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REGIONAL DEVELOPMENT AND ITS MEASUREMENT IN VISEGRAD GROUP COUNTRIES

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Abstract

The aim of the paper is to measure regional development and construct an index for the Visegrad Group countries at NUTS 2 level. This index, called the Regional Development Index - the RDI - is created as an extension of the Human Development Index in order to obtain a better composed index at regional level. Twelve socio-economic indicators are selected for this purpose: three economic indicators, three educational indicators, three health variables and three indicators of the standard of living which create four dimensions. These variables are tested for their reliability through the pairwise correlation and the min-max method is used for the construction of the index. The data are compared between 2008 and 2013 and the assumption about worsening the situation in regions after the crisis is set. The results show that the values of the RDI improved in nearly all regions (with the exception of Prague in the Czech Republic and Közép-Magyarország in Hungary) in the monitored years. The assumption that regional development was negatively influenced by economic crisis has not been confirmed.

Keywords: Min-Max method, NUTS 2, Regional Development Index, Visegrad Group countries

INTRODUCTION

Regional or national development is usually measured by indicators such as domestic product, national income, or alternatively by the Human Development Index and the Index of Sustainable Economic Welfare or Gross National Happiness (Van den Bergh, 2009). While getting the data and setting of the above mentioned measurements at national level is not too complicated, the problem arises at the level of a region. Therefore, it is necessary to modify the measurements at this level and to find suitable socio-economic indicators which should contain adequate information. As Rovan & Sambt (2003) claim, the socio-economic issue among regions should be of primary interest to economists as well as politicians and their differences should be maintained within the sustainable limits for the sake of the welfare of the country as a whole. The analysis of these indicators may serve as the basis for development policy at the regional level. The major distinction in most cases is the fact that regions are open spatial entities (in contrast to countries), while the competence of a region may normally be superseded by the nations (Nijkamp & Abreu, 2009).

The aim of this paper is to construct a regional index for selected members of the European Union by the most often used measurement of human development, the HDI, and to compare this regional index in a period before and after the economic crisis. The countries of the Visegrad Group (hereafter V4) at the NUTS 2 level have been chosen for the analysis. This group includes 35 regions in the Czech Republic, Hungary, Poland and Slovakia – eight in the Czech Republic, seven in Hungary, sixteen in Poland and four in Slovakia. The data were obtained and compared for the years 2008 (before the crisis) and 2013 (after crisis). The assumptions that regional development was negatively influenced by economic crisis and the value of the RDI worsened between 2008 and 2013 were defined.

The Regional Development Index (hereafter the RDI) will be created as an extension of the HDI in order to obtain a better composed index at regional level. Thirteen socio-economic indicators will be selected for this purpose: three economic indicators (GDP per capita, R&D expenditure and unemployment), three educational indicators (tertiary educated population, people in lifelong learning and young people neither employed nor educated), three health variables (life expectancy at birth, health personnel – number of doctors and infant mortality) and four indicators of the standard of living (stock of vehicles i.e. – passenger cars, nights spent at tourist accommodation establishments, victims by accidents – killed and municipal waste). These variables will be tested for their reliability through the pairwise correlation and the RDI will be constructed using the min-max method after the selection of the correlated indicators.

Even though this paper is not the first attempt to study the development of (not only) the above mentioned socio-economic indicators, it differs from the existing studies in using more complex concepts of the given issue in the min-max method at the regional NUTS 2 level.

The paper is organized as follows: the second section presents a brief literature review, the third section describes the model and methodology used in the paper. Section four discusses the results in detail and the fifth section concludes the paper.

THEORETICAL BACKGROUND

The selection of indicators used in this paper was inspired by many studies in which the authors confirmed linkages among some indicators.

Firstly, the implementation of the GDP indicator was influenced by Sen´s opinion (Sen, 1999) who considered the income (product) as a primary mean to achieve human development. The relationship between economic growth and unemployment is very well known according to Okun´s law. A further indicator, research and development expenditure (R&D) and its increase is very important for increasing competitiveness (Bočková, 2013). Nevima & Kiszová (2011) claim that gross domestic expenditures on research and development are the sources for further economic growth. According to Hudec & Procházková (2015), the innovative capacity of a region can be considered as its ability to produce and commercialize innovations to drive a long-term economic growth and wealth creation. They examined the regions of the Visegrad countries by considering R&D expenditures by the concept of the knowledge production function (Cobb-Douglas type). The result was that not the capital regions are the most innovative ones, because several Polish regions (Lodzkie and Malopolskie) and Czech regions (Střední Morava and Jihovýchod) belong to the most efficient regions. Similar results were obtained by Kozuń-Cieślak (2016) who used the methods of the composite indicators and the DEA method.

Secondly, higher education and lifelong learning contribute to economic development as well. Florida, Mellander & Stolarick (2008) assert that human capital and the creative class affect regional development through different channels. Whilst the creative class outperforms conventional educational attainment for regional labour productivity, conventional human capital does better for regional income. Positive relation between tertiary graduates and economic growth in Visegrad countries was found in Verner & Chudarkova (2013) as well. The adult education systems (lifelong learning) currently in place tend to reinforce existing economic disparities, with greater frequency of re-skilling and up-skilling by more educated adults, with higher income levels (WEF, 2017).

Thirdly, Michaud & van Soest (2008) claim that in many industrialized countries there is a positive association between health and wealth and population; health tends to rise with the country's level of economic development (Semyonov et al. 2013). In addition, health improvements tend to reduce the mortality rates of infants (Bloom & Canning, 2003). Anand & Bärnighausen (2004) argue that a strong relevance between health personnel and infant mortality exists in more than 80 countries.

Fourthly, Riley (2002) examined the influence of population growth, increased urbanization and economic development on the rapid growth of motor vehicles in China. Medlock & Soligo (2002) did a research on the effect of economic development on the demand (numbers) of the motor vehicles in 28 countries and developed a model of the relationship between economic development and per capita private car ownership. A practical example of relationship between economic development and an amount of vehicles is obvious with Toyota (Toyota, 2017): as the Japanese economy expanded (15% in the period of 1955-1970), the demand for passenger cars in particular grew rapidly, and the sales volume achieved an average annual growth rate of 32 percent. According to Tuan (2011), the gross regional product per capita in Thailand Provinces might have strongly exponential effects on car ownership. Shafik (1994) found out that increasing income indicates the waste generation deterioration. Eugenio-Martin et al. (2004) state that tourism provides two positive effects on economy: on one hand, an increase in production and income; on the other hand, as the tourism sector is labour intensive, it causes an increase in employment. It has certainly exerted a very important economic, productive, and cultural influence (Pérez and Nadal, 2005). Similarly, tourism plays an important role in solving economic and social problems, providing more jobs, initiating the employment growth of economically active population and increasing the welfare of a nation, and at the same time it has a stimulating effect on the development of many related fields of the economy – it contributes to socio-economic development (Gabdrakhmanov & Rubtsov, 2014). Borowy (2013) was dealing with road traffic injuries using the discourse analysis. He explored how development has been (re-)negotiated through the discourse of these injuries and *vice versa.* Gebru (2017) found that a road traffic accident is a human security threat with multifaceted effects on the economy of households and the national economies of states, especially in the developing countries. It affects the national economy of countries and households directly or indirectly because it causes a loss of the economically active population. According to Agbeboh & Osarumwense (2013) accidents cause heavy costs to society especially in case of a loss of able bodied men and women who would have been involved in productive economic activities as a loss of intellectuals, a loss of resources to government and families, a loss to insurance companies and a damage to properties. Road traffic injuries and deaths are a growing public health problems worldwide. Banthia et al. (2006) have shown that road traffic injuries are major causes of death and disability globally, with a disproportionate number occurring in developing countries.

The Human Development Index is primarily a nation level indicator, estimated for a country as a whole (Basu & Basu, 2005), but due to its general nature it cannot be applied by all economies in general. Therefore, many countries have introduced their own modified indexes in order to reflect their local circumstances better (Pagliani, 2010, or Gaye & Jha, 2010). Gnesi et al. (2010) have published the Index of the Regional Quality of Development (QUARS) with the aim of providing a multidimensional measure of the development of Italian regions, based on 41 individual indicators from different sources. The considered dimensions are: Environment, Economy and labour, Rights and citizenship, Health, Education and culture, Equal opportunities, Participation. The composite index is equal to the arithmetic mean of seven macro-indicators, each of which corresponds to the mean of the standardized values of the indicators that compose it.

Some authors analysed human development at regional level using cluster analysis, as in the case of China between 1982 and 2003 (Yang & Hu, 2008) or in Kasim, Fron & Yaqub (2011) regarding the HDI of Iraq in 2006. They divided the regions of the aforementioned economies into four clusters. Akócsi, Bencze & Tóth (2012) analysed the Human Development Index of the Visegrad countries on the ground of knowledge (human) resources in the period of 2002-2007 and used 13 indicators for 35 regions according to an old methodology of the HDI measurement.

Majerova & Nevima (2017) made the cluster analysis with the modified Human Development Index (RNHDI) created for 46 regions of the Visegrad Group Plus countries (countries of the V4 and Slovenia and Austria) at the NUTS 2 level. They used the same methodology as by the HDI: three components were used – the health dimension (life expectancy at birth), the knowledge dimension (tertiary educated people and participation rate in education and training) and the dimension of living standard (GDP per capita in PPS). The authors defined the hypothesis about dynamization of regions (movement from lower to higher cluster/level of development), which was not confirmed.

The above mentioned authors (Nevima & Majerova, 2016) applied factor analysis of human development within the same group of countries as well. Their assumption that the most important factor of human development is economic level, measured by gross domestic product per capita, was not confirmed and was found that the most important role is played by another factor - life-long learning. This finding confirms that education of population is a very important variable of regional as well as national significance.

The closest research to the topic of this paper was done by Hardeman & Dijkstra (2014) who developed a composite indicator which was capable to measure patterns and trends in human development across the EU region in 2012. They chose (only) six reliable indicators out of 22 – healthy life expectancy, infant mortality, NEET, general tertiary education, net disposable income and employment rate, using the min-max model.

OBJECTIVES AND METHODS

This paper investigates the impact of economic crisis on regional development of all regions in the Visegrad Group countries. At first, a sample and variables (as a model) are described and selected through pairwise correlation. Subsequently, they are used in the Regional Development Index by the min-max method (according to UNDP, 2016).

Model

The economic geography of Europe is characterised by wide levels of a number of socio-economic variables that are both a cause and a response to differences in growth and levels of income per capita (Fingleton, 2003). As it has already been mentioned, the Visegrad Group countries (V4) at the NUTS 2 level are analysed. There are 35 regions at this level – eight in the Czech Republic, seven in Hungary, sixteen in Poland and four in Slovakia. The list of the regions in our sample is shown in Table 1.

Table 1 The List of the Regions of the V4

Region	St. name	Region	St. name	Region	St. name
Praha	CZ01	Lódzkie	PL11	Bratislavský kraj	SK01
Střední Cechy	CZ02	Mazowieckie	PL12	Západné Slovensko	SK02
Jihozápad	CZ03	Malopolskie	PL21	Stredné Slovensko	SK03
Severozápad	CZ04	Slaskie	PL22	Východné Slovensko	SK04
Severovýchod	CZ05	Lubelskie	PL31		
Jihovýchod	CZ06	Podkarpackie	PL32		
Střední Morava	CZ07	Swietokrzyskie	PL33		
Moravskoslezsko	CZ08	Podlaskie	PL34		
		Wielkopolskie	PL41		
Közép-Magyarország	HU10	Zachodniopomorskie	PL42		
Közép-Dunántúl	HU21	Lubuskie	PL43		
Nyugat-Dunántúl	HU22	Dolnoslaskie	PL51		
Dél-Dunántúl	HU23	Opolskie	PL52		
Észak-Magyarország	HU31	Kujawsko-Pomorskie	PL61		
Észak-Alföld	HU32	Warminsko-Mazurskie	PL62		
Dél-Alföld	HU33	Pomorskie	PL63		

Source: Eurostat (2017)

As it has been noted, the annual data were obtained from the Eurostat regional database (Eurostat, 2017), which contains data for NUTS 1 to 3 regions. Not all the data are available for all regions of the EU and for each level of classification, so the selection of indicators was rather limited. For the purpose of this paper, thirteen regional socio-economic variables were chosen, the units, codes and relations of which can be found in Table 2. There are three economic indicators (GDP per capita, R&D expenditure and unemployment), three educational ones (tertiary educated population, proportion of people in lifelong learning and young people neither employed nor in education), three health variables (life expectancy at birth, health personnel measured by the number of doctors and infant mortality) and four indicators of the standard of living (stock of vehicles measured by the number of passenger cars, nights spent at tourist accommodation establishments, victims killed by accidents and municipal waste). For the four indicators of standard of living, the three most suitable ones have been chosen. All variables are applied in the years before crisis (2008) and after crisis (2013), for the last year when the data of all the variables in all regions are available.

Since some variables have been listed in absolute values that are not suitable for constructing the composite index, they have to be recalculated and relative indicators are created, adjusting the values for the total population of the respective regions, see column "Unit". Some of the variables are considered to have a positive impact on development and some of them negative. This assumption is tested in the following section and the direction is very important for choosing a proper method of measurement (see in the following part as well).

Table 2 Development indicators (units, codes and direction)

Indicator	Unit	Code	Impact
Gross domestic product	per capita in PPS	GDP	positive
Research and development expenditure	per capita in PPS	RDE	positive
Unemployment rate	% of total active population (age 25-64)	UNP	negative
Tertiary educated people	% of total active population	TEE	positive
Lifelong learning	% of total population	LLL	positive
Young people neither in employment nor in education and training	% of population (age 15-24)	NET	negative
Life expectancy at birth	years	LEB	positive
Health personnel	per 100 thousand inhabitants	HEP	positive
Infant mortality	numbers per 1000 live births	MRT	negative
Stock of vehicles (passenger cars)	per 1000 inhabitants	PSC	positive
Nights spent in tourist accommodation establishment	per 1000 inhabitants	NTS	positive
Victims of accidents	per Mio inhabitants	VOA	negative
Municipal waste	tones per capita	WST	negative

Source: authors´ own processing

The first chosen variable is the **GDP per capita** (GDP). The per capita values reflect the economic level better than absolute values. In contrast to income of households, GDP per capita reflects the economic performance of all entities in the region, so it is more appropriate for the creation of a composite index. The indicator is measured by an artificial European currency unit, the purchasing power standard (PPS). The price differences across countries and regions mean that different amounts of national currency units are needed for the same goods and services. The Purchasing Power Standard (PPS) is a fictive currency unit that removes differences in purchasing power, i.e. different price levels between countries. These parities are obtained as a weighted average of relative price ratios with respect to a homogeneous basket of goods and services, both comparable and representative for each country. Theoretically, one PPS can buy the same amount of goods and services in each country (Eurostat, 2014). The higher values of GDP per capita are associated with higher levels of development.

Intramural **R&D expenditures** (RDE) are all expenditures for R&D performed within a statistical unit or sector of the economy during a specific period, whatever the source of funds (OECD, 2002, p. 108). R&D is an activity involving significant transfers of resources among units, organisations and sectors and especially between government and other actors. The main disadvantage of expressing R&D input series in monetary terms is that they are affected by differences in price levels between countries and over time. It can be shown that current exchange rates often do not reflect the balance of R&D prices between countries and that in times of high inflation general price indices do not accurately reflect trends in the cost of performing R&D. The OECD (2002) recommends using purchasing power parities (PPP) and the implicit gross domestic product (GDP) for R&D statistics, although it is recognized that they reflect the opportunity cost of the resources devoted to R&D rather than the "real" amounts involved. For the purpose of this paper, relative indicator per capita in PPS was used. This indicator is positive for the regional development.

An indicator of **Unemployment** (UNP) by sex, and age in NUTS 2 regions represents all inhabitants aged 25 or over and is expressed as a percentage of active inhabitants in the age of 25-64 years. This age level was chosen to complement the age group used in the indicator NET, i. e. the age group between 15 and 24. This indicator (its high level) has negative effects on regional development, representing a social problem connected with negative effects on economic activities.

The share of **Tertiary educated people** (TEE) in the productive age population of the region is connected with the ability of people (and regions) to reflect the needs of knowledge of economy, and it also reflects the level of human development.

Lifelong learning (LLL) as the percentage of the regional population participating in education and training encompasses all learning activities undertaken throughout life (after the end of initial education) with the aim of improving knowledge, skills and competences, within personal, civic, social or employment-related perspectives (Eurostat, 2017). Due to lifelong learning people extend their possibilities for increasing their incomes, well-being and development. These indicators´ higher values are associated with higher levels of development.

The indicator **Young people neither employed nor in education or training** (NET) corresponds to the percentage of the total population of a given age group (15-24) that is not employed and not involved in further education or training. The age group was selected to complement the age range used for UNP to eliminate too high correlation or autocorrelation. This variable has a negative effect on development.

The **life expectancy at birth (LEB)** reflects the level of health and quality of life and it measures the qualitative aspects of living a healthy life. Its high values are associated with higher levels of human development – the higher the healthy life expectancy of a region, the more developed it is.

The higher values of number of health personnel are associated with higher levels of the economic development as well. **Health personnel** indicator (HEP) includes medical doctors that are active in the health care sector, irrespective of the sector of employment (i.e. whether they are independent, employed by a hospital or any other healthcare provider). The density rates are used to describe the *availability of this kind of medical staff and* expressed as their number per 100,000 inhabitants.

Infant mortality rate (MRT) reflects the number of deaths of children under one year of age per thousand live births. Regional differences in infant mortality may reflect the differences in wealth and spending of healthcare. In our research, the infant mortality rate can be a measure of the health and social condition of the region. It is a composite of a number of component rates, which have their separate relationship with various social factors and can often be seen as an indicator to measure the level of socio-economic diversity within regions.

The indicators of standard of living are stock of vehicles (cars), nights spent in a tourist establishment, amount of waste, and victims of accidents. In this paper, the **Stock of vehicles** represents the number of passenger cars (PSC)[1] per thousand inhabitants in the mentioned regions. *The* number of cars corresponds to the standard of living of the population in the direct proportion; therefore the development impact is positive.

The variable **Nights spent at tourist accommodation establishments** (NST) is calculated as total nights per thousand inhabitants spent by a guest, resident or a non-resident in a region.

[1]Passenger car is presented by road motor vehicle, other than a moped or a motorcycle, intended for the carriage of passengers and designed to seat no more than nine persons (including the driver). Included are: passenger cars, includes micro cars (needing no permit to be driven), vans designed and used primarily for transport of passengers, taxis, hire cars (provided that they have fewer than ten seats), ambulances and motor homes. Excluded are light goods road vehicles, as well as motor-coaches and buses, and mini-buses/mini-coaches (Eurostat, 2017).

Tourist establishments are hotels and similar accommodation, holiday and other short-stay accommodation, camping grounds, recreational vehicle parks and trailer parks. As it has been mentioned, tourism (in this research the capacity utilization of tourist facilities) contributes to the development of a region.

The quantity of waste reflects the differences in economic wealth among regions – wealthier regions usually generate more municipal waste and have a negative impact not only on environment but on development as well. In this paper, **Municipal waste** (WST) expresses the total waste per inhabitant in tons and it consists of waste collected by the municipal authorities, or directly by the private sector (business or private non-profit institutions). The bulk of the waste stream originates from households, though similar wastes from sources such as commerce, offices, public institutions and selected municipal services are included as well. It also contains bulky waste, but excludes waste from municipal sewage networks and municipal construction and demolition waste (Eurostat, 2017).

The last but not least variable is the **Victims of accidents** (VOA) per million inhabitants of the region. For the purpose of our paper the persons killed (any person killed immediately or dying as a result of an injury accident[2], *with the exception of terrorist acts* and suicides), were selected, due to no possibility of their further positive contribution to enhance regional development (through consumption, higher education or lifelong learning etc.). This variable is chosen as a factor with a negative influence.

Methodology

The purpose of this paper is to construct a composite index of regional development using the min-max model (UNDP, 2016). A majority of the previous studies were devoted to analyses of other methods or a narrower range of this index, but a more comprehensive analysis is made in this paper.

Concerning the RDI index, not only the same method as the HDI construction was chosen (with minor deviations, see below), but also the same principle of its creation, i.e. – the component indicators should be assigned the same weight and divided into the relevant dimensions with a positive or negative influence on development. Suitability of selected indicators, weight and impact, was tested through the pairwise correlation analysis, namely

[2]Injury accident is any accident involving at least one road vehicle in motion on a public road or private road to which the public has a right of access, resulting in at least one injured or killed person. It includes *collisions between road vehicles; between road vehicles and pedestrians; between road vehicles and animals or fixed obstacles and with one road vehicle alone. Included are collisions between road and rail vehicles. Multi-vehicle collisions are counted as only one accident provided that any successive collisions happen within a very short time period. Injury accidents exclude accidents incurring only material damage (Eurostat, 2017).*

the Pearson correlation coefficient (UNDP, 2015 or Halásková & Mikušová Meričková, 2017).

When using equal weights, it may happen that – by combining variables highly correlated (above ±0.90) – an element of double counting may be introduced into the index. In response to this problem the indicators are tested for statistical correlation – and then only those indicators are chosen which report a low degree of correlation (but more than ±0.30[3]) or adjusting weights correspondingly, e.g. giving less weight to correlated indicators (OECD, 2002). The results of the pairwise correlation can be seen in Table 3, when both years (2008 and 2013) were tested.

Table 3 Correlation Matrix for 2008 and 2013

2008	*GDP*	*RDE*	*UNP*	*TEE*	*LLL*	*NET*	*LEB*	*HEP*	*MRT*	*PSC*	*NST*	*VOA*	*WST*
GDP	1												
RDE	0.8871	1											
UNP	-0.5513	-0.5330	1										
TEE	0.6113	0.6064	-0.3574	1									
LLL	0.7562	0.7380	-0.6356	0.3797	1								
NET	-0.5625	-0.5549	0.8727	-0.4049	-0.5948	1							
LEB	0.5155	0.5556	-0.7475	0.2680	0.7719	-0.7398	1						
HEP	0.9001	0.8078	-0.3533	0.5019	0.6583	-0.4051	-0.5446	1					
MRT	-0.5960	-0.5578	0.6890	-0.1401	-0.7166	0.5984	-0.0325	-0.4239	1				
PSC	0.2060	0.3110	-0.5794	0.1442	0.4778	-0.5391	0.5959	-0.1827	-0.3784	1			
NST	0.6026	0.6760	-0.2810	0.1897	0.5719	-0.2192	-0.6251	0.6352	-0.4937	0.3309	1		
VOA	-0.5110	-0.5239	0.0667	-0.1465	-0.2708	0.0533	-0.0712	-0.6369	0.1639	0.2463	-0.4666	1	
WST	-0.1062	-0.0880	-0.0287	0.0637	-0.1662	-0.0271	-0.5446	-0.0785	0.0528	0.1897	-0.1405	0.2736	1
2013	*GDP*	*RDE*	*UNP*	*TEE*	*LLL*	*NET*	*LEB*	*HEP*	*MRT*	*PSC*	*NST*	*VOA*	*WST*
GDP	1												
RDE	0.8921	1											
UNP	-0.5574	-0.6155	1										
TEE	0.7401	0.6343	-0.3662	1									
LLL	0.4107	0.5426	-0.5852	0.0792	1								
NET	-0.6295	-0.6565	0.7094	-0.4460	-0.6565	1							
LEB	0.5403	0.6488	-0.5477	0.4645	0.6701	-0.7186	1						
HEP	0.8323	0.8656	-0.3936	0.4900	0.4226	-0.4613	0.4125	1					
MRT	-0.5489	-0.5957	0.6860	-0.2981	-0.6783	0.7263	-0.7102	-0.4239	1				
PSC	0.1546	0.0519	-0.3144	0.3184	0.1753	-0.4396	0.4988	-0.1827	-0.3363	1			
NST	0.5501	0.6182	-0.4607	0.2626	0.3556	-0.3416	0.4004	0.6352	-0.3461	0.1231	1		
VOA	-0.5117	-0.5484	0.1537	-0.0708	-0.2595	0.0585	-0.1460	-0.6369	0.1942	0.3857	-0.4633	1	
WST	-0.0812	-0.1155	0.0866	0.0027	-0.1506	-0.0594	-0.2490	-0.0785	0.0456	0.2042	-0.1373	0.2723	1

Source: author´s own
Note: all correlations are statistically significant at level α=0.05

[3] The values between 0 and ±0.30 are considered as very week, according to Moore et al. (2013).

As shown in the above table, the indicator of waste (WST) reported a very low value (less than ±0.30) in both monitored years, so it does not correlate with any other indicators and has been excluded for further analysis. Even though the indicator VOA showed lower values of correlation in more than half of the cases, it has not been excluded from further analysis (because of higher value of the rest of indicators). Then, 12 indicators with the same weight were left, and four dimensions were created from these indicators, each with three indicators, two positive and one negative, according to the results of correlation (see Table 4).

Table 4 Development indicators (units, codes and direction)

Dimension	Indicators	Index
Economic	GDP (+) RDE (+) UNP (-)	EC
Education	TEE (+) LLL (+) NET (-)	ED
Health	LEB (+) HEP (+) MRT (-)	HE
Standard of living	PSC (+) NST (+) VOA (-)	SL

Source: author´s own

The methodology of constructing a composite index follows the logic of the HDI calculation (UND, 2016 and Hardeman & Dijkstra, 2014). However, the calculation of the new index has to be modified. Firstly, the same values were not used due to the inclusion of minimum values from data corresponding to the low level of development in developing countries. For the higher perceived value of the created RDI index, data (min/max) corresponding to the comparability of the EU regions were selected. Secondly, the modification of the data was also based on the fact that the data used for creation of the HDI index are unavailable at the regional level (available only at national one).

According to the chosen method, it was necessary to define the minimum and maximum values for each indicator in the monitored years. To determine the minima, the worst results of individual indexes from all NUTS 2 regions of the European Union have been chosen, while for the maxima the best ones. One exception was made in case of the GDP per capita, where the second highest value was chosen. The reason for this was easy – the highest values of the GDP per capita are presented in the region of Luxembourg for both monitored years and these values are extremely high, more than 20,000 PPS higher than the second highest value (Hamburg). So the values of the Hamburg region were determined as maxima. The values of indicators, regions and countries are shown in Tab. 5.

Table 5 The minimum and maximum values of indicators

Comp.	2008		2013	
	MIN	MAX	MIN	MAX
GDP	7,500 (Severozapaden, BUL)	52,600 (Hamburg, GE)	7,700 (Severozapaden, BUL)	54,500 (Hamburg, GE)
RDE	6.4 (Severen tsentralen, BUL)	1998.9 (Brabant Wallon, BE)	11.1 (Severen tsentralen, BUL)	3500.2 (Brabant Wallon, BE)
UNP	1.6 (Utrecht, NL)	15.8 (Andalucía, ES)	2.3 (Oberbayern, GE)	33.4 (Andalucía, ES)
TEE	6.7 (Sud-Mutenia, RO)	45.0 (Helsinki-Uusimaa, FIN)	11.4 (Sud-Mutenia, RO)	49.3 (Helsinki-Uusimaa, FIN)
LLL	0.8 (Notio Aigaio, GR)	34.3 (Hovestaden, DK)	0.9 (Severentsentralen, BUL)	35.4 (Hovestaden, DK)
NET	2.4 (Overijssel, NL)	27.1 (Campania, IT)	4.1 (Oberbayern, GE)	33.9 (Severozapaden, BL)
LEB	70.6 (Latvija)	82.3 (Marche, IT)	74.1 (Lietuva)	84.8 (Com. De Madrid, ES)
HEP	127.3 (Flevoland, NL)	831.5 (Attiki, GR)	132.3 (Flevoland, NL)	867.3 (Attiki, GR)
MRT	1.4 (Notio Aigaio, GR)	13 (Sud-Est, RO)	1.3 (Etela-Suomi, FI)	10.3 (Sud-Est, RO)
PSC	109 (Sud-Est, RO)	1,100 (Valle D´Aosta, IT)	167 (Sud-Est, RO)	1,051 (Valle D´Aosta, IT)
NST	450 (Nord-Est, RO)	48,691 (Tirol, AT)	487 (Nord-Est, RO)	62,552 (Notio Aigaio, GR)
VOA	16 (Wien, AT)	204 (Prov. Luxembourg, BE)	10 (Wien, AT)	159 (Alentejo, PT)

Source: Eurostat (2017)

To determine various indices, two types of calculations were used: index for variables with positive direction (1)

$$V_{index} = \frac{(V_{real} - V_{\min})}{(V_{\max} - V_{\min})} \tag{1}$$

and index for variables with negative direction (2)

$$V_{index} = \frac{(V_{real} - V_{\max})}{(V_{\min} - V_{\max})}, \tag{2}$$

where V_{index} is the respective value of the 12 component indicators, V_{real} is a real value, V_{min} is a minimum value and V_{max} is a maximum value. The values of the sub-indexes EC, ED, HE and SL are calculated as the arithmetic means of the three component values of the dimension (3)

$$V_{s-i} = \frac{V_{i,1} + V_{i,2} + V_{i,3}}{3}. \qquad (3)$$

The principle of the Regional Development Index is calculated as the geometric mean of all the above indices, as shown in (4)

$$RDI = \sqrt[4]{EL \cdot ED \cdot HE \cdot SL}. \qquad (4)$$

The required data for calculations of the RDI are listed in the Appendix I and II, the values of the components are shown for the years 2008 and 2013. 2008 was the year before the crisis in the EU and 2013 is the year after it (for which the latest data are available for all the indicators and all the countries). Decreasing values of RDI within regions were expected in the monitored period.

RESULTS AND DISCUSSION

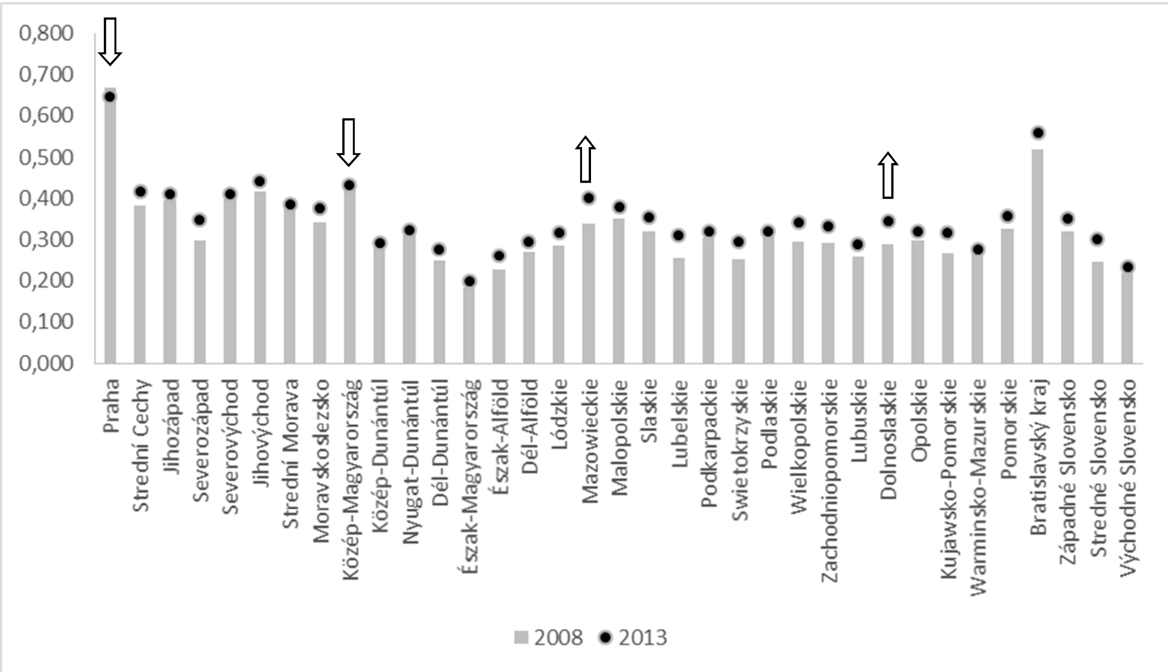
Four dimensions of regional development were used for the research – an economic index, an education index, a health index and a standard of living index. The component values of socio-economic indicators in the indexes were calculated as coefficients according to the min-max method with equal weights. These dimensions were then converted into the index RDI using a geometric mean. The sub-indexes and the composite index RDI are presented in Appendix I for the year 2008 and Appendix II for the year 2013.

The results are as follow: Firstly, the obtained values of the RDI are, with the exception of the regions of the capitals in the Czech Republic and Slovakia (Praha and Bratislavský kraj), very low taking into account the index interval of ‹0;1›. The first mentioned region reached the value above 0.6 in both monitored years, the second region more than 0.5. The rest of the regions have the values from 0.183 (Észak-Magyarország in 2008) to 0.441 (Jihovýchod in 2013). Disparities exist not only among countries, but among regions of every country as well. The biggest differences were among the regions of Slovakia (the difference between the highest and the lowest value is greater than the index value for the least developed region), followed by the regions of the Czech Republic and Hungary. The most stable values of the

RDI were found in Poland, but here the capital region does not have an outstanding value either.

Secondly, if we observe the differences between years 2008 and 2013 (see Figure 1), we can see worsening of the index values in two regions - Praha and Közép-Magyarország (arrows pointing down), the value of the RDI remained the same or improved in the rest of the regions. The largest improvement of this index was recorded in the regions Mazowiecke and Dolnoslaskie (arrows pointing up), both in Poland. Generally, the regions of Poland achieved larger improvements from 2008 to 2013 than other regions of the V4 countries and no region worsened its position from the viewpoint of the regional human development.

Figure 1 RDI in the Visegrad Group in 2008 and 2013



Source: author´s own

A comparison of the development of the RDI values from the perspective of individual economies is shown in Table 6. The highest values of the index were achieved in the regions with capitals in both monitored periods (with the exception of Poland in 2008, where the region around Krakow showed the best results). On the other hand, the border regions (with the exception of the region in central Poland in 2008) showed the lowest values of RDI index. The Czech Republic than achieved the best results, followed by Slovakia and Poland, the worst results on average achieved the Hungarian regions.

Looking at changes between 2008 and 2013, they are regionally different in the monitored economies – while the most developed border region in the Czech Republic improved most positively, the smallest change in the index was even negative. On the contrary, the smallest improvement showed the least advanced region in Slovakia, the highest improvement reached the Polish region with the capital. On average, the highest average change occurred Slovakia and Poland between 2008 and 2013, while Hungary improved the RDI index at least.

Table 6 The summary of RDI values by country and region

RDI values/Country	Czech Republic	Slovakia	Hungary	Poland
2008				
Highest RDI value	0.668 Praha	0.520 Bratislavský kraj	0.440 Közép-Magyarország	0.352 Malopolskie
Lowest RDI value	0.299 Severozápad	0.217 Východné slovensko	0.183 Észak-Magyarország	0.251 Swietokrzyskie
Average RDI value	0.412	0.326	0.284	0.295
2013				
Highest RDI value	0.646 Praha	0.558 Bratislavský kraj	0.432 Közép-Magyarország	0.402 Mazowieckie
Lowest RDI value	0.347 Severozápad	0.233 Východné Slovensko	0.200 Észak-Magyarország	0.275 Warminsko-Mazurskie
Average RDI value	0.429	0.361	0.297	0.330
Change from 2008 to 2013 (RDI 2013-RDI 2008)				
Highest change of RDI	0.048 Severozápad	0.055 Stredné Slovensko	0.034 Észak-Alföld	0.065 Mazowieckie
Lowest change of RDI	-0.006 Střední Morava	0.016 Východné Slovensko	0 Közép-Dunántúl, Nyugat-Dunántúl	0 Podlaskie
Average change of RDI	0.017	0.035	0.013	0.035

Source: own calculation

CONCLUSION

The aim of the paper was to construct a regional index for the Visegrad Group countries at NUTS 2 level. 35 regions of the Czech Republic, Hungary, Poland and Slovakia were chosen for this purpose. The data were obtained for the years 2008 (before the crisis) and 2013 (after the crisis).

The Regional Development Index, RDI, was built as an extension of the Human Development Index in order to obtain a more complex index at regional level. Therefore, twelve socio-economic indicators were selected: three economic indicators (GDP per capita, R&D expenditure and unemployment), three educational (tertiary educated population, people in lifelong learning and young people neither employed nor in education), three health variables (life expectancy at birth, health personnel measured by number of doctors and infant mortality) and three indicators of the standard of living (stock of vehicles measured by passenger cars, nights spent at tourist accommodation establishments, and victims killed by accidents). These variables were tested for their reliability by pairwise correlation and then the RDI was constructed using the min-max method.

The results revealed huge disparities among countries and among regions. The most developed ones are two capital regions – in the Czech Republic (Prague) and in Slovakia (Bratislavský kraj), in contrast to the least developed regions Észak-Magyarország (Hungary) and Východné Slovensko (Slovakia). The values of the RDI improved between 2008 and 2013 in nearly all the regions (with the exception of Prague in the Czech Republic and Közép-Magyaroszág in Hungary). The assumptions that regional development was negatively influenced by economic crisis, and the value of the RDI worsened between 2008 and 2013, have not been confirmed.

The method of computation, namely, that minimum and maximum values used for the normalisation of data were defined based on all the NUTS 2 regions of the EU, make the computed RDI values of the V4 countries comparable to similarly computed RDI values of all NUTS 2 regions of the EU in the selected years.

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Appendix I Sub-indexes and Index RDI in 2008

Country (Region)/Index	EC	ED	HE	SL	RDI
Czech Republic					
Praha	0.787	0.648	0.785	0.496	0.668
Stredni Cechy	0.450	0.412	0.501	0.230	0.383
Jihozápad	0.410	0.432	0.548	0.250	0.394
Severozápad	0.285	0.224	0.435	0.289	0.299
Severovýchod	0.382	0.399	0.540	0.305	0.398
Jihovýchod	0.404	0.449	0.591	0.284	0.418
Strední Morava	0.357	0.397	0.555	0.295	0.390
Moravskoslezsko	0.308	0.320	0.457	0.308	0.343
Hungary					
Közép-Magyarország	0.473	0.501	0.484	0.328	0.440
Közép-Dunántúl	0.319	0.354	0.303	0.215	0.293
Nyugat-Dunántúl	0.339	0.339	0.385	0.243	0.322
Dél-Dunántúl	0.192	0.234	0.387	0.224	0.250
Észak-Magyarország	0.117	0.208	0.166	0.279	0.183
Észak-Alföld	0.157	0.241	0.320	0.219	0.227
Dél-Alföld	0.227	0.336	0.298	0.232	0.270
Poland					
Lódzkie	0.291	0.393	0.327	0.177	0.285
Mazowieckie	0.402	0.512	0.411	0.153	0.337
Malopolskie	0.321	0.396	0.418	0.290	0.352
Slaskie	0.308	0.382	0.304	0.292	0.320
Lubelskie	0.227	0.380	0.332	0.149	0.256
Podkarpackie	0.238	0.351	0.395	0.258	0.304
Swietokrzyskie	0.234	0.375	0.381	0.120	0.251
Podlaskie	0.273	0.422	0.407	0.219	0.318
Wielkopolskie	0.315	0.381	0.338	0.190	0.296
Zachodniopomorskie	0.215	0.351	0.355	0.270	0.292
Lubuskie	0.275	0.306	0.324	0.162	0.258
Dolnoslaskie	0.254	0.379	0.280	0.255	0.288
Opolskie	0.282	0.353	0.346	0.226	0.297
Kujawsko-Pomorskie	0.223	0.343	0.329	0.200	0.267
Warminsko-Mazurskie	0.245	0.346	0.338	0.194	0.273
Pomorskie	0.314	0.384	0.369	0.253	0.326
Slovakia					
Bratislavský kraj	0.619	0.582	0.707	0.287	0.520
Západné Slovensko	0.319	0.314	0.398	0.267	0.321
Stredné Slovensko	0.157	0.275	0.378	0.223	0.245
Východné Slovensko	0.144	0.236	0.266	0.245	0.217

Source: author´s own

Appendix II Sub-indexes and Index RDI in 2013

Country (Region)/Index	EC	ED	HE	SL	RDI
Czech Republic					
Praha	0.705	0.643	0.764	0.501	0.646
Strední Cechy	0.431	0.448	0.499	0.314	0.417
Jihozápad	0.421	0.436	0.509	0.300	0.409
Severozápad	0.335	0.292	0.420	0.351	0.347
Severovýchod	0.375	0.448	0.509	0.332	0.411
Jihovýchod	0.439	0.464	0.572	0.323	0.441
Strední Morava	0.373	0.384	0.476	0.320	0.384
Moravskoslezsko	0.357	0.402	0.445	0.309	0.375
Hungary					
Közép-Magyarország	0.465	0.460	0.476	0.342	0.432
Közép-Dunántúl	0.347	0.324	0.270	0.244	0.293
Nyugat-Dunántúl	0.371	0.310	0.348	0.268	0.322
Dél-Dunántúl	0.304	0.268	0.250	0.282	0.275
Észak-Magyarország	0.264	0.206	0.095	0.308	0.200
Észak-Alföld	0.262	0.244	0.305	0.237	0.261
Dél-Alföld	0.297	0.282	0.363	0.245	0.294
Poland					
Lódzkie	0.323	0.391	0.303	0.264	0.317
Mazowieckie	0.467	0.548	0.408	0.250	0.402
Malopolskie	0.340	0.414	0.424	0.342	0.378
Slaskie	0.356	0.406	0.307	0.349	0.353
Lubelskie	0.307	0.405	0.357	0.208	0.310
Podkarpackie	0.281	0.307	0.388	0.316	0.321
Swietokrzyskie	0.279	0.386	0.334	0.213	0.296
Podlaskie	0.310	0.427	0.359	0.217	0.318
Wielkopolskie	0.371	0.379	0.318	0.309	0.343
Zachodniopomorskie	0.327	0.340	0.327	0.336	0.332
Lubuskie	0.324	0.292	0.274	0.269	0.289
Dolnoslaskie	0.352	0.385	0.318	0.329	0.345
Opolskie	0.320	0.348	0.348	0.267	0.319
Kujawsko-Pomorskie	0.301	0.331	0.344	0.292	0.316
Warminsko-Mazurskie	0.292	0.299	0.266	0.247	0.275
Pomorskie	0.349	0.415	0.371	0.306	0.358
Slovakia					
Bratislavský kraj	0.664	0.571	0.683	0.375	0.558
Západné Slovensko	0.331	0.307	0.393	0.378	0.351
Stredné Slovensko	0.265	0.291	0.361	0.293	0.300
Východné Slovensko	0.232	0.268	0.181	0.262	0.233

Source: author´s own