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SUSTAINABLE DEVELOPMENT IN WEST AND EAST SLAVIC COUNTRIES: A MULTIVARIATE STATISTICAL APPROACH

Introduction

West Slavic countries' entry into the European Union marked a new period of economic development for Poland, the Czech Republic and the Slovak Republic — strongly related to high GDP growth, FDI inflow and general impact on the society. However, non-EU countries, including Ukraine and Belarus, have not experienced a stable economic progress, in particular Ukraine that ended up as one of the poorest countries in Europe despite posing a competitive economy before the USSR collapse[1]. Economies of East Slavic countries were highly affected by oligarchy which had place in West Slavic countries to a certain degree too, for instance in the Czech Republic[2]. The general economic gap between above groups of countries raises a question about whether there is a possibility to distinguish a leader of development when considering it multidimensionally, taking into account not only economic aspects but also other factors like environmental, human and social issues.

The aim of the research paper is to range West and East Slavic countries according to selected macroeconomic, social and environmental variables by linear ordering. Therefore the following countries are subjected to analysis: Belarus, the Czech Republic, Poland, the Russian Federation, the Slovak Republic and Ukraine.

[1] G.A. Kumar, O. Trokhymets, *Comparative study of economic growth of Ukraine and India*, "State and Regions Series Economics and Business", 2019, vol. 109/4, s. 26–32.

[2] A. Aslund, *Comparative Oligarchy: Russia, Ukraine and the United States*, "Center for Social and Economic Research", 2005, vol. 296, s. 11–12.

1. Economic growth and development

There are some crucial differences between concepts of growth and development. Previously, in terms of economics the first one was considered to be the source of advancement but in the face of social difficulties related to globalization, and by extension to such issues as poverty and inequality, scientists put more emphasize on the second phenomenon[3]. Economic growth itself is a quantitative concept whereas economic development refers to *structural change*. In other words, this term is something broader — related to economic growth but, as a matter of fact, accompanied by qualitative changes. A region or country may experience economic growth without any development[4].

Associating economic development with economic growth came under criticism in the 1960s. Some authors pointed out that developing countries — despite significant growth processes — did not experience much change when it comes to the living conditions[5]. They suggested that development should involve more than changes in economic structures (e.g. production). Some of them proposed additional requirements in regard to the term[6]:

- decline in poverty and malnutrition;
- decline in income inequality;
- improvement of employment situation.

E.N. Nafziger states that economic growth refers to increase in production (measured mostly by gross national income (GNI) or gross domestic product (GDP)) or income per capita whereas economic development may include changes in the material well-being, a decrease in agriculture's share of GDP *etc*. as it refers to changes in economic structure and output distribution[7]. Some researchers, however, point out that nation's income per capita is used often as a measure for assessment of the level of development. Further to that, J.M. Cypher and J.L. Dietz indicate that development involves "the diverse and broad aspirations of what might be called the *good life*". They suggest that it may include for instance[8]:

- equity in distribution of wealth;
- increased opportunities for education;
- healthy environment;
- an expanded role of women and minorities in social, economic and political life;

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[3] A. Kubiczek, *Jak mierzyć dziś rozwój społeczno-gospodarczy krajów?(How to measure social and economic devolopment of countries today?)*, „Nierówności Społeczne a Wzrost Gospodarczy" ("Social Inequalities and Economic Growth"), 2014, vol. 38/2, s. 40–56.

[4] A. Szirmai, *Socio-economic development*, Cambridge University Press, Cambridge 2015, s. 4–5.

[5] Ibidem.

[6] Ibidem.

[7] E.W. Nafziger, *Economic development*, Cambridge University Press, New York 2005, s. 15.

[8] J.M. Cypher, J.L. Dietz, *The process of economic development*, Routledge, Abingdon 2009, s. 30–31.

– improvements in health care;
– an increasing standard of living;
– a fairly administered public sector.

Especially in recent years the concept of development has been viewed as multidimensional. Many scholars point out that there is more place these days in underlying theory of development for such issues as gender empowerment, natural environment and the problem of poverty[9]. The following figure depicts the overview of the concept of development.

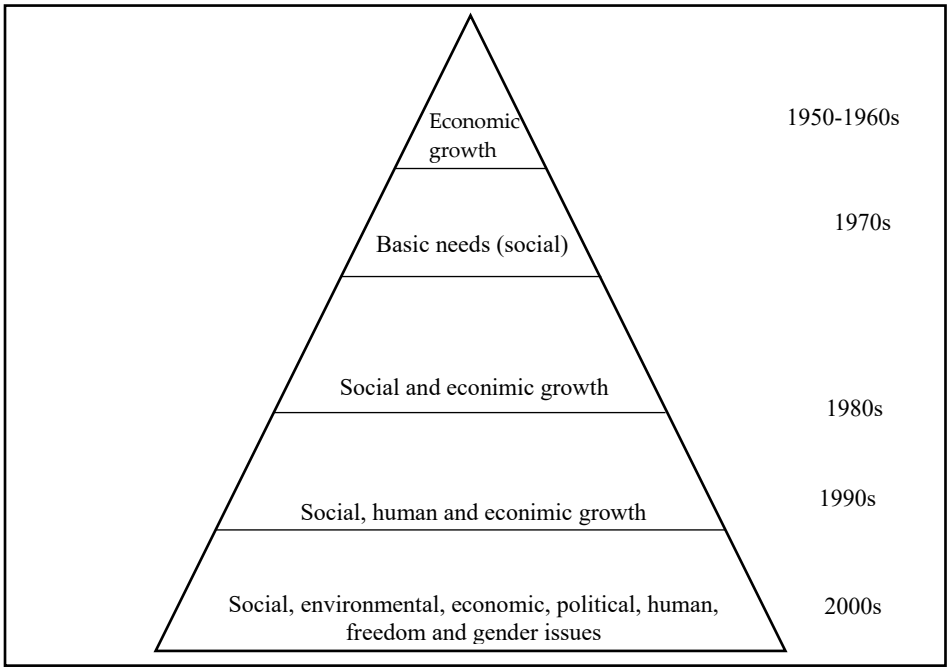

Figure 1. The overview of the concept of development from historical perspective

Source: P.B. Cobbinah, R. Black, R. Thwaites, *Reflections on six decades of the concept of development: Evaluation and future research*, "Journal of Sustainable Development in Africa", 2011, vol. 13/7.

As it can be gathered from the figure, the primary literature in the field of development covers issues related to freedom, human and gender issues posing a much broader concept in comparison to past views.

The term of development has evolved latterly and now it is considered complex. In particular the emphasize is put on the concept of sustainable development that could be understood as a progress that is not achieved at the expense of

[9] P.B. Cobbinah, R. Black, R. Thwaites, *Reflections on six decades of the concept of development: Evaluation and future research*, "Journal of Sustainable Development in Africa", 2011, vol. 13/7.

future generations — and thus refers essentially to environmental, spatial and social affairs[10].

2. Methodology

Huge data sets can be analyzed by statistical and mathematical procedures. Multivariate statistical analysis is one of them. The concept refers to methods used when individuals or objects (research units) are measured by several variables at the same time[11]. Companies may be considered an example of units and financial indicators (ROA, ROE *etc*.) — variables. In macroeconomic analysis units refer mostly to countries or regions[12].

Objects are research subject that can be for instance classified and depicted followingly[13]:

$$\Omega = \{Q_1, Q_2, Q_3, ..., Q_n\},$$

where: Ω refers to set of objects and Q_1, Q_2, Q_3, …, Q_n – to individual objects.

Variables, in turn, can be understood as characteristics that describe the collection of objects. They are used in order to measure particular phenomena that are affecting research units, and to objectivize their impact. The following formula represents the mathematical depiction of set of variables[14]:

$$X_z = \{X_1, X_2, X_3, \ldots, X_m\},$$

where: X_z refers to set of variables and X_1, X_2, X_3, …, X_m represent particular variables.

Objects and variables can by illustrated in an observation matrix as follows[15]:

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

[10] J.A. Elliott, *An introduction to sustainable development*, Routledge, Abingdon 2013, s. 19–20.

[11] A.C. Rencher, *Methods of multivariate analysis*, Wiley, New York 2002, s. 1.

[12] Ibidem, s. 1–2.

[13] K. Ulmann, *Ocena rozwoju społeczno-gospodarczego państw przyjętych w 2004 roku do Unii Europejskiej za pomocą wielowymiarowej analizy porównawczej (Assessment of the socio-economic development of the countries admitted in 2004 to the European Union with the use of multi-dimensional comparative analysis)*, „Zeszyty Studenckie Wydziału Ekonomicznego Uniwersytetu Gdańskiego Nasze Studia" ("Our Studies"), 2020, vol. 10, s. 156–168.

[14] K. Jajuga, *Statystyczna analiza wielowymiarowa (Multivariate statistical analysis)*, PWN, Warszawa 1993, s. 18–19.

[15] Ibidem.

where: X depicts the observation matrix and x_{nm} — value of mth variable on nth unit.

It is to be emphasized in this context that some scholars point out that one can encounter difficulties when applying some of the techniques of multivariate analysis to data sets with variables for which the measurement scale is neither interval not ratio[16].

Multivariate analysis implies that variables should be comparable and this refers to variable normalization. One of the possible procedures when it comes to achieving comparability of data set is standardization which helps to receive such variables for which the mean is equal to 0 and the standard deviation — to 1. To change the character of variables according to normalization procedure one can use the following formula[17]:

$$z_{ij} = \frac{x_{ij} - \overline{x}_j}{s_j},$$

where: $j = 1, 2, 3, \ldots, m$; s_j refers to standard deviation of the variable x_{ij} and $\overline{x}_j$ represents arithmetic mean of a particular variable.

Variables can be seen as stimulants, destimulants and nominants. The first term refers to such features that have a positive impact on objects; the second — to these variables that affect research units negatively. Nominants, in turn, do not have a specific direction of impact; they should fall within the ambit of a given range[18].

As it was stated above, multivariate analysis refers to the collection of methods. In view of character of the paper the following refers to linear ordering. The method helps to range a set of research units according to given criteria. A use for application purposes can find a pattern or non-pattern method with weighted or unweighted variants. A pattern linear ordering implies finding an artificial unit that represents the best empirical values of each variables; then distances (mostly Euclidean) of units from the pattern are to be measured. The second method refers to ranging objects without forming an artificial one. In such a case 'the best' unit could be considered to be a pattern[19].

From combinatorics point of view, set of N objects can be ordered in $N!$ ways, but in linear ordering methods it is to find one particular order. When a pattern

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[16] A.C. Rencher, *Methods of multivariate analysis*…, s. 2.

[17] A. Balicki, *Statystyczna analiza wielowymiarowa i jej zastosowania społeczno-ekonomiczne (Multivariate statistical analysis and its socio-economic applications)*, Wydawnictwo Uniwersytetu Gdańskiego, Gdańsk 2009, s. 27.

[18] M. Łuniewska, W. Tarczyński, *Metody wielowymiarowej analizy porównawczej na rynku kapitałowym (Methods of multivariate comparative analysis on capital market)*, PWN, Warszawa 2006, s. 9.

[19] Ibidem, s. 157.

method is applied, one need to define an artificial object with 'the best' empirical features. Variable vector can be depicted followingly[20]:

$$z_o = [z_{01}, z_{02}, \ldots, z_{op}],$$

where: $z_{oj} = max\{z_{ij}\}$, when the variable j is considered a stimulant and $z_{oj} = min\{z_{ij}\}$, when the variable j is seen as a destimulant.

Then one can formulate another artificial unit with 'the worst' values of variables with vector:

$$z_{-0} = [z_{-01}, z_{-02}, \ldots, z_{-op}],$$

where: $z_{-oj} = min\{z_{ij}\}$, when the variable j is considered a stimulant and $z_{-oj} = max\{z_{ij}\}$, when the variable j is seen as a destimulant.

When the pattern is defined, one need to measure the similarity of units and the pattern, mostly by Euclidian distance[21]:

$$d_{i0} = \sqrt{\sum_{j=1}^{p} (z_{ij} - z_{oj})^2},$$

for $i = 1, 2, \ldots, N$.

The results should be compared with the maximal distance between the pattern and anti-pattern given by the following formula:

$$d_0 = \sqrt{\sum_{j=1}^{p} (z_{0j} - z_{-oj})^2}.$$

At the end there is a need to define the taxonomic measure of development[22] for all economic units according to the formula:

$$m_i = 1 - \frac{d_{i0}}{d_0},$$

for $i = 1, 2, \ldots, N$.

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[20] A. Balicki, *Statystyczna analiza wielowymiarowa...*, s. 317–322.

[21] Ibidem.

[22] The taxonomic measure of development was originally proposed by Z. Hellwig in 1968; see Z. Hellwig, *Zastosowanie metody taksonomicznej do typologicznego podziału krajów ze względu na poziom ich rozwoju oraz zasoby i strukturę wykwalifikowanych kadr (The use of taxonomic method to typological classification of countries on account of their development, resources and structure of qualified human resources)*, „Przegląd Statystyczny" ("Statistical Review"), 1968, vol. 15/4.

3. Empirical research on sustainable development

There are six countries that are subjected to analysis: Belarus, the Czech Republic, Poland, the Russian Federation, the Slovak Republic and Ukraine. The basis of the research are eight development indicators[23]: (1) electricity production from renewable sources, excluding hydroelectric (% of total), (2) GDP (PPP) per capita (in international USD), (3) life expectancy at birth, (4) national poverty headcount ratio at national poverty lines (% of population), (5) PM2.5 air pollution (mean annual exposure in micrograms per cubic meter), (6) current health expenditures per capita (in USD), (7) research and development expenditure (% of GDP) and (8) gender gap index. Two of the indicators are considered destimulants (D; 4 and 5) and the rest — stimulants (S). Research question is the sustainable development in West and East Slavic countries and possible similarities between countries that have entered the EU in 2004. Data set presents features for the year 2016[24].

Table 1. Selected development indicators by country in 2016

Variable	1	2	3	4	5	6	7	8
Character	S	S	S	D	D	S	S	S
Belarus	0,5017	17725,75	73,8268	5,7	18,8782	297,543	0,5006	0,74
Czech Republic	9,2319	35876,73	79,9268	9,1	16,1006	1321,62	1,6802	0,69
Poland	12,6876	28283,7	77,8512	15	20,9758	813,4728	0,9641	0,73
Russian Federation	0,091	24125,4	71,6512	13,3	16,2199	469,1309	1,0973	0,69
Slovak Republic	8,1613	29651,52	77,1659	12,4	17,3537	1174,799	0,789	0,68
Ukraine	1,0524	11148,2	71,4763	3,8	20,6182	141,9353	0,484	0,7

Source: own elaboration.

As it can be gathered from the table 1, there are a lot of differences between analyzed countries. It is to be emphasized that the European Union member states (the Czech Republic, Poland and the Slovak Republic) are characterized by significantly better economic condition, for instance when it comes to GDP per capita, but — on the other hand — the gender gap index implies better female position in the East Slavic countries. Table 2 depicts basic descriptive statistics of the variable set.

[23] All the data come from http://worldbank.com [access: 10.12.2020].

[24] Electricity production form renewables is the only one indicator for which there is no data available for 2016, hence data for 2015 are used for analysis in this case.

Table 2. Descriptive statistics of the variable set

Variable	1	2	3	4	5	6	7	8
Mean	5,29	24468,55	75,32	9,88	18,36	703,08	0,92	0,71
Standard deviation	4,94	8109,46	3,20	4,07	1,95	438,06	0,41	0,02
Kurtosis	-2,26	-0,47	-2,05	-1,75	-2,21	-1,96	0,89	-1,46
Skewness	0,31	-0,42	0,08	-0,37	0,23	0,24	0,98	0,75
Maximum value	12,69	35876,73	79,93	15,00	20,98	1321,62	1,68	0,74
Minimum value	0,09	11148,20	71,48	3,80	16,10	141,94	0,48	0,68

Source: own elaboration.

Mean and standard deviation are needed when it comes to data set normalization. Maximal and minimal values (after normalization) serve when pattern and anti-pattern objects are being created and now they can illustrate how big differences between countries are. Kurtosis and skewness depicts the character of the distribution. One can conclude that there are some differences between particular features which proves data set normalization is needed.

The first step of data proceeding is their standardization — in order to receive variables for which the mean is equal to 0 and the standard deviation — to 1. The following table includes normalized data set.

Table 3. Normalized data set

Variable	1	2	3	4	5	6	7	8
Character	S	S	S	D	D	S	S	S
Belarus	-0,9688	-0,8315	-0,4653	-1,0283	0,2664	-0,9258	-1,0282	1,5785
Czech Republic	0,7984	1,4068	1,4401	-0,1925	-1,1552	1,4120	1,8693	-0,6765
Poland	1,4980	0,4705	0,7917	1,2577	1,3399	0,2520	0,1103	1,1275
Russian Federation	-1,0520	-0,0423	-1,1448	0,8398	-1,0941	-0,5341	0,4375	-0,6765
Slovak Republic	0,5817	0,6391	0,5777	0,6186	-0,5138	1,0768	-0,3198	-1,1275
Ukraine	-0,8573	-1,6426	-1,1994	-1,4953	1,1569	-1,2810	-1,0690	-0,2255

Source: own elaboration.

It is worth noticing that the data set includes no more indicators in years, USD, % *etc*. After the normalization procedure all the variables are comparable and cannot be seen in the same way as the input data.

Followingly, pattern and anti-pattern objects are to be defined by maximum and minimum values of standardized features what the table 4 presents.

Table 4. Characteristics of pattern and anti-pattern objects

Variable	1	2	3	4	5	6	7	8
Character	S	S	S	D	D	S	S	S
Pattern	1,498	1,407	1,440	-1,495	-1,155	1,412	1,869	1,579
Anti-pattern	-1,052	-1,642	-1,199	1,258	1,340	-1,281	-1,069	-1,128

Source: own elaboration.

Pattern and anti-pattern objects consist of the maximum or minimum values of particular standardized variables depending on their character (stimulant or destimulant).

The next step of the research is calculation of Euclidian distances between pattern and economic objects.

Table 5. Euclidian distances between objects and pattern

Country	Sum of the squares of the distances	Euclidian distances
Belarus	30,8244	5,5520
Czech Republic	7,2712	2,6965
Poland	19,7440	4,4434
Russian Federation	31,6618	5,6269
Slovak Republic	19,2787	4,3908
Ukraine	46,2980	6,8043

Source: own elaboration.

It could be concluded that the Czech Republic is characterized by the least distance from the pattern object, but the Euclidian distances could be much more comparable when they would be referred to a particular value. In order to achieve the comparability of the distances there is a need to define the Euclidian distance between pattern and anti-pattern objects which total 7,4724. Eventually, one can calculate the taxonomic measure of development by the formula:

$$m_i = 1 - \frac{d_{i0}}{d_0}.$$

for $i = 1, 2, \ldots, N$, where d_{i0} represents the Euclidian distance between i th object and pattern and d_0 depicts the Euclidian distance between pattern and anti-pattern. The following table illustrates the results of the research.

Table 6. Taxonomic measure of development for the analyzed countries

Country	Taxonomic measure of development
Czech Republic	0,6391
Slovak Republic	0,4124
Poland	0,4054
Belarus	0,2570
Russian Federation	0,2470
Ukraine	0,0894

Source: own elaboration.

As it can be gathered from the results of TMD (taxonomic measure of development), the Czech Republic should be considered the leader of sustainable development in group that consists of West and East Slavic countries. It is worth emphasizing that the European Union Member States are characterized by better condition in general. Interesting could be considered also position of Belarus — similar to the Russian Federation — even though Russia poses a better developed economy. The final result was, however, affected by other issues, including social, environmental and human aspects. One can conclude form input data that Belarus is characterized by — when compared to Russia — better gender gap index which should be seen in a positive way.

There are, in turn, some similarities between the Czech Republic, Poland and the Slovak Republic — countries that are EU Member States. Firstly, relatively high GDP (PPP) per capita should be taken into consideration. Especially the level of GDP per capita of the Czech Republic places this country high in the ranking. Secondly, given countries use more renewables than the three that are not in the EU. One could take into consideration the use of renewable sources of electricity in West Slavic countries — between 8% and 12%, and as a comparison the same indicator for East Slavic countries that oscillates between 0% and 1%. When it comes to life expectancy at birth and current health expenditures per capita, the EU Member States are also leaders among selected countries. West Slavic countries' citizens live much more longer that those from the three other states — up to nearly 80 years. Health expenditures per capita are also even several times higher in West Slavic countries when compared to the rest of analyzed states.

Conclusions

The aim of the paper was to order West and East Slavic countries according to selected development indicators, considering the term *development* multidimensionally.

From theoretical dilatation it is to be pointed out that the terms of growth and development refer to different phenomena. The first is strongly related to quantitative changes and the second — to everything that could qualitatively improve a human life. The sustainable development, the phenomenon analyzed in the research, is seen as progress that is not achieved at the expense of future generations.

Methodological elaboration proves that multivariate statistical analysis is — on the one hand — a collection of complex methods, but — on the other hand — quite simple when it comes to its application.

From the results of linear ordering one could conclude that the Czech Republic is the leader of sustainable development among the six analyzed countries. The EU Member States — the Czech Republic, Poland and the Slovak Republic — are characterized not only by a significantly better economic conditions (for instance when it comes to GDP per capita) but they are prospering better in several other issues, including environmental (the use of renewables in electricity production) and social as well as human factors (e.g. life expectancy at birth). GDP (PPP) per capita which is significantly higher in West Slavic countries could be considered a proper example when it comes to economic aspects. Furthermore, life expectancy at birth that oscillates between 77 and 80 years when it comes to the EU Member States is also an important factor. Countries that have not entered the EU are, in turn, doing well when it comes to gender gap index (for instance Belarus which scored 74 points in the analyzed year). It is to be noticed that the results of gender gap index for the Czech Republic (0,69) and the Slovak Republic are relatively low.

All things considered, one can state that West Slavic countries, EU Member States, are much more developed when compared to East Slavic countries.

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Worldbank, URL: http://worldbank.com.

Summary

The aim of the following research paper is to rank West and East Slavic countries according to selected development indicators, including variables representing economic, social, human, environmental and gender issues, and to answer the question if there are similarities between the three countries that entered the EU in 2004. The paper consist of three parts. In the first part the term of development is discussed in comparison to the phenomenon of economic growth. The second part includes the methodological elaboration on multivariate statistical analysis and one of its method — linear ordering. The third part poses an empirical research on sustainable development in the analyzed countries.

Keywords: sustainable development, Slavic countries, multivariate analysis, linear ordering

ROZWÓJ ZRÓWNOWAŻONY W KRAJACH WSCHODNIO- I ZACHODNIOSŁOWIAŃSKICH: PODEJŚCIE WIELOWYMIAROWE

Streszczenie

Celem pracy jest uporządkowanie krajów wschodnio- oraz zachodniosłowiańskich na podstawie określonych wskaźników rozwoju, w tym cech diagnostycznych odnoszących się do aspektów ekonomicznych, społecznych, naturalnych, środowiskowych oraz tych związanych z równością płci. Ponadto, praca prezentuje odpowiedź na pytanie o to, czy

pomiędzy krajami z grupy wymienionej powyżej, które wstąpiły w 2004 roku do struktur Unii Europejskiej, występują podobieństwa w aspekcie zrównoważonego rozwoju. Artykuł składa się z trzech części. Pierwsza część stanowi opis zjawiska rozwoju i jego porównanie w stosunku do terminu wzrostu gospodarczego. Część druga zawiera podstawy metodologiczne związane z wielowymiarową analizą statystyczną oraz z porządkowaniem liniowym, które stanowi jedną z metod stosowanych w ramach analizy wielowymiarowej. Ostatnia część pracy ilustruje wyniki badania empirycznego na temat zrównoważonego rozwoju w krajach wschodnio- i zachodniosłowiańskich przeprowadzonego za pomocą porządkowania liniowego.

Słowa kluczowe: rozwój zrównoważony, kraje słowiańskie, analiza wielowymiarowa, porządkowanie liniowe