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Marta Ewa Kuc
Gdansk University of Technology, Faculty of Management and Economics, marta.kuc@zie.pg.gda.pl

Przestrzenny taksonomiczny miernik rozwoju w analizach poziomu życia ludności

Streszczenie: Uwzględnienie zależności przestrzennych w konstrukcji taksonomicznego miernika rozwoju zyskuje popularność w polskiej literaturze naukowej. Jednakże, nie ma jednego wspólnego stanowiska odnośnie sposobu i miejsca uwzględniania zależności przestrzennych w konstrukcji miernika syntetycznego. Wydaje się, że uwzględnienie zależności przestrzennych jest szczególnie ważne w analizach mniejszych jednostek regionalnych, gdyż są one silniej zależne od sytuacji w regionach sąsiednich. W związku z czym, w niniejszym artykule skonstruowano rankingi poziomu życia ludności w regionach NUTS-3 państw nordyckich. Wykorzystano do tego celu propozycje konstrukcji przestrzennych taksonomicznych mierników rozwoju zaproponowanych przez Antczak, Pietrzaka oraz Sobolewskiego, Migały-Warchoł i Mentela. Celem niniejszego badania jest wskazanie zalet i wad poszczególnych mierników oraz porównanie zgodności wyników uzyskanych na ich podstawie.

Słowa kluczowe: przestrzenny taksonomiczny miernik rozwoju, poziom życia

JEL: C10, R12

1. Introduction

The main goal of this research is to compare different methods of construction of the taxonomy spatial measure of development and attempt to identify the advantages and disadvantages of those approaches. The analysis is deduced from the data concerning regions of the Nordic countries. The Nordic countries stand out against the background of today's developed countries, not only in terms of a higher standard of living (*The lottery of life*, 2012: 1; *OECD Better Life Index*, 2013: 1; *Global Peace Index*, 2015: 7; *Human Development Report*, 2015: 47; *The Legatum Prosperity Index Ranking*, 2015: 3; *World Happiness Report*, 2016: 20) but also the relatively better condition of their economies (*The Global Competitiveness Report*, 2015: 15). Therefore, those countries have high positions in different rankings on happiness and quality of life, as well as the competitiveness of their economies. Due to their geographical proximity and common historical roots, the Nordic countries are often wrongly treated as united. However, in reality, different regions of the Nordic countries are diverse in terms of socio-economic development.

In 1952, Denmark, Iceland, Norway and Sweden formed the Nordic Council, which was later joined by Finland and also by the autonomous territories Greenland, Åland and the Faroe Islands. In 1962, the Nordic countries signed the so-called 'Helsinki Treaty' (*The Helsinki Treaty*, 1962), which regulates cooperation between them. The Nordic Council and cooperating Nordic Council of Ministers are responsible for the agreements within the Nordic countries and the pursuit of the sustainable development of associated regions. Currently, the fourth strategy for the sustainable development of the Nordic region is implemented (*A Good Life in a Sustainable Nordic Region. Nordic Strategy for Sustainable Development*, 2013: 5–32). The time frame of this strategy covers the period up to 2025. In this strategy, the emphasis is on cooperation leading to higher employment, green economic growth and increasing the competitiveness of the economies but also the safe, healthy and decent life of inhabitants. It seems that the issues concerning the standard of living comprise one of the priorities of the Helsinki Treaty.

In this research, the term *standard of living* refers to the level of wealth, comfort, material goods and necessities available to a certain socioeconomic class in a certain geographic area (Bywalec, Wydymus, 1992: 669–687). The standard of living is a multidimensional category; hence, the taxonomy spatial measure of development was used as its approximation. Measures based on GDP were rejected, as many authors claim that GDP per capita cannot be used alone as the standard of living measurement (Daly, Cobb, 1990: 62–82; Khan, 1991: 469–502; Clarke, 2005: 3; Stiglitz, Sen, Fitoussi, 2009: 21–40).

In this study, different taxonomy spatial measures of development were used to assess the standard of living in different Nordic regions. In order to compare the spatial approach with the classical approach, the classical taxonomy measure of development was also calculated. The analysis was conducted for 67 NUTS-3 regions of Nordic countries (excluding: Höfuðborgarsvæði, Landsbyggð, Grønland, Føroyar, Åland, Gotland and Bornholm) in 2014. Empirical material was taken from the national statistical offices of analysed countries.

2. The location component in taxonomy measure of development

There are at least six reasons to include spatial factors into the standard of living analysis. Firstly, as Waldo Tobler said, "Everything is related to everything else, but near things are more related than distant things" (Tobler, 1970: 234–240). Secondly the use of a regional dataset implies consideration of the possibility that observations may not be independent, as a result of the inter-connections between neighbouring regions (Buccellato, 2007: 1). Thirdly, it is better to use the simplest weight matrix than assume the independence in advance (Griffith, 1996: 351–367). Fourthly, the diversification of economic phenomena in an established group of regions is highly affected by the spatial conditions (Pietrzak, Wilk, Bivand, Kossowski, 2014: 202–220). Fifthly, empirical analyses that have ignored the influence of spatial location may have produced biased results (Fingleton, Lopez-Bazo, 2006: 178). Finally, the convergence analysis based on spatial synthetic measure gives models that fit more closely to the data and indicate a faster rate of convergence (Kuc, 2014: 12). Moreover, one should be aware that no region in the contemporary world is developing in isolation. All these arguments suggest that the spatial factor should be included both in the standard of living and social convergence analyses.

The first published research including the location component in the measure of development construction approach was proposed by Antczak (2013: 37–53). In her research, the taxonomy spatial measure of development was used to analyse the sustainable development in voivodships of Poland in 2000 and 2010. The second published research about the taxonomy spatial measure of development approach was proposed by Pietrzak (2014: 181–201). In his research, the taxonomy spatial measure of development was used to analyse the economic development level of Polish sub-regions in 2011. The third research, including the locational component, was proposed by Sobolewski, Migała-Warchoł and Mentel (2014: 159–172). In their research, the taxonomy spatial measure of development was used to analyse the standard of living in Polish counties from 2003–2012. In the next section of this article, the different ways to construct the taxonomy spatial measure of development, proposed by the above mentioned authors, will be presented. In the further part of this research, those approaches will be used to assess the standard of living in the Nordic NUTS-3 regions.

3. Taxonomy spatial measure of development proposed by Antczak

The modification of the classical measure of development, proposed by Antczak, was made by adding the spatial weight matrix to the formula of Hellwig's classical development measure (Hellwig, 1968: 307–326). Antczak's measure allows the conducting of simultaneous analyses in three dimensions: section, time and space.

The taxonomy spatial measure of development, according to Antczak (2013: 39–43), is calculated as follows:

1. From the wild set of potential diagnostic variables, remove those that do not meet the formal conditions.
2. Test the final set of diagnostic variables for the presence of spatial autocorrelation using Moran's I statistics (Suchecki, 2010: 112):

$$I = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}\left(x_i - \bar{x}\right)\left(x_j - \bar{x}\right)}{\sum_{i=1}^{n}\left(x_i - \bar{x}\right)^2} \quad (i = 1,..,n;\ j = 1,...,n) \tag{1}$$

where:
I – the value of Moran's I statistics,
n – number of observations,
w_{ij} – spatial weight matrix,
x_i, x_j – the value of analysed variable in i and j objects.
$\bar{x}$ – the mean average of analysed variable.

The variables for which the value of Moran's I statistic are statistically significant are included in the group of 'spatial' variables and otherwise – in the group of variables having no spatial character ('non-spatial' variables).

3. Change destimulants for stimulants and standardise variables depending on which group they belong to:
   3.1. 'Non-spatial' variables standardised using following formula:

$$z_{ij} = \frac{x_{ij} - \bar{x}_j}{s_j} \quad (i = 1,...,n;\ j = 1,...,m) \tag{2}$$

where:
z_{ij} – standardised value of j variable in i object,
x_{ij} – the value of j variable in i object,
$\bar{x}_j$ – the mean average of j variable,
s_j – the standard deviation of j variable.

3.2. For 'spatial' variables use:

$$z_{ij}^{*} = \frac{x_{ij}^{*} - \overline{x}_{j}^{*}}{s_{j}^{*}} \quad (i = 1,...,n;\ j = 1,...,m) \tag{3}$$

where:
z_{ij}^{*} – standardised value of spatially adjusted j variable in i object,
$\overline{x}_{j}^{*}$ – the mean average of spatially adjusted j variable,
s_{j}^{*} – the standard of spatially adjusted j variable,
x_{ij}^{*} – the spatially adjusted value of variable j in the i object, calculates as:

$$x_{ij}^{*} = \mathrm{W}x_{ij} \tag{4}$$

W – spatial weight matrix.

4. Calculate the distance between i object and 'ideal' object:

$$d_{spi}^{*} = \begin{cases} \sqrt{\sum_{j=1}^{m}\left(z_{ij}^{*} - \varphi_{j}^{*}\right)^{2}} \\ or \\ \sqrt{\sum_{j=1}^{m}\left(z_{ij} - \varphi_{j}\right)^{2}} \end{cases} \quad (i = 1,...,n;\ j = 1,...,m) \tag{5}$$

where:
d_{spi}^{*} – the distance between object i and 'ideal' object.
The upper part of formula (5) refers to variables with spatial character (variables for which Moran's I is statistically significant), therefore:
z_{ij}^{*} – standardised value of spatially adjusted j variable in i object,
φ_{ij}^{*} – the 'ideal' object for variables with spatial character (with the highest values for stimulants and lowest for destimulants).

The bottom part of formula (5) refers to variables without spatial character (variables for which Moran's I is not statistically significant), therefore:
z_{ij} – standardised value of j variable in i object,
φ_{j} – the 'ideal' object for variables without spatial character

5. Calculate the taxonomy spatial measure of development according to formula (Antczak, 2013: 43):

$$\mu_{spi}^{*} = 1 - \frac{d_{spi}^{*}}{d_{spi-}^{*}} \quad (i = 1,...,n) \tag{6}$$

where:

$$d^*_{spi-} = \overline{d}^*_{sp} + 2s^*_{dsp} \qquad (i = 1,...,n) \tag{7}$$

μ^*_{spi} – the taxonomy spatial measure of development for the county i,
d^*_{spi} – the distance between object i and 'ideal' object,
$\overline{d}^*_{sp}$ – the average value of d_{sp} vector ($d_{sp} = d_{sp1}, d_{sp2}, \ldots, d_{spn}$),
s^*_{spd} – the standard deviation of dsp vector.
The higher the value of μ^*_{spi} the better from the point of view of analysed phenomena.

The advantage of Antczak's approach is that one must recognize the fact that presence of spatial autocorrelation is tested for each variable. It should be noted that both types of variables can occur in the initial set of variables, with and without the spatial character. Therefore, testing each variable is crucial, as it is extremely important to correctly identify the presence of spatial relationships. Another advantage of this instrument is its relative simplicity. In Antczak's approach, the actual values of the spatial variables are replaced by the values of their spatial delay. Besides the standard range of calculations related to the taxonomy measure of development, Antczak's approach requires the calculation of Moran's I statistics only. Therefore, this method should not cause too much difficulty, even for someone unfamiliar with the spatial statistics.

The disadvantage of this method is the equal strength of spatial relationship for each variable. It appears that it would be reasonable to separately examine the strength of spatial relation for each variable, as they represent various aspects of socio-economic environment and therefore may interact in different directions or varying intensity.

4. Taxonomy spatial measure of development proposed by Pietrzak

Pietrzak's (2014: 181–201) research suggests that, instead of modifying the standardisation formula, the potential strength of interaction among regions should be taken into consideration. This should be calculated separately for each variable, since the interactions can occur with varying intensity. The strength and direction of spatial influence should be obtained from the SAR (spatial autoregressive model) model estimation.

The taxonomy spatial measure of development according to Pietrzak (2014: 187–189) is calculated as follows:

1. From the wild set of potential diagnostic variables remove those that do not meet the formal conditions.

2. Test the final set of diagnostic variables to the presence of spatial autocorrelation using Moran's I statistics (1).
3. Estimate the SAR model for each variable from 'spatial' group of variables (LeSage, 1999: 43):

$$\mathrm{X_j} = \rho \mathrm{W} \mathrm{X_j} + \varepsilon \tag{8}$$

where:
X_j – the vector of analysed j variable,
ρ – the spatial autoregression parameter,
W – the spatial weight matrix,
ε – the spatially correlated residuals.
4. Prepare the set of diagnostic variables:
4.1. Adjust the values of variables from 'spatial' group according to formula:

$$\mathrm{Z}_j = (I - \rho \mathrm{W})^{-1} \mathrm{X}_j \tag{9}$$

$$V(\mathrm{W}) = \left(I - \rho \mathrm{W}\right)^{-1} \tag{10}$$

where:
Z_j – the vector of spatially adjusted j variable,
I – identity matrix,
ρ – the spatial autoregression parameter,
W – the spatial weight matrix,
X_j – the vector of analyzed j variable,
$V(W)$– the potencial strenght matrix.
4.2. Do not change the values of variables from 'non-spatial' group.
5. Change destimulants for stimulants and standardise variables according to Hellwig's formula (2).
6. Calculate the distance between the i object and 'ideal' object:

$$d_i = \sqrt{\sum_{j=1}^{m} \left(z_{ij} - \varphi_j\right)^2} \quad (i = 1,\ldots,n;\ j = 1,\ldots,m) \tag{11}$$

7. Calculate the spatial taxonomy measure of development according to formula (Pietrzak, 2014: 187):

$$sTMD_i(\mathrm{W}) = 1 - \frac{d_i}{\bar{d}_s + 2s_d} \tag{12}$$

where:
d_i – the distance between object i and 'ideal' object,
z_{ij} – the standardised value of j variable in j object,
φ_j – the 'ideal' object for variables without spatial character (with the highest values for stimulants and lowest for destimulants),

The higher the value of $sTMD_i(W)$ the better from the point of view of analysed phenomena.

The advantage of Pietrzak's approach, in addition to Antczak's, is testing the presence of spatial autocorrelation for each variable. Another advantage of this approach is to diversify the potential power of spatial interaction for each variable. Such treatment is possible by estimating the SAR model for each variable with spatial character. The estimated parameter from the SAR model allows modifying the original value of the diagnostic variable by taking into account the variable's values in the neighbourhood. Moreover, it encompasses the different impact of a particular neighbour.

The method presented by Pietrzak demands appropriate software that allows the estimation of SAR models and more importantly, requires knowledge of the spatial statistics and econometric issues. This can contribute to this method's reduced popularity, compared with the alternatives. The need to estimate SAR models for each variable with spatial character increases the research time which, for some, may be a disadvantage.

5. Taxonomy spatial measure of development proposed by Sobolewski, Migała-Warchoł and Mentel

Sobolewski, Migała-Warchoł and Mentel (2014: 159–172) proposed a different approach. According to their idea, the locational component should be included at the end of analysis. In this approach, the occurrence of spatial relationships is tested only for synthetic measure, not for all diagnostic variables.

The taxonomy spatial measure of development according to Sobolewski, Migała-Warchoł and Mentel (2014: 169) is calculated as follows:

1. From the wild set of potential diagnostic variables remove those that do not meet the formal conditions,
2. Change destimulants for stimulants and standardise variables according to formula (2)[1],

[1] In the original work the zeroed unitarisation method was used. However, different standardisation methods may lead to different ranking. Therefore, in this study, the standardisation method was changed to Hellwig's proposition so the results can be comparable.

3. Calculate the distance between the *i* object and 'ideal' object according to formula (11),
4. Calculate the taxonomy measure of development:

$$\mu_i = 1 - \frac{d_i}{\overline{d}_s + 2s_d} \quad (13)$$

where:
μ_i – taxonomy measure of development,
d_i – the distance between object *i* and 'ideal' object,
$\overline{d}_s$ – the average value of *di* vector ($d_i = d_1, d_2, \ldots, d_n$),
$2s_d$ – the standard deviation of *di* vector
5. Calculate taxonomy spatial measure of development according to formula (Sobolewski, Migała-Warchoł, Mentel, 2014: 169):

$$\mu_i^* = \alpha\mu_i + (1-\alpha)\sum_{i \neq j} w_{ij}\mu_i \qquad (i = 1,\ldots,n) \quad (14)$$

where:
μ^*_i – taxonomy spatial measure of development,
α – weight determined arbitrarily, in Sobolewski, Migała-Warchoł and Mentel's (2014: 169) research α =0,6,
w_{ij} – spatial weight matrix,
μ_i – taxonomy measure of development.

The advantages of the last of the presented approaches are simplicity and fast calculations. The procedure for determining sTMD does not differ substantially from the classic approach. It does not generally require a greater knowledge of the statistics and spatial econometrics issues, or using specialised software.

The principal disadvantage is the fact that spatial autocorrelation is not tested for each variable. Most economic variables showed positive spatial correlation, however, one may have in diagnostic variables only variables that do not signify such properties. Therefore, it seems that the spatial weight matrix should be taken into consideration at an earlier stage of the analysis. Moreover, the arbitrary selection of a parameter in the equation (14) is doubtful. It should be tested how the different values of a parameters influence the final results.

6. Empirical Analysis

As previously mentioned in this research, a comparison between different approaches in taxonomy spatial measure of development construction will be conducted. The base of the analysis is the standard of living in Nordic NUTS-3 regions.

The standard of living was calculated based on a set of 18 diagnostic variables, divided into 9 groups[2] (Table 1).

Table 1. The set of diagnostic variables

Domain	Variables
Population	x_1 – the net migration rate (S),
Labour market	x_2 – the unemployment rate (D), x_3 – the average income of household in euro (current prices) (S),
Health care	x_4 – the number of deaths due to tuberculosis per 100 000 inhabitants (D), x_5 – the number of deaths due to malignant neoplasm per 100 000 inhabitants (D), x_6 – the number of deaths due to heart diseases per 100 000 inhabitants (D), x_7 – the number of new AIDS cases per 100 000 inhabitants (D), x_8 – the number of physician per 100 000 inhabitants (S),
Education	x_9 – the number of students in tertiary education per 1000 inhabitants (S),
Leisure time	x_{10} – the number of hotels per 1000 inhabitants (S), x_{11} – the number of museums per 100 000 inhabitants (S),
Living conditions	x_{12} – the number of new dwellings completed per 1000 inhabitants (S),
Transport and communication	x_{13} – transport infrastructure in km per km2 of land area (S), x_{14} – the number of cars per 1000 inhabitants (S),
Social security	x_{15} – the number of suicides per 100 000 inhabitants (D), x_{16} – the number of divorces per 1000 marriages (D),
Natural environment	x_{17} – protected area as % of land area (S), x_{18} – the CO_2 emission in kg per capita per year (D).

Source: Author's own study. (S) – for stimulants, (D) – for destimulants.

On the basis of the above-mentioned variables, the spatial taxonomy measures of development were calculated on approaches presented in section 3–5. The classical taxonomy measure of development was also calculated. In approaches proposed by Antczak (2013: 37–53) and Pietrzak (2014: 181–201), it is necessary to test the existence of spatial autocorrelation using Moran I statistics. An important part of this investigation is choosing the spatial weight matrix form. Spatial factors can be determined on the basis of, among others:

1) neighbourhood – ie. on the existence of the common border,

[2] It is assumed that the variables may be correlated between the groups; however, there must be no evidence of correlation within the group. Overly restrictive conditions, regarding the lack of correlation in the whole set of variables, could lead to an excessive reduction of a diagnostic variable set.

2) physical distance – expressed eg. in the form of a distance between the capital cities or centres of objects,
3) the number of k-common neighbours,
4) the length of the common border,
5) social distance, (Doreian, 1980: 29–60)
6) economic distance. (Conley, 1999: 1–45; Pietrzak, 2010: 177–185).

In the literature, one can find many different ways to define a spatial weight matrix and Cliff, Ord (1981), Getis, Aldstadt (2004: 147–163) Łaszkiewicz (2014: 169–172), among others, reviewed them.

In this research, spatial contiguity weight matrix was used, since it is a matrix that appears most frequently in the studies, taking into account the spatial relationship. These weights basically indicate whether regions share a common boundary or not.

$$w_{ij} = \begin{cases} 1, & bnd(i) \cap bnd(j) \neq \varnothing \\ 0, & bnd(i) \cap bnd(j) = \varnothing \\ 0, & i = j \end{cases} \quad (15)$$

1 refers to the situation in which region i and j have a common boundary; 0, if not. Diagonal elements in matrix W have value equal to 0 as the object cannot be its own neighbour. Spatial weight matrix was row standardised. Row standardisation involves dividing each neighbour weight for the country i by the sum of weights for its all neighbours.

Table 2. Moran's I statistics and corresponding p-values

Variable's number	Moran's I	p-value	Variable's number	Moran's I	p-value	Variable's number	Moran's I	p-value
x_1	0,500	0,003	x_7	0,021	0,028	x_{13}	0,473	0,001
x_2	0,335	0,016	x_8	–0,114	0,349	x_{14}	0,619	0,000
x_3	0,511	0,002	x_9	0,275	0,046	x_{15}	0,061	0,252
x_4	0,518	0,002	x_{10}	0,160	0,104	x_{16}	0,022	0,357
x_5	–0,116	0,355	x_{11}	0,138	0,127	x_{17}	0,128	0,166
x_6	0,004	0,405	x_{12}	–0,001	0,400	x_{18}	0,361	0,017

Source: Author's own investigation

The spatial autocorrelation occurs when p-value corresponding to the Moran's I statistics is no higher than the assumed significance level (α). In this research, $\alpha = 0,05$. As can be seen in Table 2, half of the used variables reveal spatial autocorrelation (x_1, x_2, x_3, x_4, x_7, x_9, x_{13}, x_{14}, x_{18}).

Above-mentioned variables, in Antczak's approach, were standardised according to formula (3); the remaining according to formula (2). Following the standardisation, the distance between each region and 'ideal' region was calculated, based on formula (5) and the sTMD was calculated using formula (6).

Table 3. Nordic NUTS-3 regions rankings due to the standard of living in 2014, based on different methods of constructing the synthetic measure

Regions	Methods				Regions	Methods			
	C	A	P	S		C	A	P	S
Byen København	10	13	12	12	Västmanland	40	43	40	38
Københavns omegn	25	44	34	25	Jönköping	21	30	24	23
Nordsjælland	44	45	47	44	Kronoberg	45	23	41	39
Østsjælland	50	50	50	50	Kalmar	32	42	36	28
Vest– og Sydsjælland	42	41	46	45	Blekinge	1	14	7	10
Fyn	53	52	53	51	Skåne	23	35	18	26
Sydjylland	46	48	48	49	Halland	30	24	29	29
Vestjylland	49	46	49	48	Västra Götaland	26	29	21	27
Østjylland	24	40	30	32	Värmland	43	36	39	40
Nordjylland	29	38	32	36	Dalarna	27	26	27	22
Oslo	4	8	3	2	Gävleborg	31	31	28	30
Akershus	9	3	6	11	Västernorrland	19	28	22	17
Hedmark	33	19	26	19	Jämtland	34	18	35	24
Oppland	8	10	10	6	Västerbotten	13	16	15	14
Østfold	38	20	31	37	Norrbotten	18	39	25	21
Buskerud	14	9	14	13	Pohjois-Savo	56	66	59	58
Vestfold	37	17	33	31	Pohjois-Karjala	58	57	58	57
Telemark	47	22	42	34	Kainuu	60	63	61	61
Aust-Agder	5	12	8	9	Uusimaa	36	51	45	47
Vest-Agder	12	2	11	7	Itä-Uusimaa	35	37	38	46
Rogaland	3	4	2	1	Varsinais-Suomi	52	55	52	54
Sør-Trøndelag	2	5	1	5	Kanta-Häme	51	53	51	52
Nord-Trøndelag	20	11	13	15	Päijät-Häme	55	54	54	55
Hordaland	6	7	5	8	Kymenlaakso	67	60	66	59
Sogn og Fjordane	7	6	9	4	Etelä-Karjala	57	61	60	63
Møre og Romsdal	11	1	4	3	Satakunta	66	65	67	66
Nordland	22	15	17	16	Pirkanmaa	54	58	56	56
Troms	15	25	16	18	Keski-Suomi	63	59	64	60
Finnmark	17	34	20	33	Etelä-Pohjanmaa	62	62	63	64
Stockholm	28	27	23	35	Pohjanmaa	65	64	65	67
Uppsala	39	32	37	41	Keski-Pohjanmaa	59	67	62	65
Södermanland	41	47	43	42	Pohjois-Pohjanmaa	61	56	57	62
Östergötland	48	33	44	43	Lappi	64	49	55	53
Örebro	16	21	19	20	----	----	----	----	----

Source: Author's own investigation. C – classic approach, A – Antczak's approach, P – Pietrzak's approach, S – Sobolewski, Migała-Warchoł and Mentel's approach

In Pietrzak's approach for each variable: x_1, x_2, x_3, x_4, x_7, x_9, x_{13}, x_{14}, $x_{18,}$ the SAR model was estimated (8)[3]. For example, the potential strength of interaction among Sogn of Fjordene region for x_1 variable and Møre og Romsadal is 0,005; Oppland 0,132; Buskerud 0,027 and Hordaland 0,004. On the other hand, the potential strength of interaction among Sogn of Fjordene region for x_{14} variable and Møre og Romsadal is 0,010; Oppland 0,022; Buskerud 0,035 and Hordaland 0,101. The potential strength matrix V(W) was used to adjust 'spatial' variables according to forumula (9), the 'non-spatial' variables were not modified. Afterwards, the sTMD was calculated according to (11)–(12).

In Sobolewski's approach, no distinction of 'spatial' on 'non-spatial' variables was made. The taxonomy synthetic measure of development was calculated according to forumla (2), (11) and (13). The final ranking was adjusted according to (14), taking as authors $\alpha = 0{,}6$.

In the classical approach, the spatial relationships were not taken into consideration in any way and the taxonomy measure of development was calculated according to (2), (11) and (13). Table 3 consists of the rankings made, based on the values of synthetic variables.

As can be seen in Table 3, region positions in ranking, due to the standard of living in 2014, based on different methods, are rather similar. To make it easier to analyse in Table 4, the best 5 and worst 5 regions in each approach are presented.

Table 4. Best 5 and worst 5 regions due to the standard of living in 2014, in each approach

Position in ranking	Best five regions due to the standard of living in 2014			
	Classic	**Antczak**	**Pietrzak**	**Sobolewski**
1	Blekinge	Møre og Romsdal	Sør-Trøndelag	Rogaland
2	Sør-Trøndelag	Vest-Agder	Rogaland	Oslo
3	Rogaland	Akershus	Oslo	Møre og Romsdal
4	Oslo	Rogaland	Møre og Romsdal	Sogn og Fjordane
5	Aust-Agder	Sør-Trøndelag	Hordaland	Sør-Trøndelag
	Worst five regions due to the standard of living in 2014			
	Classic	Antczak	Pietrzak	Sobolewski
63	Keski-Suomi	Kainuu	Etelä-Pohjanmaa	Etelä-Karjala
64	Lappi	Pohjanmaa	Keski-Suomi	Etelä-Pohjanmaa
65	Pohjanmaa	Satakunta	Pohjanmaa	Keski-Pohjanmaa
66	Satakunta	Pohjois-Savo	Kymenlaakso	Satakunta
67	Kymenlaakso	Keski-Pohjanmaa	Satakunta	Pohjanmaa

Source: Author's own investigation

[3] Due to the limited space of the article, it is impossible to present the estimation results of *V*(*W*) matrix, because it would require presentation of 67 x 67 matrix for each of the nine variables exhibiting the spatial character.

Through analysing the data from Table 4, it can easily be seen that the regions with the highest standard of living are those which are situated on the west coast of Norway and also Oslo. These results should not be surprising due to the presence of the highly developed oil and gas industry, affording high employment and relatively higher earnings, which have an impact on the material aspect of the inhabitants' standard of living. The regions with the lowest standard of living are forested regions of central Finland, with poorly developed industry, communications infrastructure and high unemployment.

Analysis of the ordering compliance at the top and the bottom of the ranking is hardly enough to be able to hold the view that the similarity of the orderings of the data exists regardless of the method used. To conduct a formal analysis, Kendall's rank correlation coefficient was calculated.

Table 5. Kendall's rank correlation coefficient

	Classic	**Antczak**	**Pietrzak**	**Sobolewski**
Classic	----	0,695***	0,894***	0,834***
Antczak	0,695***	----	0,783***	0,805***
Pierzak	0,894***	0,783***	----	0,875***
Sobolewski	0,834***	0,805***	0,875***	----

Source: Author's own investigation. *** p-value ≤ 0,01, ** p-value ≤ 0,05, * p-value ≤ 0,1

Through analysis of the data in Table 5, it can be seen that there is a high agreement in rankings regardless of the method used to create the synthetic variable. All Kendall's rank correlation coefficients are statistically significant at significance level of 0,01. However, it should be noted that the weakest correlation exists between the measure presented by Antczak and other methods.

The analysed regions were also grouped on the basis of similar values of synthetic measure. Those groups were constructed as follows:

1) the highest standard of living: $s_i \geq \bar{s} + sd_s$,
2) medium standard of living: $\bar{s} + sd_s > s_i \geq \bar{s}$,
3) low standard of living: $\bar{s} > s_i \geq \bar{s} - sd_s$,
4) the lowest standard of living: $s_i < \bar{s} - sd_s$,

where:

s_i – the value of synthetic measure in country i (in Anczak's approach $s_i = \mu^*_{spi}$ (6), in Pietrzak approach $s_i = sTMD_i(W)$ (12), in Sobolewski's approach $s_i = \mu^*_i$ (14) and in classic approach $s_i = \mu_i$ (13).

$\bar{s}$ – the average value of synthetic measure,

sd_s – the standard deviation of synthetic measure.

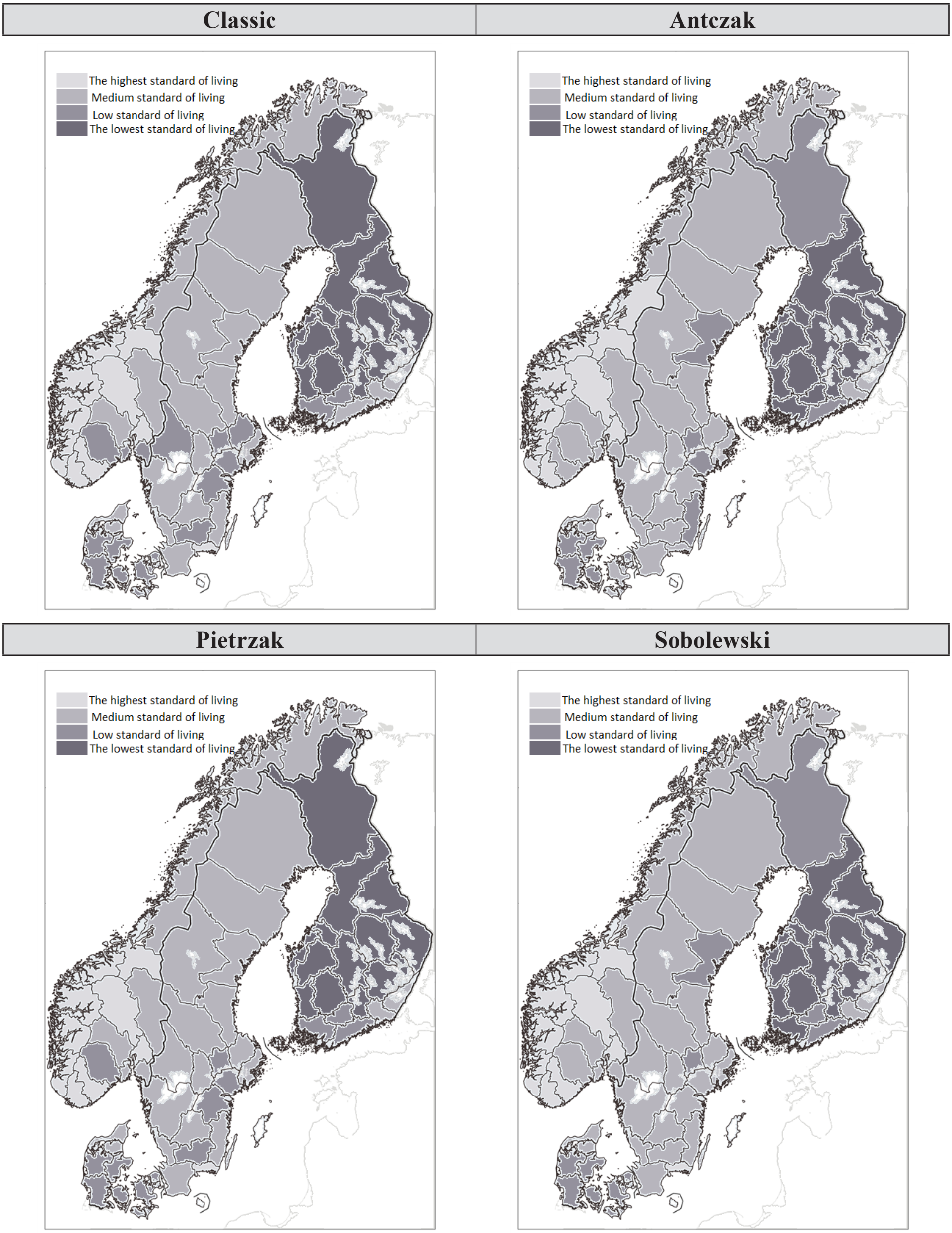

Figure 1. Similar group of Nordic NUTS-2 regions in terms of the standard of living in 2014

Source: Author's own investigation

Figure 1 presents group of similar regions in terms of the standard of living in 2014. Figure 1 shows that the regions with higher standard of living are those situated on the west coast of Norway which, as previously mentioned, concerns the oil industry, the capital regions of analysed countries and the Danish regions situated in Jutland. The regions with lower standard of living are, as already stated, those situated in the forestry areas of central Finland and regions located above the Arctic Circle.

To check whether the presented groups of regions formed on the basis of the different measures are more or less the same, the V-Cramer statistics was used.

Table 6. The values of V-Cramer statistics

	Classic	Antczak	Pietrzak	Sobolewski
Classic	----	0,684***	0,904***	0,813***
Antczak	0,684***	----	0,748***	0,768***
Pierzak	0,904***	0,748***	----	0,835***
Sobolewski	0,813***	0,768***	0,835***	----

Source: Author's own investigation. *** p-value ≤ 0,01, ** p-value ≤ 0,05, * p-value ≤ 0,1

Analysing the data in Table 6, it can be seen that there is a high agreement in regions' grouping, regardless of the method used to create the synthetic variable. All V-Cramer's statistics are statistically significant at significance level of 0,01. However, once again, the weakest correlation exists between the measure presented by Antczak and other methods.

7. Conclusions

In this article, the ordering and grouping of Nordic NUTS-3 regions was conducted due to the inhabitants' standard of living in 2014. As the standard of living approximation, the taxonomy measure of development was implemented in four different variants: ie. the classic approach without incorporating any spatial relationships and three measures including, in different ways, the locational component (approaches proposed by Antczak, Pietrzak and Sobolewski). Regardless of the used method of construction of the synthetic measure of the standard of living, regions with the highest level of life turned out to be those situated on the west coast of Norway which, as already mentioned, is related to the oil and gas industry, the capital regions of analysed countries and the Danish regions situated in Jutland. The regions with the lowest standard of living are those situated in the forestry areas of central Finland and regions located above the Arctic Circle. The results seem to be consistent and logically correct.

Nonetheless, the main aim of this study was to test whether the proposed method of construction, the taxonomy spatial measure of development, will lead to obtain coherent results. Analysis of Kendall's rank correlation coefficients and V-Cramer's statistics revealed the high correlation of regions' linear orderings and grouping. All the calculated association measures were statistically significant at a significance level of 0.01. It can, therefore, be assumed that the presented approaches can be used interchangeably. Importantly, it also revealed a strong correlation between those measures and the classical measure. It is an eligible phenomenon as the inclusion of locational component made it possible to extend the analysis of the extra dimension, without distorting the actual situation in analysed objects.

It is also worth mentioning that there are no methods that will indicate which linear ordering is better than another, regardless of whether the differences occur in terms of the standardisation method, aggregation method, conversion destimulants to stimulants or the way to incorporate the spatial relationships. One can only indicate whether the results are consistent or not. However, in this research, the attempt to identify the advantages and disadvantages of each method for creating spatial taxonomy measure of development was made. A brief summary is presented in Table 7.

Table 7. Advantages and disadvantages of different taxonomy spatial measures of development

	Antczak	**Pietrzak**	**Sobolewski**
Advantages	– testing the existence of spatial autocorrelation for each variable, – relatively simple,	– testing the existence of spatial autocorrelation for each variable, – different potential strength of interaction for each variable,	– simplicity, – time-saving,
Disadvantages	– the same strength of interaction for each variable,	– relatively complicated and time consuming,	– not testing the existence of spatial autocorrelation for each variable – arbitrary selection of aparameter in formula (14).

Source: Author's own investigation

Despite the fact that each of the presented methods have greater or lesser faults, it seems that the inclusion of spatial relationships in the construction of taxonomic measure of development is justified. In addition to the arguments set out at the beginning of this article, it is worth noting that the spatial objects (countries, regions or counties) are not isolated in space and can be affected by other units. It seems that the lower the administrative areas investigated, the greater the impact will be.

Therefore, it is reasonable to take into account spatial dependence for each analysed variable. However, that gives rise to the following problem: the values of taxonomy spatial measure of development are determined by the method of constructing the spatial weight matrix. The use of a specific spatial weigh matrix should be adapted to the nature of the research, the nature of the analysed phenomenon or a subjective researcher's intuition because different matrix specifications may lead to different results (Timmins, Hunter, Catter, Srenhouse, 2013: 359–379). However, the big advantage of sTMD is the fact that it is complementary to the classical approach and allows to extend the analysis of the immeasurable spatial effects. Moreover, it avoids cognitive errors and increases the reliability of analysis. It is worth noticing that classical approach should still be used in all complex phenomenon analysis which does not apply to regional analysis or when variables do not have spatial character. In other cases, the author of this research, recommends the use of Pietrzak's approach as it eliminates the disadvantages of alternative approaches.

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The Taxonomy Spatial Measure of Development in the Standard of Living Analysis

Abstract: Incorporation of spatial relationships in the construction of taxonomy measure of development is gaining popularity in Polish literature. However, there is no one common idea concerning how the spatial relationship should be taken into account when creating a synthetic variable nor, indeed, where the spatial weight matrix should be placed. It seems that the inclusion of spatial relationships is more important in smaller regions' analysis, as they are more affected by the situation in the neighbourhood. This explains why, in this research, rankings of the standard of living in Nordic regions were constructed on the basis of proposals presented by Antczak, Pietrzak and Sobolewski, Migała-Warchoł and Mentel. The aim of this study is to identify the advantages and disadvantages of above-mentioned approaches and to compare the compliance of results obtained from them.

Keywords: taxonomy spatial measure of development, the standard of living

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