaran, Ansaloni, and Rubin, 2010, p. 7).

Thus, natural capital is a source of functions significant to economic systems and to human life. The loss of these functions may significantly affect the chances for future development. According to the current state of knowledge, natural capital is a key resource in the process of development. This way of perceiving natural capital is more and more widely accepted in economic sciences (Malovics, 2007).

What is more, the significance of environment quality in supporting regional development, including the competitiveness of regions, is one of the premise for coordinating environmental and regional policies. It is also emphasized that the competitiveness of the region is determined by its social and economic attractiveness, depending, among other factors, on clean space.

Respective regions do not develop at the same pace and are at different levels of development. At each of those levels, specific factors determine the competitiveness of regions, which indicates that the key elements of the model are of major significance, considering that each level of economic development generates its own growth drivers (Vilcinya and Boronenko, 2008, p. 172).

In the opinion of Wiatrak, elements of the natural environment should especially be considered under regional policy. Here, one must consider aspects related to the reasonable use of production factors in the region, adaptation of the structure of activity to such resources and the environmental potential, protection of the natural environment, and reasonable land management and prevention of economic extensification (Wiatrak, 1998, p. 88).

In turn, Marszałkowska (2000, p. 90) claims that the high quality of the environment, or measures to achieve such quality are significant elements of development fostering the absorption of innovation and the introduction of cleaner technologies. This again contributes to increasing the competitiveness of the economy, also at the meso-economic level.

Achieving a competitive advantage over other regions based on existing environmental potential, the ability to use the socio-economic growth and development processes, and the low level of anthropopression, may be defined as the **green competitiveness of a region.** This competitiveness should be considered in two ways. Firstly, it may be related to the environmental conditions occurring in a given region, while secondly it concerns their skillful use in socio-economic processes, which will impact upon any increase in the region's competitiveness. (Kasztelan, 2010).

Whereas the natural resources are not man-made, their quality and capability to supply specific goods and services, and thus their value as inputs, are determined by human activity. In many cases, the measurable effects of production activity (e.g. crop farming) are preconditioned by an adequate combination of natural elements (soil, water) and anthropogenic elements (irrigation, transport infrastructure). Hence, the conceptual distinction between natural capital and human-made capital is still useful (OECD, 2008, p. 30).

The main aim of this paper is to evaluate the green competitiveness of Polish regions (NUTS 2), based on the Statistics Poland (GUS) data and taxonomic linear ordering method, enabling a multidimensional comparative analysis of multi-featured objects. This type of analysis provides answers to the following questions: (1) What changes in shaping green competitiveness have been recorded in individual voivodeships since Poland's accession to the European Union? (2) What is the overall situation of Polish regions according to the studied phenomenon? (3) What areas of green competitiveness require decisive corrective action?

2. Characteristics of the research method

The evaluation of green competitiveness was based on a taxonomic linear ordering method, which in turn is based on the construction of a synthetic measure (Hellwig, 1968). Taxonomic procedures are used in the study of complex phenomena that cannot be measured directly. This kind of analysis provides an estimate of the level of diversity of objects (e.g. regions) described by a set of statistical characteristics (e.g. indicators). In a linear hierarchy the maximum degree is 1 (Łogwiniuk, 2011).

At the first stage of the study procedure, the indicators were initially selected. The reference years 2004 and 2018 were chosen due to data availability on the Statistics Poland (GUS) database. Diagnostic variables defining the level of green competitiveness for particular regions were adjusted in an attempt to meet two criteria: substantive and formal. The selection of substantive indicators was based on literature studies (Borys, 2005; Kijek and Kasztelan, 2013; Kruk, 2010), as well as on a review of the databases. The next step was to check if they meet formal criteria, i.e. whether they are measurable, complete and ensure comparability. Finally, 25 diagnostic variables were selected for the green competitiveness analysis (Table 1).

Among the selected variables, 16 were considered to be the larger-the-better (stimulants) characteristics having a positive influence on the measure, whereas 9 were regarded as the smaller-the-better (destimulants) reducing the synthetic measure of green competitiveness. Stimulants (selected indicators) are explanatory (independent) variables whose increased values cause an increased value in the dependent variable (green competitiveness of regions), while destimulants are explanatory variables whose increased values induce a decrease in the value of the dependent variable. The values of variables (X_j, $j = 1, 2, \ldots, m$) representing each

Table 1. Indicators of green competitiveness

Symbol	Indicator
x_1	The proportion of organic land within the overall area of the voivodeship (as %)
x_2	The proportion of forested land within the overall area of the voivodeship (as %)
x_3	The proportion of land under surface waters within the overall area of the voivodeship (as %)
x_4	The proportion of recreation and leisure areas within the overall area of the voivodeship (as %)
x_5	The proportion of devastated and degraded land requiring reclamation and management within the overall area of the voivodeship (as %)
x_6	Consumption of artificial fertilizers in terms of pure ingredient over the economic years 2003/2004 and 2017/2018 (in kg/ha of agricultural land)
x_7	Exploitable underground water resources in Poland (in hm^3 per year)
x_8	Water withdrawal for the needs of the national economy and population (in dam^3/km^2)
x_9	Consumption of water for production purposes in closed cycles (as % of total consumption)
x_{10}	Water consumption in households (in m^3 per capita in cities)
x_{11}	Amount of industrial and municipal wastewater discharged into waters or into the ground (in m^3 per km^2 of voivodeship area)
x_{12}	The proportion of treated wastewater to all wastewater requiring treatment (as %)
x_{13}	Population in cities connected to wastewater treatment plants (as % of total population of cities)
x_{14}	Population in villages connected to wastewater treatment plants (as % of total population of villages)
x_{15}	Degree of reduction in generated particulate pollutants in especially noxious plants (as %)
x_{16}	Degree of reduction in generated gaseous pollutants in especially noxious plants (as %)
x_{17}	Area of special natural value protected by law (as % of voivodeship area)
x_{18}	The area of parks, lawns and green belt land (in m^2 per capita)
x_{19}	Industrial waste generated during a year (in tones/km^2)
x_{20}	Recovered waste (as % of generated wastes)
x_{21}	Waste accumulated so far on own landfill areas (in tones/km^2)
x_{22}	Municipal waste generated (in kg/1 inhabitant)
x_{23}	The proportion of municipal waste collected selectively in relation to the total amount of collected municipal waste (as %)
x_{24}	Levels of recycling of packaging waste (as %)
x_{25}	The proportion of plants exceeding permissible noise levels in relation to the overall number of entities of this type controlled (as %)

Source: own elaboration based on (Kasztelan, 2015; Główny Urząd Statystyczny [GUS]. 2005; Główny Urząd Statystyczny [GUS]. 2019).

region (O_i, $i = 1, 2, \ldots, n$) are presented as a matrix of observations in the form (Grzebyk and Stec, 2015):

$$X = \begin{bmatrix} x_{11} & x_{12} & \ldots & x_{1m} \\ x_{21} & x_{22} & \ldots & x_{2m} \\ \ldots & \ldots & \ldots & \ldots \\ x_{n1} & x_{n2} & \ldots & x_{nm} \end{bmatrix}.$$

Since the set of independent features contains variables that cannot be aggregated directly using appropriate standardization, normalization formulas were applied. Among the formulas, the method of zero unitarization was selected based on the interval of a normalized variable. The first mention of this method can be found in Wesołowski (1971) and Kolman (1973). The indicators selected for testing green competitiveness were subjected to a standardization process based on the following formulas (Kukuła, 1999):

- for stimulants:

$$z_{ij} = \frac{x_{ij} - \min(x_{ij})_i}{\max(x_{ij})_i - \min(x_{ij})_i},$$

- for destimulants:

$$z_{ij} = \frac{\min(x_{ij})_i - x_{ij}}{\max(x_{ij})_i - \min(x_{ij})_i},$$

where: z_{ij} is the normalized value of the j-th variable in the i-th country; x_{ij} is the initial value of the j-th variable in the i-th country.

The diagnostic features normalized in the abovementioned way take the value from the interval [0; 1]. The closer the value to unity, the better the situation in terms of the investigated feature, and the closer the value to zero, the worse the situation.

In the next step, the normalized values of variables formed the basis for calculating the median and standard deviation for each of the countries studied. Median values were determined using the formula (Strahl, 2006; Grzebyk and Stec, 2015):

$$Me_i = \frac{z_{\left(\frac{m}{2}\right)i} + z_{\left(\frac{m}{2}+1\right)i}}{2},$$

for an even number of observations, or:

$$Me_i = z_{\left(\frac{m}{2}+1\right)i},$$

for an odd number of observations,

where: $z_{i(j)}$ is the j-th statistical ordinal for the vector (z_{i1}, z_{i2}, …, z_{im}), $i = 1, 2, \ldots, n$; $j = 1, 2, \ldots, m$.

In turn, the standard deviation was calculated according to the following formula:

$$Se_i = \sqrt{\frac{1}{m}\sum_{j=1}^{m}(z_{ij} - \overline{z})}.$$

Based on the median and standard deviation, an aggregate measure of green growth in the agricultural sector was developed for each country (w_i):

$$w_i = Me_i\,(1 - Se_i),\ w_i < 1.$$

The values of the measure closer to one indicate a higher level of the greening of agriculture in the specific member state, resulting in a higher rank. The aggregate measure prefers countries with a higher median of features describing the specific country and with smaller differentiation between the values of features in the particular country expressed as a standard deviation.

The procedure chosen for evaluating the green growth in agriculture provided multidimensional comparative analysis. It allowed a comparison between member states of the EU providing grounds for classifying them into uniform groups:

group I:	$w_i \geq \overline{w} + S$	high level
group II:	$\overline{w} + S > w_i \geq \overline{w}$	medium–high level
group III:	$\overline{w} > w_i \geq \overline{w} - S$	medium–low level
group IV:	$w_i < \overline{w} - S$	low level

where: $\overline{\ }$ is the mean value of the synthetic measure and S is the standard deviation of the synthetic measure.

According to the w_i values, the EU countries were assigned to one of the groups with regard to their level of the greening the agricultural sector.

3. Research results

The research results show that both in 2004 and 2018 only two regions were classified into group I with the highest green competitiveness rating (Figure 1). Compared to 2004, there was a decrease in the number of regions in group II (medium-high) while in group III (medium-low) an increase was recorded. The quantitative status in group IV, characterized by the lowest level of green competitiveness, did not change. It should also be noted that there was a reshuffling of individual regions between groups during the period considered.

Among the analysed voivodeships, an advancement between individual groups was observed for Zachodniopomorskie (from group IV to group II), Łódzkie (from III to II) and Świętokrzyskie (from IV to III), while the situation deteriorated in Podlaskie (from II to IV), as well as in Lubelskie and Dolnośląskie (from II to III). Regarding the changes in the ranking of voivodeships in Poland (Table 2), seven voivodeships improved their position, also the position of seven deteriorated, while in the case of two the situation remained unchanged.

Table. 2. The green competitiveness of Polish regions

Voivodeships	Taxonomic metrics		Ranking in Poland		Change
	2004	2018	2004	2018	
Dolnośląskie	0.3694	0.2501	10	13	–3
Kujawsko-pomorskie	0.4082	0.3311	4	9	–5
Lubelskie	0.3797	0.3031	7	10	–3
Lubuskie	0.3927	0.3372	6	7	–1
Łódzkie	0.3291	0.3742	11	4	+7
Małopolskie	0.3726	0.3655	9	5	+4
Mazowieckie	0.1433	0.1957	16	16	0
Opolskie	0.3778	0.3312	8	8	0
Podkarpackie	0.4491	0.5220	2	1	+1
Podlaskie	0.4042	0.2100	5	15	–10
Pomorskie	0.4181	0.3614	3	6	–3
Śląskie	0.2827	0.2416	13	12	+1
Świętokrzyskie	0.2226	0.2469	15	14	+1
Warmińsko-mazurskie	0.4673	0.4520	1	2	-1
Wielkopolskie	0.3169	0.2995	12	11	+1
Zachodniopomorskie	0.2384	0.3785	14	3	+11

Source: own compilation.

The highest increase in this range was noted for Zachodniopomorskie – from 14th to 3rd position in the ranking. Among the 25 indicators, Zachodniopomorskie recorded an improvement in relation to 15 of them, mainly in the field of water and sewage management, noise emission indicators and the share of the green as well as recreational and tourist areas in the total area of the region. The highest decrease was noted for Podlaskie – from 5th to 15th. In this case, such a significant loss of position in the ranking of voivodeships was caused by the deterioration of the value of 13 out of 25 indicators including water management, air pollution reduction rate, noise emission and packaging waste management.

The conducted analysis shows that in 2004, Warmińsko-mazurskie was characterized by the highest level of green competitiveness. The taxonomic metric of this region was estimated at 0.4673. The lowest evaluation was noted in Mazowieckie for which the w_i indicator amounted to a mere 0.1433. To compare, in 2018 Podkarpackie achieved the best result (0.5220), while Mazowieckie was still the worst in the assessment (0.1957). The average value of the synthetic measure for all voivodeships was 0.3483 in 2004, and 0.3250 in 2018, taking into account the latest data.

A deeper analysis of green competitiveness factors for all regions makes it possible to state that the average standardized mean values (0.5000) were exceeded only for 10 of them (40.0%). In addition, in the years examined an improvement was

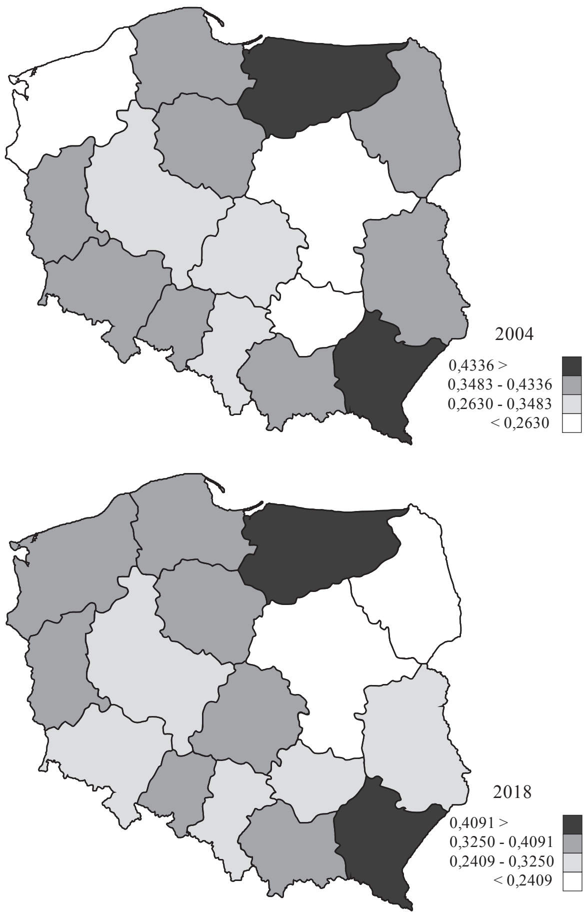

Fig. 1. The green competitiveness of Polish regions in 2004 and 2018

Source: own compilation.

observed for 11 indicators (44.0%). The analysis shows that significant problems still to be solved are:

- low levels of water consumption for production purposes in closed cycles (average w_i for 16 regions – 0.2696) while at the same time low exploitable underground water resources (0.3436),
- improvement in the levels of recycling of packaging waste (0.3129),
- low proportion of recreation and leisure areas (0.2703) as well as areas of parks, lawns and green belt land (0.3889) and forested land (0.3194) within the overall areas of the regions,
- relatively low proportion of organic land within the overall area of the voivodeships (0.3794).

4. Conclusions

The condition of the environment and the undertakings aiming to protect it are more and more often treated as a factor of economic growth and development. Natural capital directly and indirectly participates in nearly all the socio-economic processes. The uneven distribution of natural resources and values determines competitive advantage at micro, meso and macroeconomic level. The appropriate use of the inherent potential of the environment generates additional economic effects, contributes to further improvement in the condition of the environment, fosters the accomplishment of social objectives through a reduction of the level of unemployment in the region and a general improvement in the quality of life.

The article presents the results of the assessment of the green competitiveness of Polish voivodeships. Based on the methods used, synthetic measures were designed for each of the regions. The conclusions from the study are as follows:

1. The average value of the synthetic measure for all 16 regions covered by the analysis was 0.3483 in 2004 and 0.3250 in 2018, which testifies to the very low general level of the green competitiveness of the regions in Poland.
2. There was a slight decrease in the average synthetic measure over the period, which means that the overall green competitiveness rate in the regions analysed deteriorated.
3. A decrease was observed in the number of voivodeships with a medium-high green competitiveness rating (group II), while increasing the number of regions in the medium-low group (I).
4. The results of the thorough analysis of green competitiveness factors show that much still remains to be done in the greening of economic processes in Polish regions.

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