Spatial Features of the Distribution of Educational Potential and Investment in Innovation in the Regions of Central and Eastern Europe

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Abstract

Over the past decades, significant structural changes have occurred in European countries' labour markets. In this work, the following goals were set: to study the spatial features of the distribution of the educational potential of the economically active population; to analyse the investment in innovation on the example of the countries of Central and Eastern Europe; to study the development of regional markets and to identify the role of innovative enterprises in the formation of spatial regimes and regional clusters. The research methodology uses Eurostat data, spatial econometrics and statistics methods, cluster analysis methods, and time series. The article considers the problems of the spatial distribution of the educational potential of the economically active population in the NUTS 2 regions for 6 CEE countries over a long period. Conclusion: Based on the application of models of spatial econometrics, an analysis of the relationship between the educational potential of the economically active population and investments in innovations was carried out, the role of innovations and the development of regional labour markets were studied, regional disproportions and insufficient flexibility of regional markets to socioeconomic challenges were identified.

Keywords: spatial econometrics; regional policy; innovations; clusters; educational potential; labour market
JEL classification: I25; C38

Paper type: Research article
Received: 24 January 2023
Accepted: 27 April 2023

DOI: 10.54820/entrenova-2023-0015

Acknowledgements: The paper is the output of a scientific project, "International of academic entrepreneurship: innovative technologies for research, education and business".

Introduction

Over the past decades, significant structural changes have taken place in the labour markets in the developed countries of Europe and post-transformation or former socialist countries. The historically important political transformations of the late 1980s and early 1990s (O'Neill, 1995 and Castells, 1996) and the active migration of the population, mostly of working age, from the countries of Eastern Europe to the West led to new challenges for the European economy that the European Union faced before its enlargement in 2004 (Ciechański, 2003, Lisbon Strategy evaluation document, 2010). Among the flows of migrants, a fairly large part were people with higher education who could not always find a job in their speciality and found their jobs in the labour markets of Western and Central Europe (Beneva, Dubrovina, 2013).

A new economic and social policy of the European Union, which was presented and formulated in the Lisbon Agreement and other key EU documents, aimed at increasing the competitiveness of the economies of the EU countries through innovation and a higher educational level of human resources (Burger, 2016, World Bank, 2018). These policy documents of the EU and WB emphasised the role of higher education, and they focused on the importance of the need to ensure greater access for young people to receive adequate education, increase the mobility of labour resources, and close connection of educational programs with trends in labour markets (Ballarino et al., 2013, Bal-Domańska, Sobczak, 2018).

At the same time, as is known from the analysis of the situation in the EU countries, not all the tasks presented in the Lisbon Strategy have been successfully implemented. These problems were noted in the European Commission report entitled Progress towards the Lisbon Objectives in Education and Training. Indicators and benchmarks (European Commission, 2008). Many approaches to solving the problem of employment and ensuring the competitiveness of labour resources need to be more clearly coordinated both in the EU countries and in those countries with which the EU is most actively cooperating in the framework of cross-border programs (Dubrovina, 2012, Beneva et al., 2013, Brunello et al., 2016). As it was noted in many documents and reports of the European Commission, the mentioned problems led to the need to revise the employment policy and ensure greater openness of labour markets for migrants, primarily from countries – "new members" of EU or candidate countries to accession (Beneva, Dubrovina, 2013, Bal-Domańska, Sobczak, 2018).

It should be noted that the focus on the study of these problems led to the appearance of numerous publications. In a brief review of some papers and reports, we demonstrate the different approaches for the study of educational potential, factors adjusted to its formation and the impact of educational potential on economic growth and development.

As is shown in many studies, the level of regional development, measured as income per capita, plays an important role in the formation and support of need educational potential (O'Neill, 1995; Dubrovina, 2012; Beneva et al., 2013; Brunello et al., 2016, Bal-Domańska, Sobczak, 2018, Jerrim et al., 2019, Schnepf et al., 2019). Inequality in socioeconomic development and weak institutional support of good public education lead to the poor achievements of some groups of populations with relatively low levels of income (World Bank, 2018; Schnepf et al., 2019). Thus, regional income per capita should be considered an important factor in the analysis of educational potential.

In addition, it is important to study the situation in regional markets in connection with new challenges. In some papers related to these topics, the changes in social policy addressed education, innovation and employment of the economically active population of the EU countries were defined (Dubrovina et al., 2013; Beneva et al.,

2013; Madelin, Ringrose, 2016, World Bank, 2018, Bal-Domańska, Sobczak, 2018). For example, the identification of spatial effects in the distribution of socioeconomic indicators was made and characteristics of the level of development of countries and individual regions were described for the 6 CEE countries (Dubrovina, 2012); the importance of the development of a regional policy to improve socioeconomic characteristics was highlighted and possible programs to solve the problem of employment in depressed regions were discussed (Dubrovina, 2012, Beneva et al., 2013, Ballarino et al., 2013, Bal-Domańska, Sobczak, 2018).

The next important challenge in the contemporary period is the expansion of education, postgraduate, and continuous and lifelong learning. For example, in a paper presented by Ballarino et al. (Ballarino et al., 2013), the expansion of participation in education and its drivers separately for each level (lower secondary, upper secondary, tertiary) were discussed. These authors used ESS data for 26 European countries to analyse the process of expansion of participation to three levels of schooling in Europe, from the cohort born in the 20s to the one born in the first half of the 80s. They considered economic, political and social factors to test sociological theories stressing path dependency as the main driver of educational expansion (Ballarino et al., 2013). In research carried out by Bal-Domańska and Sobczak (2018), the study focused on the relationship between educational potential and the labour market. The authors defined educational potential as the resource of knowledge and skills in the region expressed by the level of formal education, the scientific potential, and the tendency to continue to improve qualifications. In this paper, the authors studied the capacities of the labour market for young people who enter the labour market after obtaining formal education. In the research, the authors used the spatial autocorrelation of educational potential and assessed the situation of young people in the cross-section of the NUTS - 2 European Union regions in 2016 (Bal-Domańska, Sobczak, 2018).

Despite the expansion of educational capacities, the actual problem, which is especially emerging after the global economic crisis in contemporary labour markets, is related to acute competition and the need for appropriate knowledge and skills of candidates for different positions and occupations. The report from the World Bank focused on the problem of skills and Europe's labour market and took a look at the skills divide and how gaps in skills play a large role in explaining the growing divide between people (World Bank, 2018.). Other papers also indicated the problem of improving dual education with wide access to innovative technologies in practice, training of employees and implementation of programs for human resource development (Burger, 2016; Madelin and Ringrose, 2016; Urbancová et al., 2021).

At the same time, it is necessary to increase the role of vocational education and training to support their strong relations with modern technologies and innovations. As mentioned in the report prepared by Cedefop, "European VET is becoming more diverse in its programmes and qualifications and also expanding into higher levels, challenging the perception of higher education as exclusively academically oriented. In some countries, this reflects a step towards making lifelong learning a reality; in others, traditional VET is coming under pressure from declining youth cohorts and a growing preference for general education and training. Such negative developments can be seen as a forewarning of future challenges" (Cedefop, 2020, p.4).

Thus, taking into account the actual problems of the study of educational potential and its relation with investments in innovations, in this work, the following goals were set: to study the spatial features of the distribution of the educational potential of the economically active population on the example of the countries of Central and Eastern Europe; to analyse the investment in innovation on the example of the

countries of Central and Eastern Europe; to study the development of regional markets and to identify the role of expenditures on R&D and innovative enterprises in the formation of spatial regimes and regional clusters.

Methodology

In the article, the educational potential of the economically active population in the NUTS2 regions for 6 CEE countries (Germany, Austria, Poland, Slovakia, Czech Republic and Hungary) is studied for a long period. The educational potential is described by the structure of the economically active population with one or another maximum achieved level of education. There are three main levels: ED02 - the proportion of the economically active population with incomplete (primary) and secondary levels of education; ED34 - the proportion of the economically active population with education above secondary but not higher; ED56 or (ED 58 in later data from Eurostat) is the proportion of the economically active population with first, second and third levels of higher (tertiary) education. The data about educational potential were collected from Eurostat from 2000 to 2020, and for statistical elaboration, Excel, Statistica and R were used. In total, 84 NUTS2 regions were analysed for each year in this sample.

In our research, we tried to continue the ideas of our previous research (Dubrovina, 2012; Dubrovina et al., 2013; Beneva et al., 2013) and studies of the quantitative analysis carried out by other authors (Kopczewska, 2006, Suchecki, 2010, Bal-Domańska, Sobczak, 2018). In this paper, the research methodology is based on the use of spatial econometrics and statistics methods, cluster analysis methods, and time series.

The article considers the problems of the spatial distribution of the educational potential of the economically active population in the NUTS2 regions for 6 CEE countries (Germany, Austria, Poland, Slovakia, Czech Republic and Hungary) over a long period from 2000 to 2020. Several reasons adjusted the selection of the mentioned countries: at first, we focused on the comparative analysis of educational potential in well-developed countries of the EU, "old members", and in "new members" or post-soviet countries, where long period for transformation was observed; at second, these countries have to join borders, and it allows to apply methods of spatial statistics and econometrics; at third, due to the visual analysis of maps on regional level and elaboration of statistical data and shape files in R, it is possible to reveal the effects of surrounding regions, "hot" and "cold" spots, spatial regimes, etc. Some of the time series for investments in R&D included complete data from 2017 or earlier, but it was enough for the understanding of tendencies and current situations in these regions of 6 CEE countries.

In the first stage of our research, we used linear trend models to analyse the dynamics of the educational potential in 6 countries of CEE and their aggregated regions. In this stage, we also calculated the basic characteristics for the descriptive statistics and found the coefficients of variance for educational potential at the regional level in 6 countries of CEE. For the linear trend models, the estimations of parameters such as intercept (a0) and slope (a1) were obtained, and coefficients of correlation (R) were calculated. The second stage of the analysis was related to the calculation of Moran I coefficients for spatial autocorrelation, the study of spatial regimes, and cluster analysis for the distribution of educational potential in the regions of 6 CEE countries, which are recommended to be carried out. In the third stage of research, we tested spatial econometric models such as the spatial lag model (SPM) and the spatial error model (SEM). The methods of spatial statistics and econometrics are described in many articles and books and demonstrate the development of the

ideas of Paelinck, Moran, Geary, Cliff, Anselin, Kelejian, Prucha, etc., in modern research (Kopczewska, 2006, Suchecki, 2010, Dubrovina, 2010, 2012, Dubrovina et al., 2013, Bal-Domańska, Sobczak, 2018, etc.).

It should be noted that for many regional studies where econometric methods are used, spatial econometric models were more applicable than multiple regression. Due to the specifics of many processes that characterise interregional relations and the effects of neighbouring regions, errors in simple regression models will not have the property of independence. In these models, there will be a significant autocorrelation of errors caused by one or another socioeconomic specificity of spatial data. Given the spatial autocorrelation of errors, the use of the ordinary least squares (OLS) method leads to incorrect estimates of the model parameters (Kopczewska, 2006; Suchecki, 2010).

The key factor in the consideration of spatial data is the study of the topology of the studied regional objects, which is possible with the use of geo-information systems (GIS) and electronic maps. Based on this information, a "weight matrix" is built, the elements of which can be determined on the basis of the following principles: 1) the presence or absence of common borders of the region with other regions; 2) the presence or absence of the regions nearest neighbours-regions at a given distance (Kopczewska, 2006).

Moran spatial autocorrelation coefficient (Moran I) is calculated according to the formula with the application of a weight matrix (Kopczewska, 2006; Suchecki, 2010). If coefficient Moran I > 0, we can observe positive spatial autocorrelation, i.e. in general, the values of observations in neighbouring regions (regional environment) are similar. If Moran I < 0, we suggest negative autocorrelation, i.e. in general, the values of observations in neighbouring regions (regional environment) have mostly opposite values than in certain regions. If Moran I is equal to 0, values of observations in neighbouring regions are randomly distributed (Kopczewska, 2006; Suchecki, 2010).

In the model specifications with spatial effects (SLM or SEM), the parameters are estimated using the maximum likelihood method or the generalised method of moments. In addition, hypotheses are tested that the parameters differ significantly from zero. To compare and select the most adequate model, the values of the Akaike and Bayes information criteria are used (Kopczewska, 2006; Suchecki, 2010; Dubrovina, 2010).

Results

As some recent studies show, this problem of the analysis of educational potential is especially relevant for the countries of Central and Eastern Europe, where the most acute are the issues of border and cross-border migration of the economically active population, especially young people and middle-aged people, with different levels of education and professional skills. The ongoing economic and social regional policy in these countries does not sufficiently take into account structural imbalances in labour markets and emerging trends, which is manifested in poor adaptation of labour markets to current and future changes (Dubrovina, 2012; Ballarino et al., 2013, Bal-Domańska, Sobczak, 2018, etc.).

In the EU countries, there are rather large country have regional disproportions in the distribution of labour potential with different levels of education (Beneva et al., 2013; Jerrim et al., 2019; Schnepf et al., 2019).

The first stage of the research was devoted to the analysis of time series for dynamics of indicators of educational potential on a regional level for 6 countries of CEE. We used three main indicators: ED02 - the proportion of the economically active population with incomplete (primary) and secondary levels of education; ED34 - the

proportion of the economically active population with education above secondary but not higher; ED56 or (ED 58 in later data from Eurostat) is the proportion of the economically active population with first, second and third levels of higher (tertiary) education. The relevant data from Eurostat was used from 2000 to 2020, and the linear trend models were tested. In the mentioned models, the estimations of intercept (a0) and slope (a1) were obtained, and coefficients of correlation (R) were calculated. The estimation of intercept indicates the adjusted level of the indicator for 2000, and the estimation for slope shows the annual change of this indicator.

In Tables 1-6, the results of the estimations for parameters and correlation coefficients are given for indicators ED02, ED34, and ED58 for 6 countries of CEE.

In Table 1, the results mentioned for Slovakia are shown. As it is clearly seen, over a long period, from 2000-2020, the tendencies of reduction of indicators ED02 and ED34 were observed, while indicator ED58 demonstrated a strong increase over this period. The highest values for intercept and slope were obtained for the Bratislava region, and low values for slope were observed for the West and Middle parts of Slovakia. Bratislava region attracts more students to the tertiary education system due to the numerous universities and higher schools. Also, the concentration of the intellectual elite is higher in the Bratislava region, where the different government institutions and international companies are located, and the living standards for inhabitants are higher.

Table 1
Estimations for the Parameters and Coefficients of Correlation in Linear Trend Models for Educational Potential in Slovakia and its Regions

	Less than primary, primary and lower secondary education (levels 0-2)			**Upper secondary and post-secondary non-tertiary education (levels 3 and 4)**			**Tertiary education (levels 5-8)**		
	a0	a1	R	a0	a1	R	a0	a1	R
Slovakia	14,11	-0,37	-0,92	76,61	-0,46	-0,89	9,28	0,83	0,99
Bratislavský kraj	9,3	-0,31	-0,96	67,91	-0,81	-0,97	22,8	1,12	0,98
Západné Slovensko	15,18	-0,5	-0,93	77,61	-0,25	-0,68	7,23	0,75	0,99
Stredné Slovensko	15,09	-0,42	-0,93	76,27	-0,32	-0,89	8,65	0,73	0,99
Východné Slovensko	14	-0,21	-0,7	79,38	-0,69	-0,9	6,67	0,89	0,98

Source: Author's work

In Table 2, the estimations for parameters and correlation coefficients are given for indicators ED02, ED34, and ED58 in Hungary. As we can see, from 2000-2020, the proportion of the economically active population with primary and secondary education was described as decreasing. However, concerning the indicator ED34, the increasing tendencies were noted in three regions: Dunántúl, Alföld és Észak and Dél-Alföld, while this indicator in the capital region, Közép-Magyarország, has decreasing tendency. The arguments for these tendencies are proper: in industrial and agricultural regions Dunántúl, Alföld és Észak and Dél-Alföld, a lot of different industrial enterprises, factories, plants, agricultural holdings and small farmer companies are concentrated, where the proportion of workers is relatively high. However, in the capital region, Közép-Magyarország, the tendency to increase the proportion of the economically active population with tertiary education is strong.

Table 2
Estimations for the Parameters and Coefficients of Correlation in Linear Trend Models for Educational Potential in Hungary and its Regions

	Less than primary, primary and lower secondary education (levels 0-2)			Upper secondary and post-secondary non-tertiary education (levels 3 and 4)			Tertiary education (levels 5-8)		
	a0	a1	R	a0	a1	R	a0	a1	R
Hungary	28,05	-0,75	-0,96	58,4	0,07	0,29	13,54	0,68	0,99
Közép-Magyarország	20,46	-0,68	-0,94	59,09	-0,36	-0,79	20,44	1,04	0,98
Dunántúl	29,39	-0,76	-0,97	59,65	0,23	0,72	10,95	0,53	0,98
Alföld és Észak	32,29	-0,75	-0,94	56,8	0,29	0,81	10,93	0,46	0,99
Dél-Alföld	31,75	-0,94	-0,96	57,67	0,35	0,88	10,6	0,58	0,98

Source: Author's work

Table 3 shows the estimations for parameters and coefficients of correlation given for linear trend models for indicators ED02, ED34 and ED58 in Czechia. In all regions of Czechia, we can see a reduction in the values of ED02 and ED34 and a strong increasing tendency for ED58 for the period of 2000-2020. The leading region in the growth of the proportion of economically active population with tertiary education is Praha, where the oldest and well-recognised HEIs research institutions and large international companies are concentrated, and the attractiveness of this region for inhabitants and foreigners is well-known.

Table 3
Estimations for the Parameters and Coefficients of Correlation in Linear Trend Models for Educational Potential in Czechia and its Regions

	Less than primary, primary and lower secondary education (levels 0-2)			Upper secondary and post-secondary non-tertiary education (levels 3 and 4)			Tertiary education (levels 5-8)		
	a0	a1	R	a0	a1	R	a0	a1	R
Czechia	12,55	-0,37	-0,96	77,78	-0,41	-0,89	9,69	0,79	0,99
Praha	5,64	-0,17	-0,94	71,92	-1,07	-0,97	22,41	1,24	0,98
Střední Cechy	15,48	-0,63	-0,88	77,92	-0,29	-0,56	6,59	0,92	0,98
Jihozápad	11,91	-0,33	-0,93	79,35	-0,28	-0,85	8,76	0,62	0,98
Severozápad	17,91	-0,3	-0,94	76,65	-0,18	-0,65	5,46	0,48	0,93
Severovýchod	11,98	-0,32	-0,96	80,29	-0,34	-0,86	7,73	0,66	0,98
Jihovýchod	11,56	-0,39	-0,96	77,96	-0,46	-0,9	10,49	0,85	0,98
Střední Morava	13,12	-0,42	-0,95	78,45	-0,24	-0,69	8,42	0,67	0,97
Moravskoslezsko	13,49	-0,36	-0,98	78,47	-0,32	-0,89	8,09	0,68	0,98

Source: Author's work

In Table 4, the estimations for parameters and correlation coefficients are given for indicators ED02, ED34, and ED58 in Poland. Here, the dynamics of the mentioned indicators are similar to those of the Czech Republic, the leading region in the formation of a proportion of the economically active population with tertiary education, which is Mazowecke voivodship with capital in Warsaw. In addition, we can see relatively higher estimations for slope in the linear trends for the dynamics of

ED58 in the regions in Poland than in regions in Slovakia, Czech Republic or Hungary. It should be noted that in Poland, the tendencies of the rapid growth of higher educational institutions were observed in the last three decades, and a lot of well-educated migrants arrived from Ukraine, Belarus, Russia, and other former republics of the USSR.

Table 4
Estimations for the Parameters and Coefficients of Correlation in Linear Trend Models for Educational Potential in Poland and its Regions

	Less than primary, primary and lower secondary education (levels 0-2)			Upper secondary and post-secondary non-tertiary education (levels 3 and 4)			Tertiary education (levels 5-8)		
	a0	a1	R	a0	a1	R	a0	a1	R
Poland	19,03	-0,65	-0,98	69,86	-0,45	-0,97	11,09	1,1	1
Makroregion Poludniowy	15,82	-0,59	-0,95	73,89	-0,54	-0,96	10,27	1,14	1
Makroregion Pólnocno-Zachodni	18,76	-0,61	-0,98	71,09	-0,33	-0,94	10,19	0,94	0,99
Makroregion Poludniowo-Zachodni	18,17	-0,63	-0,97	71,6	-0,48	-0,9	10,2	1,12	0,99
Makroregion Pólnocny	21,48	-0,64	-0,99	68,6	-0,34	-0,93	9,92	0,97	1
Makroregion Centralny	21,78	-0,74	-0,98	66,96	-0,23	-0,91	11,23	0,98	1
Makroregion Wschodni	21,51	-0,75	-0,98	67,48	-0,27	-0,89	10,99	1,02	1
Makroregion Województwo Mazowieckie	17,15	-0,63	-0,97	67,4	-0,84	-0,99	15,43	1,47	0,99

Source: Author's work

The estimations for parameters and coefficients of correlation for indicators ED02, ED34 and ED58 in Austria are presented in Table 5.

Table 5
Estimations for the Parameters and Coefficients of Correlation in Linear Trend Models for Educational Potential in Austria and its Regions

	Less than primary, primary and lower secondary education (levels 0-2)			Upper secondary and post-secondary non-tertiary education (levels 3 and 4)			Tertiary education (levels 5-8)		
	a0	a1	R	a0	a1	R	a0	a1	R
Austria	22,55	-0,44	-0,99	65,86	-0,65	-0,84	11,6	1,09	0,94
Ostösterreich	21,59	-0,36	-0,98	65,73	-0,88	-0,89	12,72	1,23	0,94
Südösterreich	20,1	-0,43	-0,95	69,68	-0,55	-0,77	10,24	0,98	0,93
Westösterreich	25,18	-0,54	-0,99	63,7	-0,41	-0,75	11,12	0,96	0,93
Wien	20,68	-0,22	-0,93	62,88	-1,12	-0,95	16,4	1,34	0,96

Source: Author's work

In the case of Austria and its regions, we can observe the decreasing tendencies in the dynamics of indicators of ED02 and ED34. For the dynamics of ED58, the tendency is increasing, and the highest estimations for intercept and slope are observed for the capital region with the centre in Wien.

In Table 6, the estimations for parameters and coefficients of correlation for indicators ED02, ED34 and ED58 are presented for Germany and its federative lands.

Table 6
Estimations for the Parameters and Coefficients of Correlation in Linear Trend Models for Educational Potential in Germany and its Regions

	Less than primary, primary and lower secondary education (levels 0-2)			Upper secondary and post-secondary non-tertiary education (levels 3 and 4)			Tertiary education (levels 5-8)		
	a0	a1	R	a0	a1	R	a0	a1	R
Germany	17,12	-0,21	-0,8	60,14	-0,16	-0,64	22,74	0,38	0,96
Baden-Württemberg	20,42	-0,36	-0,84	55,39	-0,1	-0,37	24,18	0,46	0,96
Bayern	19,31	-0,47	-0,91	58,94	-0,1	-0,42	21,73	0,57	0,97
Berlin	17,16	-0,2	-0,93	51,98	-0,36	-0,88	30,84	0,56	0,93
Brandenburg	6,44	0,04	0,38	62,98	0,07	0,27	30,58	-0,11	-0,5
Bremen	23,69	-0,23	-0,66	57,42	-0,34	-0,77	18,88	0,57	0,95
Hamburg	19,32	-0,24	-0,83	57,53	-0,49	-0,94	23,15	0,73	0,97
Hessen	17,44	-0,13	-0,5	58,6	-0,28	-0,8	23,97	0,41	0,95
Mecklenburg-Vorpommern	9,63	-0,14	-0,58	62,64	0,24	0,7	27,73	-0,1	-0,51
Niedersachsen	17,38	-0,15	-0,57	63,85	-0,21	-0,6	18,76	0,36	0,93
Nordrhein-Westfalen	20,38	-0,15	-0,8	60,85	-0,28	-0,87	18,78	0,42	0,97
Rheinland-Pfalz	19,76	-0,23	-0,81	60,37	-0,22	-0,61	21,37	0,47	0,92
Saarland	21,25	-0,32	-0,8	63,04	-0,14	-0,38	15,75	0,46	0,88
Sachsen	4,61	0,01	0,07	63,55	0,07	0,28	31,83	-0,07	-0,32
Sachsen-Anhalt	8,53	-0,07	-0,35	65,29	0,24	0,8	26,17	-0,17	-0,75
Schleswig-Holstein	15,94	-0,22	-0,84	63,76	-0,05	-0,23	20,3	0,27	0,87
Thüringen	7,09	-0,13	-0,56	63,41	0,22	0,63	29,53	-0,09	-0,41

Source: Author's work

This case is very interesting because, in the different lands, we can observe increasing or decreasing tendencies for all three indicators. It should be noted that for some lands, the tendencies of ED02, ED34 or ED58 changes have relatively lower coefficients of correlation than in the cases of the regions from other countries. In addition, we can see that initial adjusted values (intercept) of ED58 in mostly federal lands in Germany are higher than in many regions from other mentioned countries of CEE. However, the estimations of the slope are lower than in the cases of other countries; some of the estimations for the slope in the tendencies of ED58 are negative. The possible explanation of the variety in the tendencies of the indicators for a description of educational potential may be related to the large number of low-skilled migrants – refugees from African and Asian countries, or to the essential differences between East part of Germany (Former DDR) and West part of Germany, labour migrants from Poland and other countries of Eastern Europe. Nevertheless, the relatively low estimations for slope can be explained by strict criteria for enrolment of students to public universities in Germany and a relatively small number of private domestic HEIs, which are not popular among youth who plan to obtain relevant positions in the governmental sector or large international companies.

Thus, the study of the tendencies in the dynamics of education potentials in regions of 6 CEE countries highlights the importance of the analysis of spatial features in the distribution of the indicators ED02, ED34 and ED58. Then, we created the maps with the spatial distribution of educational potential in NUTS2 regions of 6 CEE countries in 2017. The data in this regional database were statistically elaborated in R, and four quartiles were calculated to group the regions. The lightest area in the maps means regions in the first quartile, with essentially lower values of indicators, while the darkest area means regions with much higher values, which belong to the fourth quartile.

For the analysis of spatial autocorrelation, Moran I coefficients were calculated. Coefficients Moran I were equal in 2017: 0,5503 for indicator ED02, 0,3596 for ED34 and 0,1198 for ED58. Thus, the middle (moderate) level of spatial autocorrelation is observed for the distribution of economically active populations with primary, secondary and upper secondary, but not higher education. In contrast, the value of the Moran I coefficient for the proportion of economically active population with tertiary education is relevantly low, which means that spatial autocorrelation is weak and spatial distribution of the indicator ED58 is close to random.

In this research, we suggest that educational potential has a relationship with the indicator GERD (general expenditure on research and development), which influences innovations and implementation of new technologies, enhancement of education and training, scientific achievements, etc. The spatial distribution of these indicators was studied for 2012 and 2017, and the Moran plot was used for the analysis of outliers. The values of coefficients Moran I for GERD in 2012 and 2017 were very close to each other and equal to 0,3844. Thus, middle autocorrelation in spatial indicators exists. As typical outliers, we can reveal such regions in Germany as Schwaben, Freiburg, Stuttgart, and Braunschweig.

As a spatial econometric model for the analysis of the influence of changes in the educational potential for ED34 and ED58 on change in GERD per inhabitant in NUTS2 regions in 6 CEE countries, we used the spatial error model (Tab.7).

Table 7

Estimations for the Parameters and Tests for Spatial Error Model

Coefficients	**(asymptotic standard errors)**			
	Estimate	Std. Error	z	value Pr(>|z|)
(Intercept)	23.4540	2.9051	8.0735	66.661e-16
DED34_12_17	5.8468	2.3171	2.5104	0.012059
DED58_12_17	5.5378	1.8893	2.9312	0.003377
Lambda: -0.40973	LR test value: 4.7835		p-value: 0.028734	
Asymptotic standard error: 0.17316	z-value: -2.3663		p-value: 0.017969	
Wald statistic: 5.5992			p-value: 0.017969	
Log-likelihood: -404.6928 for error model				
ML residual variance (sigma squared): 868.29, (sigma: 29.467)				
AIC: 819.39, (AIC for lm: 822.17)				

Source: Author's work

The changes in the values of indicators were calculated from 2012 to 2017. As is seen from Table 7, all estimations of parameters are statistically significant at level $p<0,05$. The estimation for parameter Lambda in the additional equation for errors in the model is negative and statistically significant. It means that spatial "shocks" should be taken into account for the analysis of the relationship between changes in proportions of economically active population with upper than secondary education

(DED34) and with tertiary education (DED58) with the changes of general expenditure on R&D per inhabitant (DGERD).

According to other characteristics and tests, this spatial error model (SEM) may be used for the analysis of the relationship between the indicators: the changes in educational potential and changes in expenditures on research and development. In this model, it is possible to analyse the effects of outliers (regions), where the real values were significantly distant from expected values in the models, and some important specific changes in the surrounding environment ("spatial shocks") should be studied in more detail.

Discussion

The research provided in this article can be developed later, and some important additional problems of the influence of the surrounding socioeconomic and political environment may be analysed in more detail.

Thus, the proposed framework is useful in understanding the educational potential and its relationship with labour markets in the EU. Besides, it is necessary to consider the socioeconomic and political features of the heterogeneous development of the EU markets during the last decades. The problems of the analysis of convergence or divergence appeared as the actual direction of research, and a series of different studies should be conducted from 2000 to 2020.

As an additional direction for study, it is necessary to analyse the influence of COVID-19 and other modern challenges in the turbulent geo-politics environment on the educational potential, innovations, and reaction of regional and national labour markets on the different contemporary shocks (Blaskó et al., 2021).

In a more detailed, study, it will be reasonable to analyse the spatial regimes and changes in the clusters described by the educational potential of the economically active populations in NUTS 2 regions of 6 CEE countries and to test the effects of spatial features and exogenous factors demonstrated the relationship between educational potential, specialisation of economically active population, innovations and capital investments from public and business sector with using panel data and more complicated specifications of the econometric models.

Conclusion

The calculations using the methods of spatial statistics showed the non-random nature of the spatial distribution of the educational potential of the economically active population in the NUTS2 regions of 6 countries of Central and Eastern Europe (Austria, Czech Republic, Germany, Hungary, Poland and Slovakia).

Significant disproportions in the distribution of indicators of the educational potential of economically active populations are explained by both regional and country specifics. In the spatial distribution of indicators of the educational potential of economically active populations, phenomena of moderate spatial autocorrelation are observed.

Regions with higher rates of educational potential of economically active populations are surrounded by their kind, i.e. regions with higher values of this indicator. The spatial nature of the distribution of a number of key indicators characterising the state of labour markets and the peculiarities of their development leads to the need to use the apparatus of spatial econometrics. These methods make it possible to take into account both the influence of neighbouring regions and the shocks arising in them on the state and development trends of regional markets.

The constructed econometric models for the CEE regions, taking into account regional spatial effects, make it possible to adjust the regional strategies of individual countries not only by taking into account their development scenarios but also by studying possible situations in the regions of other countries.

Investments in research and development, the concentration of innovative companies and enterprises focused on the implementation of new technologies, and well-qualified and skilled staff have a strong relationship with the educational potential of the economically active population, the dominant role of human resources with tertiary education and well-trained workers with post-secondary and dual education. Prospects of development and introduction of the programs focused on the development of human resources depend not only on separate national programs but also on coordination of target capital investments in joint European projects on improvement of educational potential structure, interregional, cross-border and trans-border cooperation, enhancement of employment with consideration for new challenges and capacities in the regional markets.

References

1. Bal-Domańska, B., Sobczak, E. (2018). Educational Potential and the Situation of the Youth on the Labour Market in the European Union Regions. Jedlicka W.P. et al.(Red.), Hradec Economic Days Vol. 8(1). Proceedings part. I of the international scientific conference Hradec Economic Days 2018 (ss. 20–31). University of Hradec Kralove.
2. Ballarino G., Meschi E., Scervini F. (2013). The expansion of education in Europe in the 20th Century. AIAS, GINI Discussion Paper 83. – 61 p.
3. Beňová E., Dubrovina N., Goncharenko M., Dubrovina V. (2013). Regional Disparities in Distribution of Educational Potential of Economically Active Population in the Countries of the Central and Eastern Europe / In: Verejná správa a regionálny rozvoj: Ekonómia a manažment.- Roč. IX, č.1(2013), s. 23-35.
4. Blaskó Z., Da Costa P., Schnepf S.V. (2021). Learning Loss and Educational Inequalities in Europe: Mapping the Potential Consequences of the COVID-19 Crisis. Discussion paper series, IZA. DP No. 14298. – 36 p.
5. Brunello, G, Weber, G and Weiss, CT (2016). Books are forever: early life conditions, education and lifetime earnings in Europe. The Economic Journal 127(600): 271–296.
6. Burger, K (2016). Intergenerational transmission of education in Europe: do more comprehensive education systems reduce social gradients in student achievement? Research in Social Stratification and Mobility 44: 54–67.
7. Castells, M. (1996). The Rise of the Network Society, The Information Age: Economy, Society and Culture, Vol. I. Cambridge, MA and Oxford, UK: Blackwell.
8. Ciechański J. (2003). Otwarta metoda koordynacji w Unii Europejskiej. Wyd. Naukowe „Scholar". – 92 s.
9. Cedefop (2020). Vocational education and training in Europe, 1995-2035: scenarios for European vocational education and training in the 21st century. Luxembourg: Publications Office of the European Union. Cedefop reference series; No 114. – 260 p.
10. Dubrovina N. A. (2012). Models of regional and spatial effects in economic development of countries of the Central and Eastern Europe. In Лібермановські читання – 2012: економічна спадщина та сучасні проблеми: Монографія / Під заг. ред. д-ра екон. наук, проф. Пономаренка В. С., д-ра екон. наук, проф. Кизима М. О. – Х.: ВД «ІНЖЕК», 2012. – 82-110 с.
11. Ekonometria przestrzenna (2010). Metody i modele analizy danych przestrzennych. Pod red. B.Sucheckiego. Warszawa, Wydawnictwo C.H.Beck, 2010. 360 s.
12. Jerrim, J, Volante, L, Klinger, DA, et al. (2019) Socio-econcomic inequality and student outcomes across education systems. In: L Volante, SV Schnepf, J Jerrim, et al. (eds) Socioeconomic Inequality and Student Outcomes: Cross-National Trends, Policies and Practices. Singapore: Springer.

13. Kopczewska K. (2006). Ekonometria i statystyka przestrzenna. Wydanie I, Warszawa, 2006. – 162 s.
14. Lisbon Strategy evaluation document (2010). Comission staff working document. SEC (2010) 114. Brussels, 2.2.2010.
15. Madelin R., Ringrose D. (2016). Opportunity now: Europe's mission to innovate. European Comission. – 348 p.
16. O'Neill, D. (1995) Education and income growth: implications for cross-country inequality, Journal of Political Economy, 103(6), pp. 1289-1301.
17. Progress towards the Lisbon Objectives in Education and Training. Indicators and benchmarks (2008). Commission staff working document. Commission of the European Communities. Brussels, 2008. - 232 pages.
18. Schnepf, SV, Klinger, DA, Volante, L, et al. (2019) Cross-national trends in addressing socioeconomic inequality in education. In: L Volante, SV Schnepf, J Jerrim, et al. (eds) Socioeconomic Inequality and Student Outcomes: Cross-National Trends, Policiesand Practices. Singapore: Springer.
19. Urbancová, H.; Vrabcová, P.; Hudáková, M.; Petru, G.J. (2021). Effective Training Evaluation: The Role of Factors Influencing the Evaluation of Effectiveness of Employee Training and Development. Sustainability 2021,13, 2721.
20. World Bank (2018). Education in the EU: Diverging Learning Opportunities? Washington, DC. World Bank.
21. World Bank (2018). World Development Report 2018: Learning to Realise Education's Promise. Washington, DC. World Bank.
22. Бенева Е., Гончаренко М.Ф., Дубровина Н.А., Дубровина В.А. (2013). Влияние образовательного потенциала экономически активного населения на развитие региональных рынков труда в странах Центральной и Восточной Европы // Сучасні концепції прогнозування розвитку складних соціально-економічних систем: монографія / За ред. О.І.Черняка, П.В.Захарченка. – Бердянськ: Видавець Ткачук, 2013. – С. 242-264.
23. Дубровина Н.А. (2010). Применение методов пространственной эконометрики в региональных исследованиях//Материалы Международной научно-практической конференции 27-28 мая 2010 г. Бизнес Информ. Харьков. ИД «ИНЖЭК», № 5(2), 2010. С.12-16.
24. Дубровина Н.А., Бенева Е., Дубровина В.А. (2013). Тенденции изменения образовательного потенциала экономически активного населения в странах Центральной и Восточной Европы // Collections of Materials of the 2nd International Scientific Conference "Problems and Prospects of Territories' Socio-Economic Development" (April 25-29, 2013, Opole, Poland). - Berdyansk: Publishing Tkachuk, 2013. - P.78-80.
25. Дубровина Н.А., Охотницкий П. (2012). Применение моделей пространственной эконометрики для исследования процессов конвергенции ВВП на душу населения в регионах Центральной и Восточной Европы //Просторова економіка: концепції, моделі та регіональні аспекти: Монографія /За заг. ред. П.В. Захарченка, Т.П. Несторенко. Бердянськ. Вид. Ткачук, 2012. – С. 40-55.

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