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The Assessment Of Geographical Borders In Economic Research[1]

Abstract

The length of common border between two geographical units is frequently used as a basic weight in spatial analysis. The newest methodological propositions such as tests for hierarchical relations (Markowska et. al. 2014; Sokołowski et. al. 2013), regional spatial moving average and new spatial correlation coefficient (Markowska et. al. 2015) are using border lengths. In cited references new methods have been illustrated by analyses for EU NUTS2 regions. It is obvious that borders between regions belonging to different countries have different socio-economic impact than borders between regions lying in the same country. A new simple method for assesment the importance of borders is proposed in the paper. It is based on a chosen macroeconomic variable available at NUTS 2 level (e.g. GDP, infant mortality, Human Development Index). For neighboring regions bigger value is divided by smaller value giving the local importance of the given border. These measures of local border importance can be than average for borders within the same country and for borders for each pair of neighboring countries.

***Keywords**: weighing systems, spatial analyses, spatial correlation*

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1. Introduction

The idea of boundaries, in the opinion of Z. Rykiel (1991, p. 12) following A. L. Sanguin (1983) function in the form of a *separating boundary*, i.e. a barrier *(la frontiere de limage-baniere)* and a *connecting border (la frontiere de Vimage-liaison).* The latter is related to the concept of a *border zone (frontiere zonale)* and the process of border "defunctionalisation" as a result of integration processes (Vallusi 1976). In such context a border becomes a location place rather than a dividing frontier. The subject literature identifies both the separating and connecting functions of a border as the focus of empirical analysis (*Les regions...*, 1975).

Currently it is emphasized that despite globalization processes (positing a new 'borderless' world, in which the barrier impact of borders became insignificant) the renaissance of border studies has been observed during the past decade, which is manifested by e.g. crossing disciplinary barriers, conducting research bringing together the teams of geographers, political scientists, sociologists, anthropologists, historians, experts in law, literature, border practitioners engaged in the practical aspects of boundary demarcation, delimitation and management (Newman 2006).

The importance of the so-called border effect (Evans 2003) has been identified as a significant aspect, which induced by various barriers, represents the measure of integration boundaries for the particular parts of a region (Kallioras et al. 2009). The impact of borders on the discontinuity of links was assessed e.g. as an absolute (Hartshorne 1933) or relative i.e. referred to border length (Rykiel 1985) number of roads or railway lines cut by a state border. J. R. Mackay (1958) and A. Lösch (1961) interpreted the border effect as the increase of social distance with respect to the adequate physical distance, whereas R. Domański (1970) in the categories of reducing the impact of boundaries on interactions (see Rykiel 1991, p. 16).

The identification of border effect in economic studies poses a research challenge. The article presents the proposal of assessing geographical importance of borders using economic variables (GDP per capita and disposable income of households per capita). The European Union countries and NUTS 2 level regions were used as the research objects.

2. The concept of borders in economic studies

During the Second World War an American geographer S. W. Boggs published a book (1940) in which he wrote: „Across more than 100,000 miles of international boundaries neighbours face one another today, some friendly, others suspicious or even hostile. Men are asking what boundaries are, how they work, and how current problems may be solved. In this brief introductory study, boundaries are considered from both larger and smaller aspects than those in which they are usually regarded:

1) larger, in order to observe how and why boundaries and boundary problems vary from continent to continent and from century to century; and
2) smaller, in order to perceive what actually happens at international boundaries and what functions they perform.

Each continent is found to differ appreciably from all the others in the origins of its boundary problems, in the manner in which its boundaries operate, or in the stage of development of its boundaries and their functions. No similar study by continents appears to have been attempted. The perspective gained by this approach to the subject may help to reveal why the boundary problems of Europe are so much more acute than those of any other continent and how greatly they differ in nature, as well as in degree, from those of the New World. There are pressing boundary problems in several continents; to be solved effectively they must be solved peacefully. When new boundaries are made, widely divergent opinions may be expressed regarding desirable and undesirable types of boundaries. A common-sense viewpoint is that whether a boundary is "good" or "bad" depends upon whether it is adapted to serve the purposes for which it is maintained, with maximum efficiency and minimum friction and expense. To understand the contemporary problems it is therefore necessary to ascertain what happens because the boundaries are there and because of' the prevailing ideas regarding the purposes which they should serve”.

The problems related to borders receive coverage in economic literature predominantly in the context of: spatial and economic importance of borders between countries (Ratti 1993; Helliwell 1998; Sachs 2003, Reitel 2011) and regions (McCallum 1995), for development (Topaloglou 2008; Topaloglou, Petrakos 2008), commercial exchange (Helliwell 1996; Hanson 1996; Yuan-Ching et al. 2004; McCallum 1995; Millimet, Osang 2007; Nitsch 2000), job markets (Heimpold 2000; Janssen 2000), business location (Hanson 1996; Holmes 1998), changes occurring along state and regional borders (Clement 1997; Heimpold 2000), integration impact on the economy of borderland states and regions (Rykiel 1995; Janssen 2000; Niebuhr, Stiller 2004; Brenton, Vancauteren 2001; van Houtum 2003;

Meinhof et al. 2003), cooperation of neighbouring regions (Heimpold 2000; Janssen 2000) and cooperation with the so-called third countries (Kallioras et al. 2009).

In the times of terrorist attacks and the crisis affecting Europe the border issue also returns in the context of managing borders (Andrijasevic, Walters 2010) and the reclosing of borders (Newman 2006).

The contemporary study of borders also focuses on the process of bordering, through which territories and peoples are respectively included or excluded within a hierarchical network of groups, affiliations and identities (Newman 2003), which can be interpreted in reorientation terms of the spatial system of links by analyzing them as e.g. the areas of changes in economic gravity.

3. The importance of borders – assessment proposal

A border is a broad term, present in the language, in academic discourse and also in everyday speech. It is usually defined as a line or a zone dividing an area, or delimiting an end on its one side and the beginning of "something" on the other (Bański 2010). As Heffner pointed out (2010) the research on the essence of this term is carried out in many fields of science and is of an interdisciplinary nature, whereas the multifaceted spatial dimension of a border shows its impact in global, regional, local and international perspective – it also refers to cross-border economic or socio-cultural ties.

Borders can be divided into e.g. artificial and natural ones, there are also such types of borders as e.g. historical, cultural, natural, administrative, economic and political – the latter are cited (Komornicki 1999) as a specific example of spatial barriers. While approaching a formal border as a spatial barrier in the flow of ideas, goods and people the following boundaries can be distinguished: open, permeable and closed borders, with many subcategories resulting from the geographical location, economic and political situation, method of control etc. (Bański 2010).

Spatial barriers are presented in terms of the innovation diffusion concept (the division of the analysed system elements into active innovation sources and its passive goals is assumed), as well as the concept of mutual interactions (the focus is on the integration of elements of the analysed socio-economic territorial system, performed through the interactions of these elements) (Rykiel 1991). The outline of the second concept (Hartshome 1933), developed by (Mackay 1958), approaches borders as spatial barriers, to be further developed at the background of regional geography, where the boundary effect term is used (Mackay 1958), or the concept of interruptive role of the boundary (Ullman

1939; Moodie 1950; Minghi 1963). As Rykiel (1991) indicates the term of barrier effect (Yuill 1965) was used on the grounds of the concept of spatial diffusion of innovation.

In Europe, along with the development of integrational processes, resulting from socio-economic transformations in the process of the border function evolution, the discussed barrier begins to disappear, the scope of border permeability is extended and its role as a spatial barrier disappears.

An attempt to assess the importance of the border in the discussed contexts seems justified. The proposal for assessing the importance of economic barriers in the European Union consists in 1/ adopting a macroeconomic variable, not used in current analyses (e.g. GDP, infant mortality rate, HDI value) and the one available at NUTS 2 level; 2/ determining the local importance of borders through dividing a larger value of this variable by a smaller one for borderline regions located on both sides of a given border; 3/ veraging the importance assessments for domestic borders in each country separately as well as for international borders; 4/ it is also possible to use the importance assessment without averaging to develop an additional weight system.

4. Assessment of the importance of borders – results of the suggested approach application

For statistical purposes the European Union is divided, in a hierarchical arrangement, into NUTS level units (*Nomenclature des unités territoriales statistiques*). From the perspective of structural policy implementation NUTS 2 and NUTS 3 represent important levels, used e.g. in the identification of areas qualified for financial support. Within the framework of NUTS 2 level units the support is offered to problem areas characterized by e.g. low development level, and at NUTS 3 level – the areas requiring restructuring and the border regions (Regions 2011). In the period 2012–2014 there were 276 NUTS 2 regions and since 2015 their total number has been 250. The changing number of territorial units makes dynamic assessments difficult and also does not facilitate the comparability of the reports published by Eurostat.

The assessment uses current data referring to two variables of macroeconomic nature[2]:

1. Gross domestic product (GDP) at current market prices by NUTS 2 regions (purchasing power standard per inhabitant);
2. Income of households by NUTS 2 regions (purchasing power standard based on final consumption per inhabitant).

The most recent data (available in Eurostat databases in June 2016) regarding GDP per capita originate from 2014 and about the disposable income of households per capita from 2011.

It should be mentioned that because of the changing: presentation forms (resulting in data merging problems due to e.g. incomparable sequence of objects in data packets from different thematic blocks), names of regions, acronyms allowing for objects' identification – database construction poses many difficulties. Moreover, a separate problem results from the existing data gaps (e.g. the data referring to Malta and Croatia were missing for the second variable).

4.1. The importance of borders – assessment results for GDP per capita

For 615 borders between the EU regions at NUTS 2 level their "importance" was calculated as the relation of GDP per capita (value from a "richer" region devided by the value from the "poorer" one). The information about this measurement distribution, in the entire group of borders (table 1), separately for domestic and international borders, to be followed by a more detailed distribution for larger countries (table 2) is presented below (table 2).

The distribution of borders' "importance" measure shows a clear right-sided asymmetry which, in fact, results from the construction of this indicator, as the relation of larger value to a smaller one. International borders are more important in the light of the adopted measurement, however, the differences are not spectacular – the median of the distribution of international borders' importance remains between the median and the upper quartile of the importance of domestic borders.

The difference between the outliers of the assessed relation was almost 2 for the regional borders within countries and almost 2.5 for the borders between regions of different countries. In case of 1/3 of all borders the value of GDP per capita relation ranged from 1 to 1.1, for 26% from 1.1 to 1.2 – but for 4% (22 borders) the discussed relation was higher than 2. The GDP per capita relation of neighbouring

[2] http://ec.europa.eu/eurostat/web/regions/data/main-tables (nama_10r_2gdp; nama_r_ehh2inc) [23.05.2016].

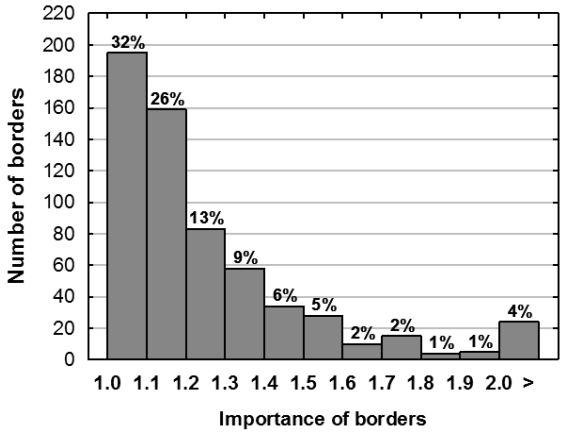
regions ranged from 1.0 to 1.2 in case of over 60% from 475 interregional (domestic) borders and for over 40% from 140 international ones (see fig. 1 and 2).

Table 1. Basic statistics – the importance of borders (GDP per capita of neighbouring regions)

Type of borders	Importance of borders (GDP per capita ratio for neighboring regions)							
	N	$\bar{x}$	Me	S	c_{25}	c_{75}	min	max
national	475	1,25	1,15	0,28	1,07	1,31	1,00	2,99
international	140	1,34	1,24	0,41	1,11	1,45	1,00	3,48
total	615	1,27	1,17	0,32	1,08	1,33	1,00	3,48
p value from Kruskal-Wallis test	0,0014							

Source: authors` calculations.

Figure 1. The distribution of values – the border total importance (GDP)

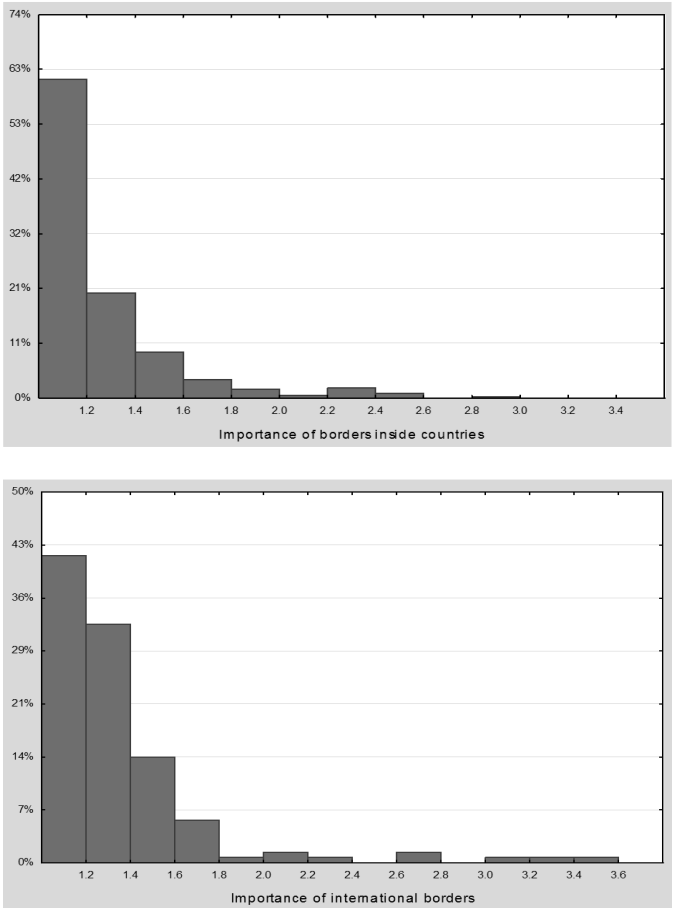


Source: authors` compilation.

Table 2 presents descriptive statistics of domestic borders distribution for the countries which are divided into at least two regions. The results are ranked according to the average importance of borders, which due to the assessment purpose (the importance of interregional borders) seemed a reasonable approach. The highest value of GDP per capita relation (1.70) occurred between the regions in Ireland (consisting of two NUTS 2 level regions), to be followed by the Slovak Republic. The subsequent countries arranged by an average value of the assessed relation are Hungary and Bulgaria. Among the countries in which the average level of GDP per capita relation between regions amounted to 1.20 and less the following are included: Great Britain, Czechia, Italy, Spain and Sweden – the number of regions in these countries ranges from 8 to 40. In Poland the average relation of GDP per capita for NUTS level regions amounts to 1.35, along with the median of these relations at the level of 1.24. The highest interval assessed as the difference

between the highest and the lowest value of GDP per capita relation between regions was recorded in 2014 in Romania (1.95) and the difference higher than 1.5 referred to the regions from such countries as Hungary (1.52) and Bulgaria (1.51). Moreover, the difference exceeding unity occurred in: the Slovak Republic (1.45), Germany (1.34), Poland (1.29), France (1.26), Czechia (1.23) and Great Britain (1.07).

Figure 2. The distribution of values – the importance of borders: domestic and international (GDP)



Source: authors` compilation.

Table 3 presents an alphabetical list of countries by the value of average GDP per capita relation between borderland regions, arranged (the first two columns) in the way showing in column 1 (country 1) the country which GDP value per capita was the denominator value – i.e. the "richer' country, whereas in column 2 the "poorer" one.

Table 2. Domestic cohesion – GDP per capita relations in the EU regions

Country	Importance of borders inside countries					
	N	$\bar{x}$	**Me**	***S***	**min**	**max**
Ireland	1	1.70	1.70	0.00	1.70	1.70
Slovak Republic	3	1.64	1.19	0.82	1.14	2.59
Hungary	11	1.60	1.35	0.58	1.02	2.54
Bulgaria	9	1.44	1.16	0.58	1.00	2.51
Slovenia	1	1.44	1.44	0.00	1.44	1.44
Romania	13	1.37	1.21	0.51	1.04	2.99
Poland	34	1.35	1.24	0.38	1.00	2.29
Belgium	20	1.31	1.29	0.23	1.01	1.70
Denmark	5	1.30	1.31	0.33	1.00	1.84
Netherlands	23	1.27	1.20	0.25	1.00	1.75
France	48	1.23	1.14	0.29	1.01	2.27
Greece	23	1.22	1.15	0.20	1.02	1.73
Austria	13	1.22	1.18	0.14	1.01	1.51
Finland	5	1.22	1.09	0.22	1.02	1.48
Deutschland	87	1.21	1.16	0.22	1.00	2.34
Portugal	12	1.21	1.08	0.23	1.01	1.58
Great Britain	74	1.20	1.14	0.19	1.00	2.07
Czechia	12	1.19	1.11	0.34	1.01	2.24
Italy	36	1.18	1.14	0.16	1.00	1.88
Spain	35	1.17	1.12	0.17	1.00	1.74
Sweden	10	1.15	1.10	0.18	1.01	1.63

N – the number of borders between NUTS 2 regions.

Source: authors` calculations.

Germany, as the first country (higher GDP per capita), borders with the largest number of the EU Member States, i.e. with the regions of six other countries: Belgium (average relation 1.34, min. 1.14 and max. 1.54), Czechia (average relation 1.63, min. 1.35 and max. 2.05), Denmark (1.07), France (average relation 1.38, min. 1.22 and max. 1.50), Netherlands (average relation 1.17, min. 1.01 and max 1.47), Poland (average relation 1.50, min. 1.25 and max. 1.67); and as the second country (lower GDP per capita) with Luxemburg (on average 2.5 times lower) and Austria (1.19).

Austria is the second country in terms of the borders number with other EU Member States – it borders with six EU countries – and with the regions of neighbouring countries its assessed relation (average) ranges from 1.09 with Italy to 1.79 with the Slovak Republic (always as the first country in the above-mentioned understanding).

Table 3. The importance of international borders – GDP per capita relation between borderland regions across the EU countries

Country 1	Country 2	Importance of international borders					
		N	$\bar{x}$	Me	*S*	min	max
Austria	Czechia	3	1.49	1.39	0.22	1.33	1.74
Austria	Deutschland	6	1.19	1.15	0.11	1.08	1.36
Austria	Slovak Republic	3	1.78	1.77	0.32	1.46	2.10
Austria	Slovenia	4	1.42	1.44	0.27	1.10	1.70
Austria	Hungary	1	1.25	1.25	0.00	1.25	1.25
Austria	Italy	5	1.09	1.05	0.11	1.00	1.28
Belgium	France	7	1.16	1.13	0.12	1.03	1.35
Cyprus	Greece	2	1.16	1.16	0.20	1.02	1.29
Czechia	Poland	5	1.15	1.08	0.13	1.01	1.29
Deutschland	Belgium	2	1.34	1.34	0.27	1.14	1.53
Deutschland	Czechia	7	1.63	1.61	0.24	1.35	2.05
Deutschland	Denmark	1	1.07	1.07	0.00	1.07	1.07
Deutschland	France	5	1.38	1.45	0.13	1.22	1.50
Deutschland	Netherlands	8	1.17	1.20	0.15	1.01	1.47
Deutschland	Poland	5	1.50	1.56	0.16	1.25	1.67
Estonia	Latvia	1	1.19	1.19	0.00	1.19	1.19
Great Britain	France	6	1.21	1.18	0.17	1.03	1.46
Greece	Bulgaria	3	1.47	1.50	0.12	1.35	1.57
Hungary	Romania	3	1.11	1.11	0.10	1.01	1.22
Italy	France	7	1.13	1.17	0.10	1.01	1.25
Italy	Malta	1	1.39	1.39	0.00	1.39	1.39
Italy	Slovenia	1	1.03	1.03	0.00	1.03	1.03
Lithuania	Latvia	1	1.18	1.18	0.00	1.18	1.18
Lithuania	Poland	1	1.54	1.54	0.00	1.54	1.54
Luxembourg	Belgium	2	3.27	3.27	0.29	3.07	3.48
Luxembourg	France	1	3.35	3.35	0.00	3.35	3.35
Luxembourg	Deutschland	2	2.46	2.46	0.31	2.24	2.68
Netherlands	Belgium	7	1.20	1.16	0.14	1.03	1.38
Slovak Republic	Czechia	4	1.11	1.13	0.06	1.03	1.16
Romania	Bulgaria	5	1.36	1.37	0.09	1.26	1.46
Slovak Republic	Poland	4	1.10	1.12	0.07	1.01	1.16
Slovak Republic	Hungary	8	1.49	1.35	0.50	1.02	2.63
Slovenia	Croatia	2	1.48	1.48	0.37	1.21	1.74
Slovenia	Hungary	1	1.04	1.04	0.00	1.04	1.04
Spain	France	6	1.19	1.17	0.12	1.04	1.34
Spain	Portugal	7	1.17	1.15	0.11	1.04	1.32
Sweden	Denmark	1	1.49	1.49	0.00	1.49	1.49
Sweden	Finland	2	1.25	1.25	0.00	1.25	1.25

N – the number of borders between NUTS 2 regions.

Source: authors` calculations.

The average relation of GDP per capita value of almost 1.5 and above was recorded e.g. between the regions of such countries as (the country with higher GDP per capita is presented as the first): Austria and Czechia, Austria and the Slovak Republic, Sweden and Denmark, the Slovak Republic and Hungary, Slovenia and Croatia, Lithuania and Poland, Germany and Poland, Germany and Czechia. Particular attention should be paid to the relation values for Luxemburg, since they are the highest, from 2.50 on average against the neighbouring German regions (from 2.20 to 2.68), up to 3.40 against the French region and 3.3 on average against Belgium regions (from 3.10 to 3.48).

In addition, while assessing the defined relations of GDP per capita values between the regions of neighbouring countries attention should be paid to the diversification even within one international border – the difference amounting to more than 0.50 between outlier values (min. and max.) occurred between the borderland regions of the following countries: Austria and the Slovak Republic, Austria and Slovenia, Germany and Czechia, Slovenia and Croatia, whereas the highest difference of 1.61 was recorded between GDP per capita in the borderland regions of the Slovak Republic and Hungary.

4.2. The importance of borders – assessment results for disposable income per capita

This part of the study determines the "importance" of 606 borders between the EU regions at NUTS 2 level, calculated as the relation of disposal income per capita (the "richer" region devided by the "poorer" one). Table 4 presents information about this measure distribution in the entire group of borders, separately for the domestic and international ones, to be followed by the detailed information for countries with higher than unity number of NUTS 2 level regions (tab. 5).

The measure distribution of the "importance" of borders for the disposable income, similar to the case of GDP per capita relation, indicates a clear right-sided asymmetry. The histogram (fig. 3) illustrates the measure distribution of borders importance in the entire analysed group. International borders are more important in the light of the adopted measure, although even here the differences are far from spectacular – the distribution median of international borders importance between the median and the upper quartile of domestic borders importance. The difference between outlier values of the assessed disposable income relation per capita amounted to almost 1.15 for the borders between the regions in countries and almost 1.30 for borders between the regions of different countries.

In case of more than half of all borders the value of disposable income per capita relation ranged from 1.0 to 1.1 and for almost 20% from 1.1 to 1.2. The

range 1.0–1.2 referred to the disposable income per capita relation of the neighbouring regions for slightly more than 64% from 471 interregional (domestic) borders and for 33% from 135 international ones (see fig. 3 and 4).

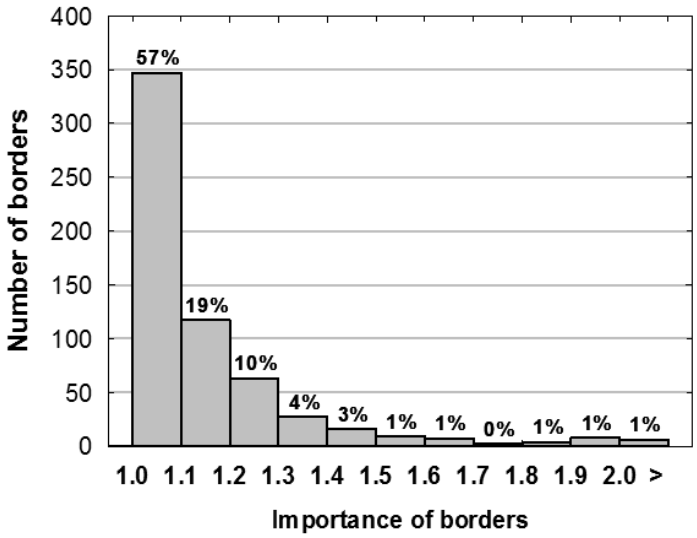
Table 4. Basic statistics – the importance of borders (disposable income per capita in regions)

Type of borders	Importance of borders (ratio of household disposable income in neighboring regions)							
	n	$\bar{x}$	Me	s	c_{25}	c_{75}	min	max
national	471	1.11	1.06	0.12	1.03	1.14	1.00	2.15
international	135	1.31	1.21	0.31	1.07	1.45	1.01	2.28
total	606	1.15	1.08	0.20	1.03	1.19	1.00	2.28
p value from Kruskal-Wallis test	0,0000***							

Source: authors` calculations.

Table 5 presents the descriptive statistics of domestic borders distribution for countries with more than one NUTS 2 level region, arranged by the average importance of borders. While in case of GDP per capita relation there were many countries (10), in which it was higher than 1.25 on regional level, in case of disposable income per capita the highest value relation was 1.24 (Bulgaria). Next value was 1.23 for the regions of the Slovak Republic and Poland (1.20).

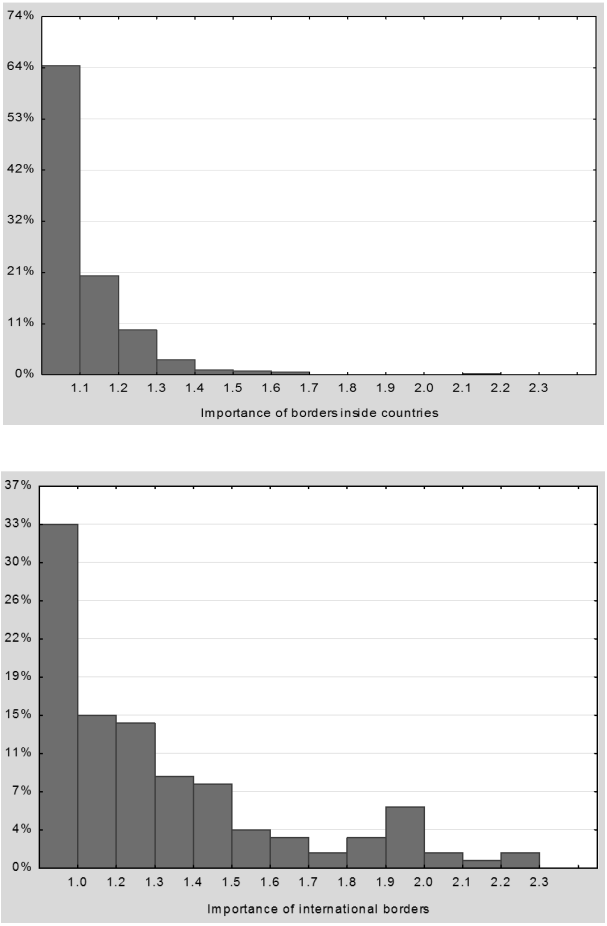
Figure 3. The distribution of values – the border total importance (Income)



Source: authors` compilation.

The subsequent countries arranged by average values of the assessed values in their regions were: Hungary, Romania, Belgium, Portugal, Spain, Ireland, Slovenia, where the average level of disposable income per capita relation ranged from 1.11 to 1.80. In the remaining ones it was 1.10 and less – down to 1.02 in Denmark.

Figure 4. The distribution of values – the importance of borders: domestic and international (Income)



Source: authors` compilation

Interregional "dissection" in the discussed sphere can be assessed based on the difference between the highest and the lowest value of the disposable income per capita relation between regions. In 2011 in Romania (1.15) and higher than 0.5 difference referred to the regions in such countries as Bulgaria (0.62), Poland (0.64) and Italy (0.54).

Table 6 presents, in alphabetical order, the countries by the value of average disposable income per capita relation between the regions of borderland states (column 1 presents the country in which the value of disposable income per capita was higher, shown in denominator, the "richer' country").

Table 5. Domestic cohesion – disposal income per capita relation in the EU regions

Country	Importance of borders inside countries					
	N	$\bar{x}$	Me	*S*	min	max
Bulgaria	9	1.24	1.19	0.18	1.00	1.62
Slovak Republic	3	1.23	1.14	0.23	1.07	1.50
Poland	34	1.20	1.15	0.18	1.00	1.64
Hungary	11	1.18	1.09	0.18	1.00	1.47
Romania	13	1.18	1.14	0.30	1.00	2.15
Belgium	20	1.15	1.12	0.11	1.01	1.35
Portugal	12	1.15	1.09	0.14	1.02	1.45
Spain	35	1.14	1.10	0.11	1.01	1.43
Ireland	1	1.12	1.12	0.00	1.12	1.12
Slovenia	1	1.11	1.11	0.00	1.11	1.11
Greece	23	1.10	1.07	0.09	1.00	1.31
Finland	5	1.10	1.06	0.09	1.02	1.22
Italy	36	1.10	1.08	0.10	1.00	1.54
Great Britain	74	1.10	1.08	0.08	1.00	1.31
Czechia	12	1.09	1.06	0.08	1.00	1.22
Deutschland	87	1.07	1.05	0.06	1.00	1.23
Netherlands	23	1.07	1.06	0.05	1.01	1.19
France	44	1.06	1.02	0.08	1.00	1.29
Sweden	10	1.05	1.04	0.06	1.00	1.21
Austria	13	1.04	1.04	0.02	1.01	1.07
Denmark	5	1.02	1.01	0.03	1.00	1.07

N – the number of borders between NUTS 2 regions.

Source: authors` calculations.

Germany as the first country (higher disposable income per capita) was listed with the regions of six other countries: Belgium (average relation 1.30, min. 1.28 and max. 1.32), Czechia (average relation 1.97, min. 1.76 and max. 2.25), Denmark (1.44), France (average relation 1.18, min. 1.12 and max. 1.24), Netherlands (average relation 1.38, min. 1.32 and max. 1.48), Poland (average relation 1.82, min. 1.69 and max. 1.98); and as the second country (lower disposable income per capita) with Luxemburg (on average by 1.24 lower) and Austria (1.13).

Austria, with the regions of each of the six EU borderland states, is listed as the first country (the values represent the numerator in the relation) has the (average) relation assessed from 1.05 against Italy to 2.28 against Hungary.

The average relation of disposable income value per capita, amounting to 1,5 and more, was recorded between the regions of such countries as (the country with higher disposable income per capita is presented as the first): Austria and Czechia, Austria and Slovenia, Austria and Hungary, Estonia and Latvia, Greece and Bulgaria, Lithuania and Latvia, Luxembourg and Belgium, Germany and Poland, Germany and Czechia.

Table 6. The importance of international borders – disposable income per capita relation between borderland regions of the EU countries

Country 1	Country 1	Importance of international borders					
		N	$\bar{x}$	Me	*S*	min	max
Austria	Czechia	3	2.05	2.08	0.05	1.99	2.08
Austria	Deutschland	6	1.13	1.14	0.09	1.01	1.23
Austria	Slovak Republic	3	1.48	1.29	0.39	1.21	1.93
Austria	Slovenia	4	1.58	1.62	0.09	1.45	1.64
Austria	Hungary	1	2.28	2.28	0.00	2.28	2.28
Austria	Italy	5	1.05	1.06	0.02	1.02	1.07
Belgium	Netherlands	7	1.19	1.21	0.10	1.03	1.31
Bulgaria	Romania	5	1.09	1.10	0.05	1.02	1.17
Czechia	Poland	5	1.10	1.11	0.05	1.04	1.18
Deutschland	Belgium	2	1.30	1.30	0.03	1.28	1.32
Deutschland	Czechia	7	1.97	1.97	0.16	1.76	2.22
Deutschland	Denmark	1	1.44	1.44	0.00	1.44	1.44
Deutschland	France	5	1.18	1.17	0.04	1.12	1.24
Deutschland	Netherlands	8	1.38	1.37	0.05	1.32	1.48
Deutschland	Poland	5	1.83	1.81	0.14	1.69	1.98
Estonia	Latvia	1	1.51	1.51	0.00	1.51	1.51
Finland	Sweden	2	1.05	1.05	0.03	1.02	1.07
France	Belgium	7	1.10	1.08	0.04	1.04	1.14
France	Spain	6	1.07	1.07	0.03	1.03	1.12
France	Great Britain	6	1.12	1.11	0.09	1.02	1.27
France	Italy	7	1.08	1.06	0.08	1.01	1.24
Greece	Bulgaria	3	1.62	1.55	0.26	1.41	1.91
Hungary	Romania	3	1.44	1.47	0.12	1.31	1.55
Italy	Slovenia	1	1.41	1.41	0.00	1.41	1.41
Lithuania	Latvia	1	1.94	1.94	0.00	1.94	1.94
Lithuania	Poland	1	1.22	1.22	0.00	1.22	1.22
Luxembourg	Belgium	2	1.55	1.55	0.02	1.54	1.57

Luxembourg	France	1	1.45	1.45	0.00	1.45	1.45
Luxembourg	Deutschland	2	1.24	1.24	0.08	1.18	1.29
Slovak Republic	Czechia	4	1.08	1.07	0.04	1.05	1.14
Slovak Republic	Poland	4	1.12	1.12	0.09	1.01	1.22
Slovak Republic	Hungary	8	1.33	1.26	0.26	1.01	1.88
Slovenia	Hungary	1	1.39	1.39	0.00	1.39	1.39
Spain	Portugal	7	1.19	1.08	0.19	1.02	1.45
Sweden	Denmark	1	1.05	1.05	0.00	1.05	1.05

N – the number of borders between NUTS 2 regions.

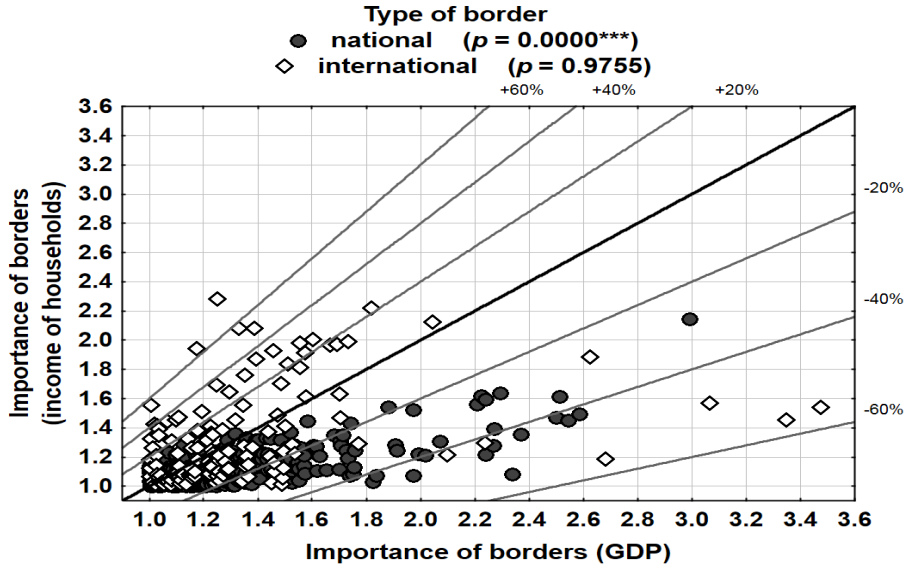
Source: authors` calculations.

Additionally, having in mind the identified relations of disposable income per capita level between the regions of borderland states, the diversification within the framework of one international border should also be assessed – the difference amounting to 0.5 and above between outlier values (minimum and maximum) occurred between the borderland regions of the following countries: Austria and the Slovak Republic, Greece and Bulgaria, the Slovak Republic and Hungary (the highest – 0.87).

4.3. The importance of borders – comparison of results for two variables

The comparison of descriptive statistics shows that the measure of the importance of borders by GDP per capita takes higher values (median 1.17 vs. 1.08 for the importance measure based on the disposable income per capita). This difference is particularly large for the domestic borders (i.e. the diversification between the neighbouring domestic regions is much higher when GDP is calculated per inhabitant than the disposable income of households). In case of international borders, however, the situation is not clear (median 1.24 vs. 1.21), which is well visible on the graph. There are borderland regions from different countries where GDP per capita diversification is higher than the household disposable income per capita, however, in some cases it does happen vice versa. The Wilcoxon signed-rank test for two related samples was used to compare the importance of borders calculated based on GDP and the disposable income, which indicated the absence of clear "tendency" for international borders. It reflects a "very insignificant" result of the Wilcoxon test (p=0.9755).

Figure 5. Scatter diagram for the importance of borders calculated based on two different variables



Source: authors` compilation

For domestic borders the comparison of two measures of the importance of borders using the Wilcoxon test gives a highly symptomatic statistical result (p=0.0000) – see fig. 5, which means that the orders of domestic borders designated using the two variables are significantly similar. It is confirmed by the value of Spearman's rank correlation coefficient amounting to 0.533 (p=0.013).

4.4. Assessment of the importance of borders based on many variables

In order to assess the importance of borders it is also possible to take the approach applying many variables, in which the quotient measures of the importance of borders have to be calculated based on the particular variables selected for the assessment. In this case it seems better not to "slice" the international borders into interregional borders. Next, it is founded to determine the global characteristics for international borders (such as average values, medians, etc.) for each variable separately. It is suggested to average the results using a geometric mean.

Averaged results for international borders using two analysed variables (GDP per capita and disposable income per capita) are presented in table 7.

Table 7. The importance of international borders – averaged values

Country 1	Country 2	The importance of international borders – averaged values
Luxembourg	Belgium	2.25
Luxembourg	France	2.20
Deutschland	Czechia	1.79
Austria	Czechia	1.75
Luxembourg	Deutschland	1.75
Austria	Hungary	1.69
Deutschland	Poland	1.66
Austria	Slovakia	1.62
Greece	Bulgaria	1.54
Lithuania	Latvia	1.51
Austria	Slovenia	1.50
Slovak Republic	Hungary	1.41
Lithuania	Poland	1.37
Estonia	Latvia	1.34
Deutschland	Belgium	1.32
Deutschland	France	1.28
Deutschland	Netherlands	1.27
Hungary	Romania	1.26
Sweden	Denmark	1.25
Deutschland	Denmark	1.24
Bulgaria	Romania	1.22
Italy	Slovenia	1.21
Slovenia	Hungary	1.20
Belgium	Netherlands	1.19
Spain	Portugal	1.18
France	Great Britain	1.16
Austria	Deutschland	1.16
Finland	Sweden	1.15
Belgium	France	1.13
Spain	France	1.13
Czechia	Poland	1.12
Slovak Republic	Poland	1.11
France	Italy	1.10
Slovak Republic	Czechia	1.09
Austria	Italy	1.07

Source: authors` calculations.

The presented ordering of weights, determined based on two variables, shows that the value higher than 2.0 refers to Luxemburg borders with Belgium and France, whereas lower than 1.1 to the Slovak Republic with Czechia, and Austria and Italy.

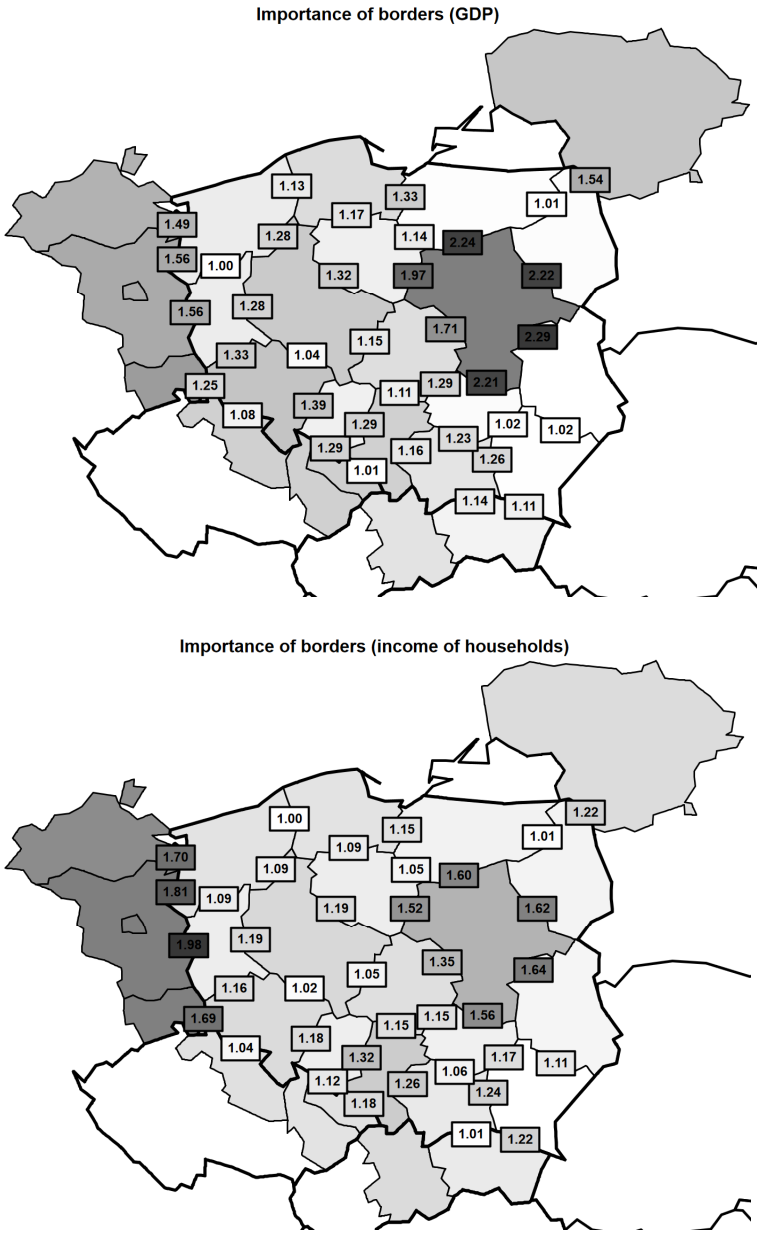
4.5. The importance of interregional borders and Polish regions with foreign neighbours

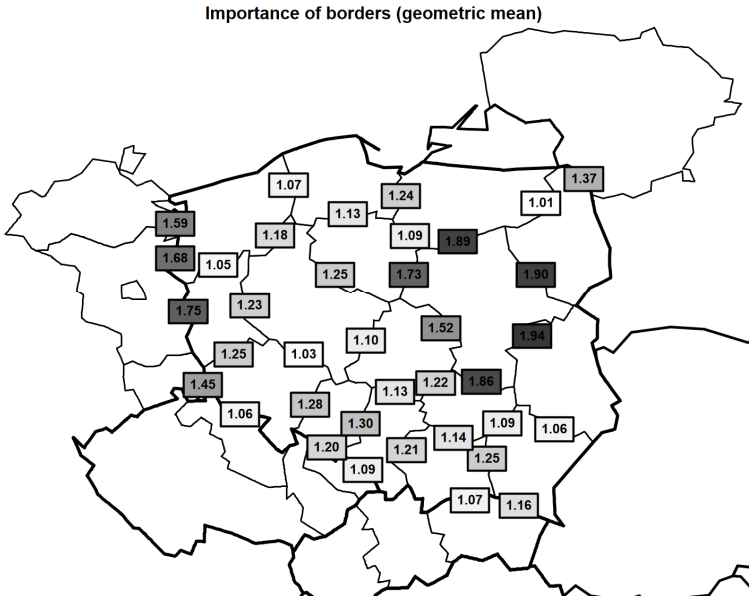
The importance of 16 Polish regional borders – the division identical to voivodeships – will be discussed separately. In the course of the first stage the spatial distribution of the assessed relations' values for each of the analysed variables was illustrated on maps, i.e. GDP per capita and disposable income per capita, and in the second stage jointly for both variables (fig. 6). In the first two cases higher variable values were marked by a darker colour on the maps and the importance measure was specified for each border. For technical reasons "short" borders, up to 50 km, were omitted. For the illustration transparency: the more important the border the darker the labelled area.

When it comes to GDP it is significant that the relations of GDP per capita between Mazowieckie region and the neighbouring regions are higher than between the regions of western Poland and German regions. Therefore, it is possible that Mazowieckie exerts higher impact on its neighbours than the eastern German regions on Wielkopolska or Pomorze Zachodnie.

The importance of borders assessed in the same way based on income is different – here the relations of disposable income per capita values for German regions against Polish regions are different: German regions exert higher "impact" on the regions of western Poland than Mazowieckie on its borderland regions.The contours on the map were not shaded for averaged values of variables. In case of geometric means for both types of relations – the importance of Polish-German border and between Mazowieckie and the neighbouring regions is much more similar than in case of the relation of two variables analysed separately.

Figure 6. GDP per capita relations, the relations of disposable income per capita and the relations of averaged values for both variables in Polish regions and in the EU regions from the borderland states





Source: authors` compilation.

5. Conclusion

The "importance", defined as it has been presented, can be understood in two ways – on the one hand, the higher the weight of borders the larger the diversification between regions, which can result in their lower impact on some socio-economic spheres (thus if the "divergence" concept is adopted – a richer region is likely to isolate itself from poorer regions). On the other hand, a significant difference in the level of regional wealth can result in these regions' more intensive impact – poorer region inhabitants seek employment in a richer one, whereas the inhabitants of a richer region go shopping to a "cheaper", poorer region, thus enhancing its development.

It should be considered how the above determined measures for the importance of borders should be used in the sense of GDP quotient or income. It seems that whether the weights of borders are consistent with the designated "importance" measure in the procedure of spatial smoothing should depend on the substantive significance of the smoothed statistical characteristic. In case of such characteristics as population income, unemployment rate, etc., it seems that the border weight should be proportional to the importance measure. It also

seems that apart from the diversification of regional development level the impact intensity is determined by the fact if they belong to the same or to different countries.

Therefore the value of importance measure can be adopted as the weight in the spatial smoothing procedure after correcting it *in minus* for international borders (e.g. multiplying it by the arbitrarily determined number lower than 1).

Further interesting developments of the presented approach – primarily in the context of cohesion policy carried out in the European Union are e.g. the sustainability assessment or changes in the importance of domestic borders for the selected socio-economic variables in dynamic perspective and the assessment of sustainability or changes in the importance of borders between countries for the selected socio-economic variables – dynamically.

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Streszczenie

OCENA WAŻNOŚCI GRANIC GEOGRAFICZNYCH W BADANIACH EKONOMICZNYCH

Długość wspólnej granicy między dwiema jednostkami geograficznymi jest często używana jako podstawowa waga w analizie zależności przestrzennych. Najnowsze propozycje dotyczą m.in. testowania wpływu podziału geograficznego wyższego rzędu na podział niższego rzędu (Markowska i in. 2014; Sokołowski i in. 2013), regionalnej przestrzennej średniej ruchomej oraz nowego współczynnika korelacji przestrzennej (Markowska i in. 2015). W cytowanych pracach nowe metody zilustrowano na przykładach analiz regionów Unii Europejskiej szczebla NUTS 2. Jest oczywiste, że w sensie oddziaływania społeczno-ekonomicznego granice pomiędzy regionami należącymi do różnych państw mają inną ważność niż granice międzyregionalne w ramach tego samego państwa. W niniejszej pracy podano prostą propozycję oceny ważności granic. Należy wziąć jakąś zmienną makroekonomiczną nie wykorzystywaną w aktualnych analizach (np. PKB, śmiertelność niemowląt, wartość HDI) a dostępną na poziomie NUTS 2 i określić lokalną ważność granic dzieląc większą wartość tej zmiennej przez mniejszą dla regionów leżących po obu stronach danej granicy. Następnie rozsądne wydaje się uśrednienie tych ocen ważności dla wewnętrznych granic w każdym z krajów osobno, oraz dla granic międzypaństwowych. Można też wykorzystać oceny ważności bez uśredniania do zbudowania dodatkowego systemu wag.

***Słowa kluczowe**: systemy wagowe, analizy przestrzenne, korelacja przestrzenna*