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Original Scientific Article

Regional Differences in the Human Resource Conditions in the European Union

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Abstract: *In recent years, the pandemic crisis generated challenges for countries highlighting serious economic structural problems. Significant social and economic development differences remain not only between countries but also within countries. There is a consensus among economists that human resources are one of the most important factors in countries to realize technological progress and improve competitiveness, which aims to moderate income disparities. The income and technological inequalities between regions can be derived from differences in human resources, which also prevent the improvement of competitiveness and economic growth. This research aims to illustrate the inequalities of human resource conditions in the NUTS-2 level regions of the European Union. Using the latest version of the Regional Competitiveness Index and the Regional Innovation Scoreboard, the regional differences in human resources by innovation performance groups are analyzed with multivariate statistical methods to identify the critical human factor(s) that affect the region's competitiveness and innovation performance. The improvement of these factors can be essential to moderate regional inequalities in the European Union.*

Keywords: *Human resources, Regional disparities, Regional competitiveness, Innovation, European Union.*

JEL Classification O15 · O31

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1. INTRODUCTION

In recent years the pandemic highlighted increasing regional differences despite that the European Union's regional policy aims to reduce disparities between the European regions by catching up the underdeveloped areas. Lukovics (2009) pointed out that regional disparities cannot be measured only with the GDP per capita, a complex indicator based on competitiveness can be used to identify which factors cause the regional inequalities. As the OECD (2023) formulated, a competitive region can attract and maintain successful firms, and skilled labour and maintain or increase standards of living for the region's inhabitants. The pyramidal model of regional competitiveness contains research and technological development, as well as human capital as development factors of regional competitiveness (Lengyel, 2000). The relationship between innovation, human capital, and regional competitiveness was analysed by Golejewska (2013b) who concluded that innovation and human capital have a growing impact on regional competitiveness. In the era of the Fourth Industrial Revolution, the role of human factors is more appreciated, and the regional adaptation to digital challenges can be the main driver of reducing regional disparities in the European Union. Despite supporting the digital adaptation of regions, as Balakrishnan et al. (2022, p. 19) also pointed out, regional disparities in Europe increased in recent years due to the pandemic. The authors concluded that the convergence had stopped between countries pre-pandemic, but was still progressing within countries. In addition, the major part of the level of disparities across regions can be attributed to disparities in regional productivity. The pandemic effect depends on the sectoral specialisation, differs from region to region, and may exacerbate regional disparities (Hudecz et al., 2020). After the pandemic, the concept of sustainable regional competitiveness became more important emphasizing that not only economic but also social and environmental factors need to be considered (Dziembała, 2021). According to Dziembała (2021), the economic dimension of sustainable competitiveness including the education and human capital factor is fundamental for economic growth. The role of human resources in regional development is also emphasized by Jašková and Havierniková (2020), Saleh et al. (2020), Affandi et al. (2019), Gennaioli et al. (2013), Golejewska (2013a), Faggian and McCann (2009) and Kokuytseva and Ovchinnikova (2020).

This study analyses the regional differences in the field of human resources in the European Union using the Regional Competitiveness Index 2.0. After the pandemic crisis, the methodology of the Regional Competitiveness Index (RCI) was revised, and it revealed a remarkable spatial pattern across EU regions. The analysis involves the indicators of basic and higher education, as well as digital skills, in addition to the different forms of employment that are important for competitiveness in the digital era. The human conditions of regions will be compared by regional innovation performance groups using the Regional Innovation Index to highlight what is the critical human area that has to be improved to realize a more competitive regional economy. The correlation between the Regional Innovation Index and the Regional Competitiveness Index is strong and positive (the correlation coefficient is 0.8663). Because of this strong relationship, the categorization of regional innovation performance groups can be used to analyse the differences in the human resource conditions at the regional level. Two hypotheses are formulated related to our analysis.

Hypothesis One: Comparing the human resource conditions of European regions by innovation performance groups, we assume that there is a significant difference in all fields that are related to human resources, not only in basic and higher education but also in innovation-related employment.

Hypothesis Two: Analysing the regional differences in human resources in the European Union, it is assumed that those human factors that are required by innovation in the era of the Fourth Industrial Revolution differentiate better the innovation performance groups.

2. DATABASE AND METHODOLOGY

The analysis refers to the regional differences in human resources in the European Union using the Regional Competitiveness Index and Regional Innovation Index. The Regional Competitiveness Index measures the major factors of competitiveness for all the NUTS-2 level regions across the European Union. The latest version of RCI 2.0 is a set of indicators classified into three sub-indices – Basic, Efficiency, and Innovation – and 11 pillars. The Basic sub-index refers to the basic drivers of all types of economies, it contains Institutions, Macroeconomic stability, Infrastructure, Health, and Basic education pillars. The Efficiency sub-index includes three pillars, such as Higher education, training and lifelong learning, Labour market efficiency, and Market size. The innovation sub-index focuses on the drivers of improvement at the most advanced stage of economic development, it contains Technological readiness, Business sophistication, and Innovation pillar. Based on Dijkstra et al. (2023) one of the main findings of the RCI 2022 was that the capital regions tend to be the most competitive ones within the Member States, except for three countries, Germany, Italy, and the Netherlands where the capital regions are not the most competitive. In most countries, the gap between the capital city region and the remaining regions is particularly wide, especially in France, Spain, Portugal, and many of the eastern EU Member States. The best-performing region based on the 2022 edition of the RCI was the region of Utrecht (Netherlands), followed by Zuid-Holland (Netherlands) and the French capital region of Île-de-France. In the TOP 10, there were 5 regions of the Netherlands, 2 regions of Belgium, and one region of France, Sweden, and Denmark. The bottom 10 regions are related mainly to Romania (6 regions) while there were two regions from the worst performing ones in Bulgaria and Greece. Comparing the RCI and its components over time, it can be concluded that the less developed regions are catching up. The performance improved not only in Basic, but also in the Innovation sub-index, and a clear process of catching-up was observed in regions located in the eastern and southern EU Member States.

The analysis focuses on human resources, so 13 variables are selected from the RCI which are related to basic education, higher education and lifelong learning, technological readiness, and innovation-related employment to measure the regional differences in the 234 regions of the European Union. The variables are as follows:

- *Basic education* (3): low achievement in reading, maths, and science (15-year-olds);
- *Higher education and lifelong learning* (5): higher educational attainment, lifelong learning, early school leavers, university accessibility, lower-secondary completion only;
- *Technological readiness* (1): individuals with above-basic overall digital skills;
- *Innovation* (4): core creative class employment, knowledge workers, human resources in science and technology, employment in technology and knowledge-intensive sectors.

In the case of basic education, the variables whose source is the PISA test are measured at the country level so there are no regional differences within countries. 5 variables from the 13 such as low achievement in reading, maths, and science, early school leavers, and lower-secondary completion only are measured in reverse scale. There are missing values related to some variables, in these cases, there are no imputations.

The regional economic performance can be measured from the aspect of innovation which is a key element in both competitiveness and growth. Like the European Innovation Scoreboard (EIS), innovation performance can be measured at the regional level. The Regional Innovation Scoreboard (RIS) which is a regional extension of the EIS, provides a comparative assessment of the factors related to innovation across European regions. It is not surprising that the most innovative regions are typically in the most innovative countries. Based on the Regional Innovation Index

2023 created from the Regional Innovation Scoreboard to measure the overall innovation performance, the most innovative region in Europe is Hovedstaden in Denmark, followed by Helsinki-Uusimaa in Finland, Ober-Bayern in Germany, Stockholm in Sweden, and Berlin in Germany. Using the Regional Innovation Index (RII) which is created from the RIS, the EU's regions can be classified into four innovation performance groups:

- *Regional innovation leaders* (performing more than 125% above the EU average),
- *Regional strong innovators* (performing between 100% and 125% of the EU average),
- *Regional moderate innovators* (performing between 70% and 100% of the EU average),
- *Regional emerging innovators* (performing below 70% of the EU average).

According to RIS, 30 regions are innovation leaders, 66 regions are strong innovators, 74 regions belong to moderate innovators, and 64 regions are emerging innovators (the classification of the regions is in the appendix).[3]

To analyse the differences in human resources across EU regions grouped by innovation performance, parametric and non-parametric tests can be used. Firstly, the normal distribution of variables is tested using the Kolmogorov-Smirnov test. If a variable has a normal distribution, ANOVA is used to compare means of more than two innovation performance groups, in contrast, in the lack of normal distribution, the Kruskal-Wallis test can be run. The Levene test is used to test homoscedasticity which is another prerequisite of the ANOVA. If equal variances are not assumed, Welch's test is used to compare means instead of the classical F test related to ANOVA. In the case of independent two samples, like innovation performance group by pairs, a t-test can be run if there is a normal distribution and the Mann-Whitney U test in the case of lack of criteria. Using these hypothesis tests we got a comprehensive picture of significant differences between innovation performance groups at the regional level in selected human resource factors.

3. EMPIRICAL RESULTS

Firstly, the selected variables related to human resources are compared to highlight the differences between regional innovation performance groups. We separate the reverse-scaled variables from the normal indicators, the comparison can be seen in Figure 1.

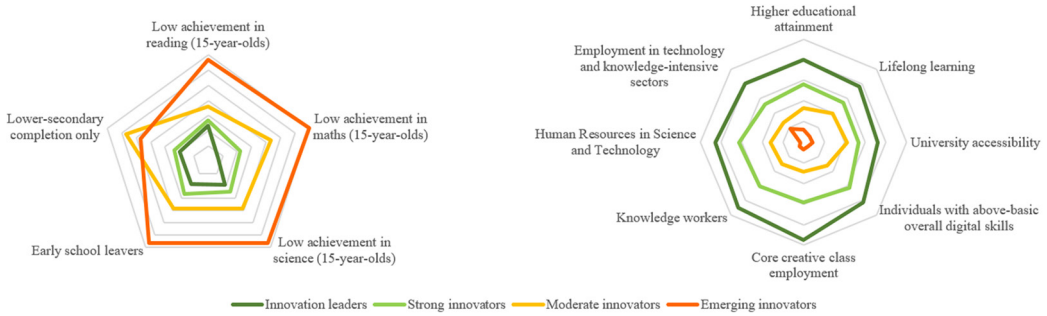

Figure 1. The difference between the EU's regional innovation performance groups in the field of human resources

Source: Own construction based on RCI (2022) and RIS (2023)

[3] The number of regions are not equal in the RCI and in the RIS. The RCI contains 234 regions, while the RIS includes 239 regions. The difference is come from mainly the different region categorization of Austria, Belgium and France. The other source of difference is that the RCI manages the capital region with their commuting zone. Cyprus, Estonia, Latvia, Luxembourg and Malta are included at the country level in both database.

Figure 1 shows that in the field of higher education and innovation-related employment, there can be significant differences between regional innovation performance groups. Regional innovation leaders' advantage is the highest in core creative class employment and knowledge workers while in the field of lifelong learning and university accessibility, both strong and moderate innovators approach them. Moderate innovators lag behind strong innovators in the variable of individuals with above-basic overall digital skills and higher educational attainment. There is no huge difference between moderate and emerging innovators in employment in technology and knowledge-intensive sectors but they lag behind leaders and strong innovators. In the case of reverse-scaled variables, there is a surprising difference between innovation leaders and strong innovators with low achievement in maths. In lower-secondary completion only, the performance of moderate innovators is worse than emerging innovators.

In the next step of the analysis, the normality of variables is tested by the Kolmogorov-Smirnov test, but there are only two variables that have normal distribution, higher educational attainment and knowledge workers. In the case of normal distribution, ANOVA is used, in other cases, the Kruskal-Wallis test is run to compare the means of the variable to show significant differences between regional innovation performance groups (see Table 1).

Table 1. The results of the Kolmogorov-Smirnov tests, ANOVA, and the Kruskal-Wallis tests in comparing regional innovation performance groups

Variable	***Test of normality***		***Comparing means***	
	Test statistic	**Sig.**	**Test statistic**	**Sig.**
Low achievement in reading (15-year-olds)	,236	,000	9,907	,019
Low achievement in maths (15-year-olds)	,221	,000	54,832	,000
Low achievement in science (15-year-olds)	,251	,000	20,902	,000
Higher educational attainment	*,057*	*,065*	35,836*	,000
Lifelong learning	,118	,000	92,782	,000
Early school leavers	,113	,000	14,913	,002
University accessibility	,151	,000	73,895	,000
Lower-secondary completion only	,149	,000	14,919	,002
Individuals with above-basic overall digital skills	,072	,005	100,491	,000
Core creative class employment	,085	,000	126,237	,000
Knowledge workers	*,040*	*,200*	74,185*	,000
Human Resources in Science and Technology	,062	,032	121,334	,000
Employment in technology and knowledge-intensive sectors	,111	,000	74,239	,000

***** ANOVA is used because the variable has normal distribution and homoscedasticity (tested by the Levene test)

Source: Own calculations based on RCI (2022) and RSI (2023)

Using ANOVA and the Kruskal-Wallis test to compare the means of four innovation performance groups, there is a significant difference in all fields. It is not surprising because human factors affect both competitiveness and innovation. In the case of basic education, the difference is quite the same between groups with low achievement in reading and science, while innovation leaders' performance is about 20%, and the emerging innovators' ratio is 26%. In the case of low achievement in math, the ratios are higher and the difference is greater between groups, innovation leaders' performance is about 40%, and the ratio is 50% in emerging innovator regions. There is a huge difference in LLL, adult participation in lifelong learning is fourfold in innovation leaders than in emerging innovators. There is also a significant difference in individuals with above-basic overall digital skills, while innovation leaders' performance is 150.64 % of the EU average, emerging innovators realize only 63.35%. In the field of innovation-related employment, the difference between best and worst-performing regions is about double, but the difference in employment in technology and knowledge-intensive sectors is threefold.

Because of the comparison which can be seen in Figure 1, it is worth comparing means of innovation performance groups by pairs that fit the order. Table 2 shows the results of t-tests if the variable has a normal distribution and Mann-Whitney tests in the case of lack of normality.

Table 2. The results of the t-tests and the Mann-Whitney tests in comparing regional innovation performance groups by pairs

Variable	*Comparing means between innovation leaders and strong innovators*		*Comparing means between strong and moderate innovators*		*Comparing means between moderate and emerging innovators*	
	Test statistic	**Sig.**	**Test statistic**	**Sig.**	**Test statistic**	**Sig.**
Low achievement in reading (15-year-olds)	-3,024	,002	-5,593	,000	-7,156	,000
Low achievement in maths (15-year-olds)	-,483	**,629**	-1,131	**,258**	-1,847	**,065**
Low achievement in science (15-year-olds)	-2,847	,004	-4,929	,000	-2,002	,045
*Higher educational attainment**	3,296	,002	3,875	,000	3,787	,000
Lifelong learning	-3,146	,002	-3,415	,001	-3,382	,001
Early school leavers	-1,854	**,064**	-2,365	,018	-7,016	,000
University accessibility	-1,431	**,153**	-1,743	**,081**	-1,816	**,069**
Lower-secondary completion only	-3,375	,001	-2,271	,023	-4,991	,000
Individuals with above-basic overall digital skills	-,522	**,602**	-3,621	,000	-1,227	**,220**
Core creative class employment	-2,824	,005	-5,214	,000	-3,882	,000
*Knowledge workers**	5,301	,000	6,200	,000	4,471	,000
Human Resources in Science and Technology	-4,940	,000	-5,944	,000	-4,178	,000
Employment in technology and knowledge-intensive sectors	-4,170	,000	-5,730	,000	-4,939	,000

* t-test is used because the variable has a normal distribution

Source: Own calculations based on RCI (2022) and RSI (2023)

When means are compared by pairs using the t-test and the Mann-Whitney test, there is no significant difference in some cases. The indicators of low achievement in maths (15-year-olds) and university accessibility are specific because all comparison by pairs shows that there is no significant difference between paired regional innovation performance groups. The difference is not significant in individuals with above-basic overall digital skills between innovation leaders and strong innovators, as well as between moderate and emerging innovators. There is no significant difference in early school leavers between innovation leaders and strong innovators.

4. FUTURE RESEARCH DIRECTIONS

This analysis is the starting point of a complex comparison in the field of human resources among European regions. We can conclude that there is a strong relationship between human factors, innovation, and regional development, the regional disparities can be explained by differences in human resources. In the future, it is worth creating a complex indicator for measuring the human resource conditions and trying to group the regions in two dimensions, such as economic innovation and human conditions.

5. CONCLUSION

In recent years the regional disparities increased in Europe despite the accelerated digital adaption due to the pandemic. This study tries to illustrate the regional differences in human resource conditions which are important for both innovation and economic growth. Using the Regional Competitiveness Index and Regional Innovation Scoreboard human factors, i.e. basic and higher education, lifelong learning, digital skills, and innovation-related employment are compared between innovation performance groups. There is a significant difference in all selected human factors, the following innovators mainly lag behind in mathematical competencies related to basic education, participation in lifelong learning, individuals above-basic overall digital skills, and employment in technology and knowledge-intensive sectors. This analysis focuses on education, technological readiness, and innovation-related employment, we can conclude that there is a higher difference between innovation leaders and followers in the human factors which are required by innovation.

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APPENDIX

Table 1. The classification of regions by country based on the innovation performance using RII

INNOVATION LEADERS (30)			
Region name	Country Name	Region name	Country Name
Vienna and its commuting zone	Austria	Köln	Germany
Burgenland	Austria	Hovedstaden	Denmark
Brussels and its commuting zone	Belgium	Midtjylland	Denmark
Antwerpen	Belgium	Nordjylland	Denmark
Limburg (BE)	Belgium	Helsinki-Uusimaa	Finland
Oost-Vlaanderen	Belgium	Ile-de-France	France
West-Vlaanderen	Belgium	Gelderland	Netherlands
Prague and its commuting zone	Czechia	Utrecht	Netherlands
Berlin and its commuting zone	Germany	Zuid-Holland	Netherlands
Stuttgart	Germany	Noord-Brabant	Netherlands
Karlsruhe	Germany	Limburg (NL)	Netherlands
Tübingen	Germany	Stockholm	Sweden
Oberbayern	Germany	Östra Mellansverige	Sweden
Mittelfranken	Germany	Sydsverige	Sweden
Hamburg	Germany	Västsverige	Sweden
STRONG INNOVATORS (66)			
Region name	Country Name	Region name	Country Name
Kärnten	Austria	Syddanmark	Denmark
Steiermark	Austria	País Vasco	Spain
Oberösterreich	Austria	Com. Foral de Navarra	Spain
Salzburg	Austria	Comunidad de Madrid	Spain
Tirol	Austria	Cataluña	Spain
Vorarlberg	Austria	Länsi-Suomi	Finland
Hainaut	Belgium	Etelä-Suomi	Finland
Liège	Belgium	Pohjois- ja Itä-Suomi	Finland
Namur	Belgium	Bretagne	France
Luxembourg (BE)	Belgium	Languedoc-Roussillon	France
Kýpros	Cyprus	Midi-Pyrénées	France
Jihovýchod	Czechia	Auvergne	France
Freiburg	Germany	Rhône-Alpes	France
Oberpfalz	Germany	Provence-Alpes-Côte d'Azur	France
Oberfranken	Germany	Zagreb and its commuting zone	Croatia
Unterfranken	Germany	Budapest and its commuting zone	Hungary

Schwaben	Germany	Northern and Western	Ireland
Bremen	Germany	Southern	Ireland
Darmstadt	Germany	Eastern and Midland	Ireland
Gießen	Germany	Prov. Autonoma di Trento	Italy
Braunschweig	Germany	Friuli-Venezia Giulia	Italy
Hannover	Germany	Emilia-Romagna	Italy
Düsseldorf	Germany	Sostinės regionas	Lithuania
Detmold	Germany	Luxembourg	Luxembourg
Rheinhessen-Pfalz	Germany	Amsterdam and its commuting zone	Netherlands
Koblenz	Germany	Groningen	Netherlands
Arnsberg	Germany	Friesland (NL)	Netherlands
Saarland	Germany	Drenthe	Netherlands
Dresden	Germany	Overijssel	Netherlands
Leipzig	Germany	Zeeland	Netherlands
Schleswig-Holstein	Germany	Småland med öarna	Sweden
Thüringen	Germany	Övre Norrland	Sweden
Sjælland	Denmark	Zahodna Slovenija	Slovenia
MODERATE INNOVATIORS (74)			
Region name	Country Name	Region name	Country Name
Jihozápad	Czechia	Nord-Pas de Calais	France
Severovýchod	Czechia	Picardie	France
Střední Morava	Czechia	Alsace	France
Moravskoslezsko	Czechia	Champagne-Ardenne	France
Niederbayern	Germany	Lorraine	France
Kassel	Germany	Pays de la Loire	France
Mecklenburg-Vorpommern	Germany	Aquitaine	France
Lüneburg	Germany	Limousin	France
Weser-Ems	Germany	Poitou-Charentes	France
Münster	Germany	Piemonte	Italy
Trier	Germany	Valle d'Aosta/Vallée d'Aoste	Italy
Chemnitz	Germany	Liguria	Italy
Sachsen-Anhalt	Germany	Lombardia	Italy
Eesti	Estonia	Abruzzo	Italy
Attiki	Greece	Molise	Italy
Kriti	Greece	Campania	Italy
Kentriki Makedonia	Greece	Puglia	Italy
Ipeiros	Greece	Basilicata	Italy
Thessalia	Greece	Calabria	Italy
Dytiki Elláda	Greece	Prov. Autonoma di Bolzano/Bozen	Italy
Peloponnisos	Greece	Veneto	Italy
Galicia	Spain	Toscana	Italy
Principado de Asturias	Spain	Umbria	Italy
Cantabria	Spain	Marche	Italy
La Rioja	Spain	Lazio	Italy
Comunitat Valenciana	Spain	Vidurio ir vakarų Lietuvos regionas	Lithuania
Illes Balears	Spain	Malta	Malta
Andalucía	Spain	Małopolskie	Poland
Región de Murcia	Spain	Warszawski stołeczny	Poland
Åland	Finland	Área Metropo-litana de Lisboa	Portugal
Centre — Val de Loire	France	Centro (PT)	Portugal
Bourgogne	France	Norte	Portugal
Franche-Comté	France	Alentejo	Portugal
Basse-Normandie	France	Norra Mellansverige	Sweden
Haute-Normandie	France	Mellersta Norrland	Sweden
Aragón	Spain	Vzhodna Slovenija	Slovenia
Castilla y León	Spain	Bratislavský kraj	Slovakia

EMERGING INNOVATIORS (64)			
Region name	Country Name	Region name	Country Name
Severozapaden	Bulgaria	Sicilia	Italy
Severen tsentralen	Bulgaria	Sardegna	Italy
Severoiztochen	Bulgaria	Latvija	Latvia
Yugoiztochen	Bulgaria	Śląskie	Poland
Yugozapaden	Bulgaria	Wielkopolskie	Poland
Yuzhen tsentralen	Bulgaria	Zachodniopomorskie	Poland
Severozápad	Czechia	Lubuskie	Poland
Voreio Aigaio	Greece	Dolnośląskie	Poland
Notio Aigaio	Greece	Opolskie	Poland
Anatoliki Makedonia, Thraki	Greece	Kujawsko-pomorskie	Poland
Dytiki Makedonia	Greece	Warmińsko-mazurskie	Poland
Ionia Nisia	Greece	Pomorskie	Poland
Sterea Elláda	Greece	Łódzkie	Poland
Castilla-La Mancha	Spain	Świętokrzyskie	Poland
Extremadura	Spain	Lubelskie	Poland
Ciudad de Ceuta	Spain	Podkarpackie	Poland
Ciudad de Melilla	Spain	Podlaskie	Poland
Canarias	Spain	Mazowiecki regionalny	Poland
Corse	France	Algarve	Portugal
Guadeloupe	France	Região Autónoma dos Açores	Portugal
Martinique	France	Região Autónoma da Madeira	Portugal
Guyane	France	Nord-Vest	Romania
La Réunion	France	Centru	Romania
Mayotte	France	Nord-Est	Romania
Panonska Hrvatska	Croatia	Sud-Est	Romania
Jadranska Hrvatska	Croatia	Sud-Muntenia	Romania
Közép-Dunántúl	Hungary	Bucureşti-Ilfov	Romania
Nyugat-Dunántúl	Hungary	Sud-Vest Oltenia	Romania
Dél-Dunántúl	Hungary	Vest	Romania
Észak-Magyarország	Hungary	Západné Slovensko	Slovakia
Észak-Alföld	Hungary	Stredné Slovensko	Slovakia
Dél-Alföld	Hungary	Východné Slovensko	Slovakia