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Convergence and Catch-Up of the Region Types in the Central and Eastern European Countries

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Abstract

Our study investigates the economic growth and catch-up of the NUTS3 regions of 6 Central and Eastern European (CEE) member states of the European Union (EU), 4 countries acceding in 2004 (Czechia, Poland, Hungary, and Slovakia) and further two admitted in 2007 (Bulgaria and Romania), compared to the average of 14 older members of the EU between 2000 and 2019. We based our analysis on the urban–rural region types of the EU in the case of 185 regions, identifying predominantly urban, intermediate, and predominantly rural types. We apply Theil Index to examine the development of disparities and test the phenomena with unconditional β-convergence hypothesis. The analysis indicates that the growth of all CEE countries and their regions is faster than the EU14 average; the capitals considerably exceed it, the catch-up of other urban regions is also relatively fast, while it is very slow in the case of other regions. The convergence between the 185 regions is weak, based on the EU region typology it was initially strong between the capitals, moderate in the case of intermediate and rural types, while divergence can be observed in the urban types. The catch-up of less developed regions is very slow despite EU cohesion funding, even though 80% of the population live here. The stagnation of regional disparities and slow catch-up of less developed regions indicate the poor efficiency of the EU cohesion policy.

Keywords Economic Growth · Catch-up · Central and Eastern European Countries · Theil Index · Unconditional β-Convergence

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Introduction

One of the most important goals of the regional policy of the European Union (EU) is to facilitate territorial cohesion, i.e., the catch-up of less developed countries and subnational regions. This issue was mainly brought into focus after the turn of the millennium, following the EU accession of the Central and Eastern European countries (CEE), since the development level of these countries was well below the development level of the older member states. Besides the catch-up of less developed regions, another important goal is to increase the competitiveness of the EU, which allocates resources mainly to urban regions. These two objectives partly contradict each other, which explains that convergence processes slowed down after 2010 and the focus was put on place-based development strategies related to special conditions of regions, nevertheless, their theoretical background is highly debated (Martin et al., 2022; Rodríguez-Pose, 2020). Iammarino et al., (2019, p. 273) state, "Both mainstream and heterodox theories have gaps in their ability to explain the existence of these different regional trajectories and the weakness of the convergence processes among them".

In investigating the economic growth of the EU member states, several studies found that the less developed CEE member states are moving closer to the EU average, although at a relatively slow pace (Eurofund, 2018; Halmai & Vásáry, 2012; Kónya, 2018; Mihajlek, 2018). Farkas (2016) points out that the economic growth of the EU member states highly depends on the institutional system; the market economy model of CEE post-socialist countries is special and different from other country types, therefore, there are specific processes in the development of their regions as well.

The regional policy of the EU relies on the development level of NUTS2 regions in determining the grants of the 7-year programming periods. Becker et al. (2018) studied the Structural Supports of the EU over several periods on the basis of NUTS2 regions, and they pointed out regarding the 2007–13 Convergence Objective Regions that they succeeded in addressing employment problems after the 2008 crisis, but they hardly contributed to increasing incomes and convergence. Egri and Tánczos (2018) analysed economic (GDP/capita) and social (human development index) convergence processes between 2004 and 2014 in the CEE states. The absolute and club convergence analyses confirm the convergence on NUTS2 level for both phenomena, indicating a considerable difference according to social and economic dimensions.

In the past years, it has become more and more obvious that the NUTS2 regions are too large and heterogeneous, thus several studies based their investigation on the much smaller NUTS3 regions, which normally consist of a city and its agglomeration. In examining the convergence of the NUTS3 regions within the EU based on the annual data between 2000 and 2011, Goecke and Hüther (2016) conclude that although there is convergence between both the countries and the regions, several countries can be characterised more by divergence (e.g., Greece, Italy). Butkus et al. (2018) analysed the development of disparities between EU countries, NUTS2 regions, and NUTS3 regions over the period of 1995–2014,

and they found that although convergence can be observed on different regional levels in the EU, the speed of convergence slows down. The disparities within the EU decreased primarily due to reducing differences between the member states, but they slightly increased on each subnational level in most member states.

Monastiriotis (2014) studied the convergence of the NUTS3 regions of the EU over the period of 1990–2008, comparing the regions of the older EU15 and the new CEE member states. He found that while regional convergence could be observed in the EU15, regional disparities in the CEE increased from 1990, indicating divergence, whose level primarily depends on the development of national economies. Lengyel and Kotosz (2018) examined the convergence processes of the NUTS3 regions of the four Visegrad countries (V4: Czechia, Poland, Hungary, and Slovakia) between 2000 and 2014, and the calculations show a lack of convergence, disparities were reduced substantively only in the years after the 2008 crisis.

Many analysed the evolution of convergence or divergence based on the concentration within countries as urbanisation agglomeration economies, as well as on urban–rural typology. Castells-Quintana and Royuela (2015) studied the relationship between the spatial concentration of resources and development in the case 51 countries over the period of 1970–2007, and among their findings they highlighted that a strong impact on economic growth can be seen especially in the initial stage of urbanisation. Van Leeuwen (2015) analysed the urban–rural neighbourhood relations based on about 1000 NUTS3 regions of the EU and showed that neighbourhood is beneficial for both urban and rural regions. De Falco (2021) analysed the effect of spatial concentrations on growth in Italy on NUTS3 territorial level based on the employment data of sectors and found substantial differences between the larger regions of the country.

Chapman and Meliciani (2018) examined the decisive factors and the development of income disparities between the regions of the CEE countries in the period of 1991–2011, identifying urban, old industrialised, and peripheral areas. They found that the increase of regional disparities within countries can be explained with these region types, especially after the turn of the millennium. Lengyel (2017) identified 4 types (strong, rising, weak, and uncompetitive) in analysing the competitiveness of the NUTS3 regions of the V4 countries between 2004 and 2013, with the capitals and the traditional industrial regions forming the most competitive group.

Several studies emphasised that the economic growth of the capitals, as first-tier cities, differs from other cities, these second-tier cities being the "engines" of economic growth in the older EU member states (Cardoso & Meijers, 2016; Parkinson et al., 2015). The study of Camagni et al. (2015) pointed out that metropolitan agglomerations, small town areas, and rural regions have different development paths. Smetkowski (2018) analysed growth factors in the NUTS3 regions of CEE countries over the periods before and after the 2008 crisis, comparing metropolitan and nonmetropolitan regions, and found that the development processes of the two region groups were similar in many respects. Smirnykh and Wörgötter (2021) in studying the convergence of the NUTS3 regions of CEE countries emphasise that capitals have a different development path compared to other regions, and its investigation is of particular importance. It was also proposed that the development of cities and their agglomeration should be facilitated rather than that of regions in

the EU (Rauhut & Humer, 2020). Based on the analysis of the literature, it can be seen that there is no complete agreement between scholars on the assessment of the catch-up of regions, which can also be explained by the fact that the investigations considered different periods and different territorial levels.

In our study, we analyse the economic growth of the 185 NUTS3 regions of 6 Central and Eastern European (CEE) member states of the European Union (EU), 4 countries acceding in 2004 (Czechia, Poland, Hungary, and Slovakia) and further two admitted in 2007 (Bulgaria and Romania), between 2000 and 2019, thereby we can also include the characteristics of the post-COVID-19 period. We typed the regions based on the findings of the literature, we relied on the EU's urban–rural types, identifying predominantly urban, intermediate, and predominantly rural types. We analysed the two periods separately due to the structural break caused by the 2008 crisis, namely the periods of 2000–2008 and 2010–2019. Based on the literature of the topic, we divided the predominantly urban areas, categorising the capital regions in a distinct type as first-tier regions, while the other urban regions essentially form the group of second-tier urban areas.

We analyse three research questions:

(1) In terms of the economic growth of the 185 regions, is there convergence or divergence between 2000 and 2019?
(2) Are the convergence processes of the periods before and after the 2008 crisis until the COVID-19 similar or different?
(3) Does the catch-up of the regions of the CEE6 countries depend on the urban–rural type of the regions?

In the first part of the study, we present the database, the typology of the regions, and the applied methods, and then we cover the empirical description of the regional disparities between the region types. The phenomena show weak convergence and different growth dynamics of the region types, and we test it by using unconditional β-convergence approach. We close the study with our methodological and regional policy conclusions drawn from the analysis, as well as the questions left open for further research.

Database and Methodology

There is a total of 185 NUTS3 regions in the studied CEE6 countries: in Bulgaria 28 'oblasati', in Czechia 14 'kraje', in Poland 73 'podregiony', in Hungary 20 'megye', in Romania 42 'judet', in Slovakia 8 'kraje', and each capital forms a separate territorial unit (Eurostat, 2018). In our analysis, between 2000 and 2019 we relied on the annual Gross domestic product (GDP) at current market prices by NUTS3 regions (nama_10r_3gdp) and Average annual population given in PPS from the website of Eurostat Database by themes to calculate regional GDP data (thousand persons) by NUTS3 regions (nama_10r_3popgdp).

One of the goals of the EU cohesion policy is catching up CEE countries to older member states; in the present study, we make comparisons to the average of the 14 older member states, we do not take the United Kingdom into account. We are aware that GDP shown on Purchasing Power Parity on NUTS3 level can be considered only as an estimate, but the relevant literature also takes it as its basis (Camagni et al., 2015; Smetkowski, 2018).

For typing the regions, we relied on the categories elaborated by the Eurostat. The urban–rural typology is a classification based on the following three categories (Eurostat, 2018, p. 74):

– *"predominantly urban regions,* NUTS3 regions where more than 80% of the population live in urban clusters;
– *Intermediate regions,* NUTS3 regions where more than 50% and up to 80% of the population live in urban clusters;
– *Predominantly rural regions*, NUTS3 regions where at least 50% of the population live in rural grid cells."

The 6 countries contain 21 *predominantly urban regions* (URB), 84 *intermediate regions* (INT), and 80 *predominantly rural regions* (RUR) (see Table 1 and Appendix). As we have mentioned, the economic growth of the first-tier-level capitals of the 6 countries considerably differs from the other regions (Capello and Cerisola, 2021; Lengyel & Kotosz, 2018), therefore, we classified the 6 capitals into a separate category. Based on the above, we identified 4 types, thus 15 regions remained in the category of predominantly urban regions, which we consider second-tier urban areas.

The urban network of five out of six countries can be considered unipolar, the capital qualifies as predominantly urban (URB) type, only Poland is polycentric, where several URB urban areas can be found. In the case of the Czech and Romanian capitals, their agglomeration is also urban (URB), the agglomeration of the Hungarian capital is intermediate (INT), while the agglomeration of the Slovakian and Bulgarian capital is rural (RUR).

In our study, we apply several methods to address our research questions. We use Theil Index to analyse the development of the differences in the values of GDP per capita and the disparities between the regions and their types. Given a per-unit

Table 1 Types of NUTS3 territorial units of CCE6

Countries	CAP	URB	INT	RUR	Total
Bulgaria	1	-	20	7	28
Czechia	1	1	8	4	14
Hungary	1	-	13	6	20
Romania	1	1	12	28	42
Poland	1	13	27	32	73
Slovakia	1	-	4	3	8
Total	6	15	84	80	185

variable (Y_i), which is calculated as a quotient of two absolute variables (X_i és F_i), the disparity in the per-unit variable can be given with the help of generalised *Theil Index (TE)* (Lengyel & Kotosz, 2018; Niebuhr & Peters, 2021):

$$TE = \sum_{i=1}^{N} x_i log \frac{x_i}{f_i}$$

where x_i and f_i are distribution ratios constituted from the absolute variables.

The base of the logarithm is optional, it is common to use binary or exponential logarithm. The generalised *Theil* Index measures the disparities between the units of observation, the closer it is to 0, the greater the alignment, i.e., level of equalisation (Lengyel & Kotosz, 2018; Thissen et al., 2013).

The generalised *Theil* Index is also suitable to determine what extent of the total disparities comes from the disparities within the aggregated territorial units (TE_{within}) and between the aggregated territorial units ($TE_{between}$) through aggregating the territorial level, i.e., the *TE* value can be decomposed into the sum of two values (Gorzelak, 2021):

$$TE = \sum_{i=1}^{n} x_i log \frac{x_i}{f_i} = TE_{within} + TE_{between}$$

To interpret the convergence between regions, we test unconditional β-convergence hypothesis carried out on cross-sectional data based on the study of Barro and Sala-i-Martin (1995). Take t=0 as the first year and t=T as the last year of the period, then the following regression equation can be used for testing (Gallo and Fingleton, 2021; Smirnykh & Wörgötter, 2021; Viegas & Antunes, 2013):

$$\frac{1}{T} log \frac{y_{i,T}}{y_{i,0}} = \beta_0 + \beta_1 log y_{i,0} + \varepsilon_i$$

where n is the number of regions and $i=1,\ldots n$, while $y_{i,0}$ and $y_{i,T}$ are the indicator applied for examining convergence (in this case, GDP capita) in i^{th} region in the first and last observed year; β_0 is a constant, ε_i is the random error. The average growth rate between the two points in time is showed by $log \frac{y_{i,T}}{y_{i,0}}$. There is unconditional β-convergence if β_1 is negative and significant. The speed of convergence between regions can be estimated as follows:

$$\gamma = -\frac{1}{T} \ln(1 + \beta_1 T)$$

Regional disparities within CCE6

There is significant economic growth in the CEE6 countries between 2000 and 2019, they move increasingly closer to the EU14 average (Fig. 1). Per-unit GDP increased in Romania and Bulgaria to the greatest extent, although starting at a low value. Czechia stands out from the CEE6 countries, reaching 86% of EU14

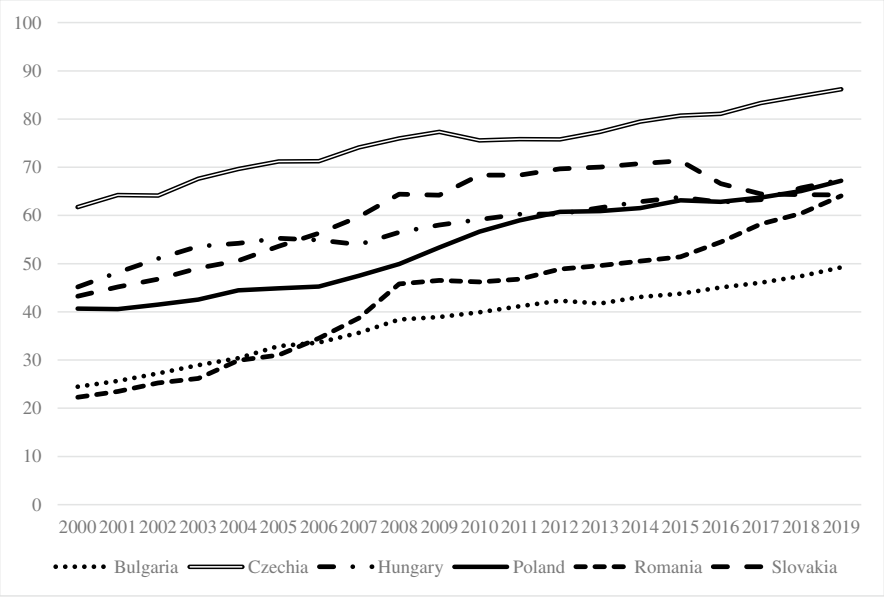

Fig. 1 GDP/capita by countries, EU14 = 100. Source: Author's elaboration on Eurostat data

average by the end of the studied period; four countries (Poland, Hungary, Romania, and Slovakia) reached a similar level, between 64–67%, while Bulgaria showed 49% lagging behind the others. A dynamic catch-up can be observed for each country compared to the starting position, which stalls due to the 2008 crisis, but it is relatively consistent again from 2010, with the exception of Slovakia, falling back in 2015.

GDP per capita increased between 2000 and 2019 in all 185 NUTS3 regions, although to a different extent, but the relationship between the two time series can be regarded relatively close ($R^2 = 0.734$) (Fig. 2). The economic growth of the six capitals stands out, in 2000 only two capitals exceeded the EU14 average, Praha (122%) and Warszawa (116%). However, in 2019 several regions, the capitals in particular, exceeded the EU14-average, Warszawa (200%) and Praha (191%), with Bucuresti (169%), Bratislava (148%), and Budapest (140%) slightly behind. They are followed by three Polish metropolitan regions (Poznan 136%, Wroclaw 117%, and Kraków 114%), while the capital of Bulgaria (Sofia) is found behind them (111%), and two further Polish regions exceed the EU14 average (Plocki 107% and Trojmiejski 101%). Most of the regions are concentrated in the lower left corner of the Fig. 2, 93 out of the 185 regions did not reach 50% of the EU14 average in 2019.

Regarding the economic growth of regions, not only the country effect but also the type of region can be important, and, as we have mentioned, we created 4 region types. The effect of the differentiating factors between countries and within countries, as well as between types and within types can be distinguished by using Theil Index (Fig. 3). The EU cohesion policy relies on NUTS2 regions; therefore, it is also practical to show the development of disparities between and within NUTS2.

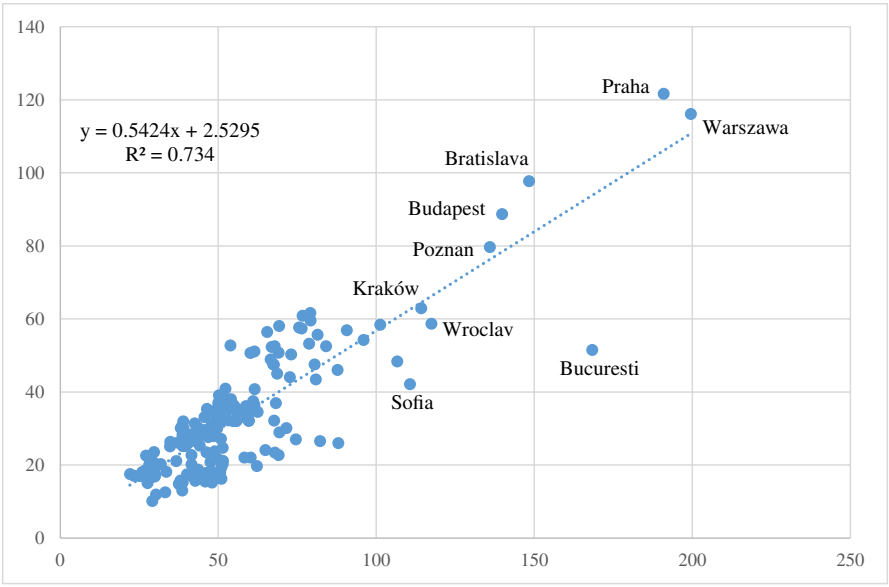

Fig. 2 GDP/capita of NUTS3 regions in 2000 and 2019, EU14 = 100. Source: Author's elaboration on Eurostat data

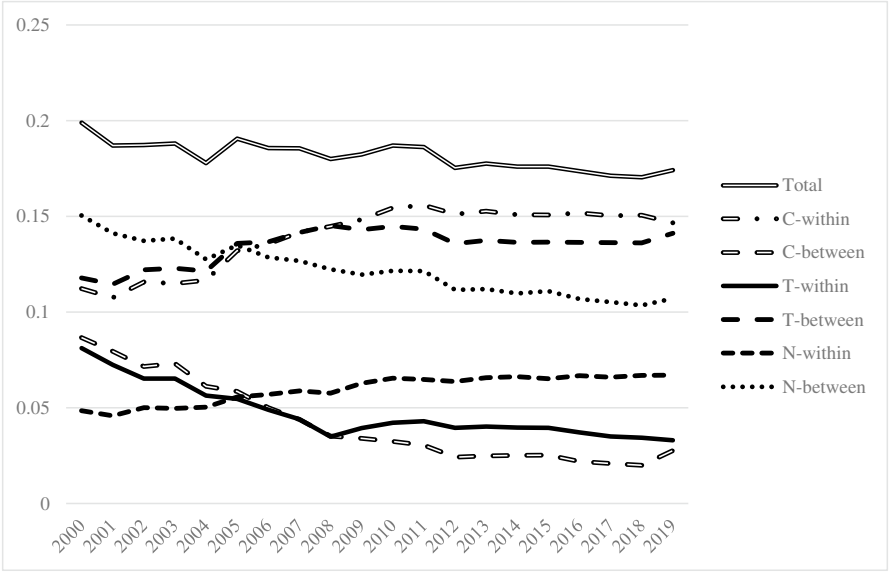

Fig. 3 Regional disparities of region types by Theil Index. *Note*: Theil Index of disparities within (*C-within*) and between (*C-between*) countries, within (*T-within*) and between (*T-between*) region types, within (*N-within*) and between (*N-between*) NUTS2 regions

The disparities (*Total*) between the 185 regions reduced to a limited extent over two decades, in the meantime, smaller discontinuities can be found in 2004 and 2012. Total disparities are significantly affected by disparities within countries (*C-within*), which increase after 2004 and stagnate from 2010. In line with this, the differentiation between countries (*C-between*) continuously decrease from 2000, as it is indicated by Fig. 1, and stagnates at a low level from 2010. Relying on urban–rural typology, the moderation of total disparities is primarily caused by the equalisation within each type (*T-within*), while the disparities between types (*T-between*) intensify until 2008 and stagnate at a high level from that point. The differences between NUTS2 regions (*N-between*) – as the basis of analysing territorial cohesion in the EU regional policy – decreased, even though with smaller fluctuations, while they increased moderately within NUTS2 regions (*N-within*). The disparities between NUTS2 regions were probably reduced by the EU cohesion funding, while these funds are concentrated in urban areas within the regions, thereby increasing disparities within regions.

The 4 region types become increasingly distinct since, as we have described, the disparities within region types (*T-within*) decrease and relatively small, while they are large between region types (*T-between*). Similarly to countries, catch-up is shown in each region type between 2000 and 2019 (Fig. 4). The growth of the capital type (CAP) is dynamic, it exceeds the EU14 average as early as in 2005, after the slowdown of 2008 it is strong again from 2010 and it reaches its 162% in 2019. The catch-up of the predominantly urban (URB) type without capitals is also fast, reaching 85% of the EU14 average in 2019. However, the economic

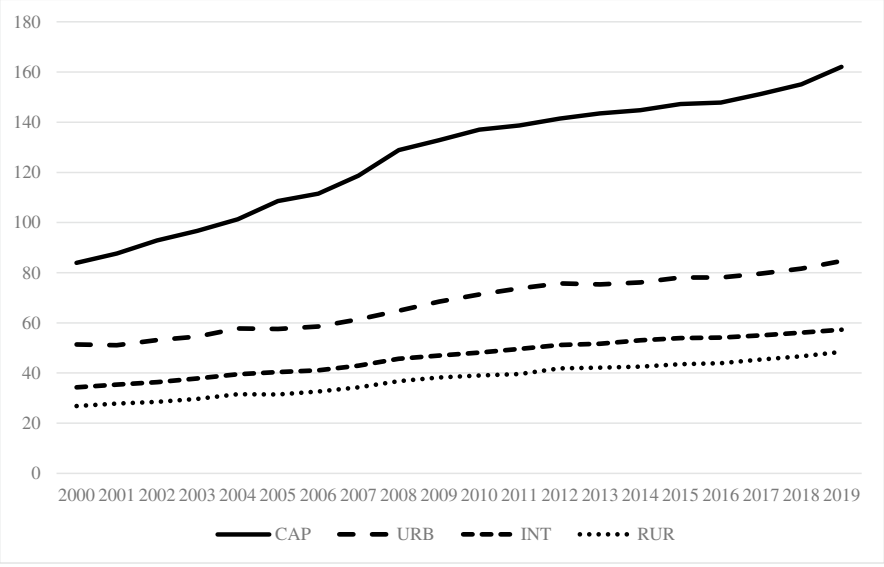

Fig. 4 GDP/capita by region types, EU14 = 100. Source: Author's elaboration on Eurostat data. Note: CAP – capitals; URB – predominantly urban regions (except capitals); INT – intermediate regions; RUR—predominantly rural regions

growth of intermediate (INT) and predominantly rural (RUR) types is much more contained, reaching 57% and 48% of EU14 average in 2019, respectively. It can be observed that in the older member states of the EU the growth of second-tier cities is strong rather than that of the capitals, while in the CEE countries the role of capitals is prominent, other urban areas are less relevant.

The increase of GDP per capita can also be influenced by the change of population. The number of population in the CEE6 countries was 94.7 million in 2000, which decreased to 90.6 million in 2019, i.e., by 4.3%-kal (Table 2). This process is contrary to what can be observed in the EU14, where 319 million people lived in 2000, and 343 million in 2019.

The population of capitals (CAP) and urban areas (URB) in the CEE6 countries increased minimally, while INT decreased by 1.8 million and RUR by 2.7 million. The distribution of GDP between region types only slightly changed, which was obviously influenced by the change of population. The economic role of the capitals is outstanding, the proportion of population living here is 9.6%, but they produce 23.1% of GDP. The economy of other urban areas (URB) did not change significantly over the two decades. The GDP share of INT and RUR regions decreased, in 2019, GDP accounted for 63.4%, while their population for 79.7%. Four fifths of the population of the CEE6 countries still live in less developed regions at present, their catch-up process has a rather slow pace. A moderate spatial concentration of both population and GDP can be seen, the latter being somewhat more intensive.

According to the presented empirical data, catch-up to the EU14 average can be observed in each region, but at a different rate by type. Intermediate (INT) and rural (RUR) regions are significantly behind the economic growth of capitals and urban areas and, as a result, the territorial cohesion measured on NUTS3 level within the CEE6 countries is slow, what is more, spatial disparities stagnate rather than decrease despite substantial EU fundings in the past years.

Growth in the period preceding and following the economic crisis also reflects urban–rural differentiation in economic growth. In the pre-crisis period, the Polish cities, the urban regions of Romania and the metropolitan areas (Prague, Bratislava, Bucharest, Sofia) had a significant advantage. In the period 2010–2019, Polish and Romanian urban areas also stand out in terms of economic growth.

Table 2 Population of region types and distribution of GDP (PPS)

Region types	Population, million inhabitants		Distribution, %			
			Population		GDP	
	2000	2019	2000	2019	2000	2019
CAP	8.5	8.7	9.0	9.6	19.9	23.1
URB	9.6	9.8	10.1	10.8	13.8	13.6
INT	42.9	41.1	45.3	45.4	41.1	38.7
RUR	33.8	31.1	35.7	34.3	25.3	24.7
Total	94.7	90.6	100.0	100.0	100.0	100.0

Convergence Between and Within Region Types

On each region, as well as within each urban–rural type we apply the indicator of weighted relative standard deviation to measure the development of disparities in the values of GDP per capita (sigma-convergence). If the value of the indicator decreases, it indicates convergence, and if it increases, it refers to divergence.

The weighted relative standard deviation of per-unit GDP in the case of the 185 regions – similarly to the total Theil Index – shows a slight change from 2000 to 2004, but we can see slightly increasing divergence after 2004, which turned into moderate convergence after 2011 (Fig. 7). There is strong convergence between the capitals (CAP) before 2008, then slight divergence until 2013, followed by weakly decreasing differences, i.e., convergence emerges again. There is slight convergence between urban areas (URB) until 2004, followed by gradual divergence until 2019. Similarly, there are diminishing disparities alongside smaller fluctuations for intermediate (INT) and rural (RUR) regions, which indicates convergence. The extent of deviation becomes very close for three region types (URB, INT, RUR) in 2019.

The development of the Theil Index (Fig. 3) and deviation (Fig. 5) only illustrates the existence of convergence or divergence between the 185 regions and within region types, it is also needed to conduct a more accurate analysis of these phenomena. In our study, we apply the approach of unconditional β-convergence to test convergence, i.e., we assume that the regions with lower income have a higher rate of growth and vice versa. As the periods before and after the 2088 crisis mostly have partly different trends, we separate the two time periods (Figures 6 and 7).

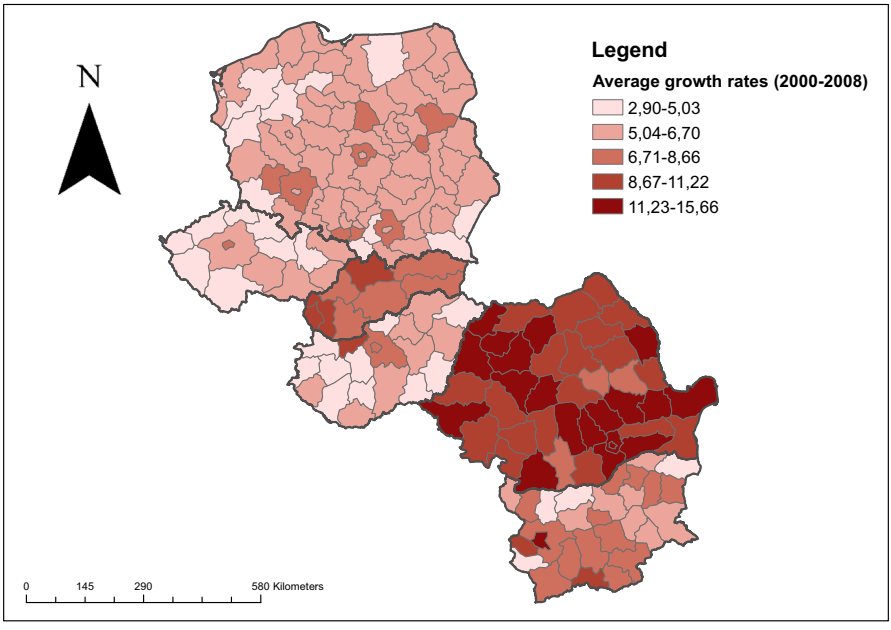

Fig. 5 Annual average GDP/cap growth (2000–2008)

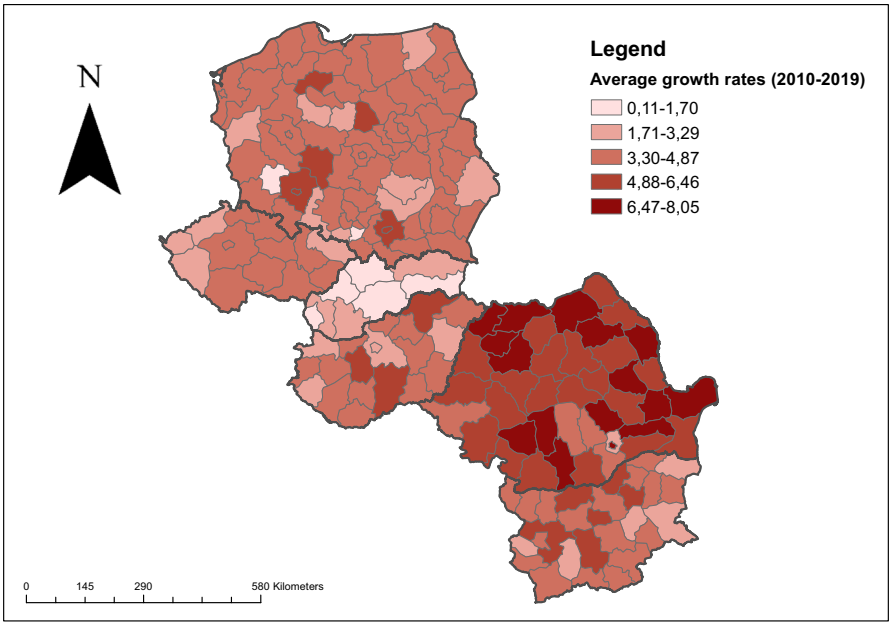

Fig. 6 Annual average GDP/cap growth (2010–2019)

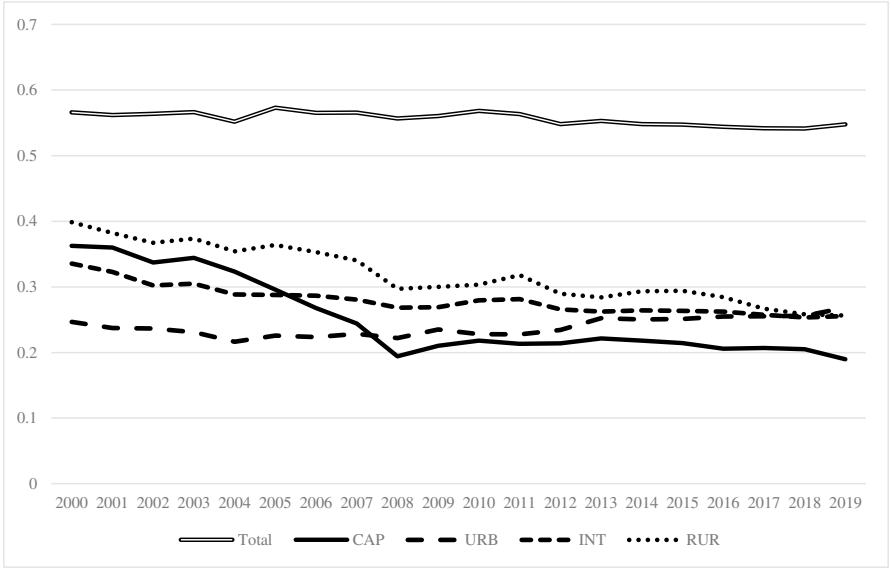

Fig. 7 Development of weighted relative standard deviation by region types

Table 3 Unconditional β-convergence of the regions in CEE6

	2000–2008	2010–2019	2000–2019
Initial level	−0.029***	-0.012***	−0.017***
	(0.004)	(0,002)	(0.002)
Intercept	0.326***	0.157***	0.198***
	(0.033)	(0,022)	(0.018)
Observations	185	185	185
AIC	-871.2	-1071.4	-1100.7
LogL	437.6	537.7	552.3
R^2 Adjusted	0.241	0.120	0.266
Speed of convergence (%)	3.30	1.27	2.05
Half-life (year)	21.00	54.58	33.81

The brackets contain the standard error of the estimation. Significance: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

In the case of the 185 regions, we tested our regression models explaining convergence on the periods of 2000–2008, 2010–2019, and 2000–2019 (Table 3). According to the OLS regressions, all three periods are characterised by absolute convergence, i.e., the growth of less developed regions is significantly higher, indicating catch-up to more developed regions. This phenomenon can be experienced alongside the persistence of spatial disparities, i.e., Barro and Sala-i Martin (1995) accurately point out that beta-convergence does not necessarily result in sigma-convergence.

The speed of convergence can also be calculated with beta coefficients, which is relatively high in the period of 2000–2008 (3.3%), but it significantly drops, by almost half, between 2010 and 2019. Considering the entire period, there is an intermediate speed of convergence of 2% provided by Barro and Sala-i Martin (1995). The half-life is in line with the above speed of convergence, based on the growth in the period of 2000–2008 the shortest time can be observed until the half of the total convergence, which is 21 years.

Both the Theil Index (Fig. 3) and the per-unit GDP of each urban–rural region type (Fig. 4) indicate that these region types can also be interpreted as convergence clubs having specific disparity and growth path (Szakálné Kanó & Lengyel, 2021). For testing this, we completed the traditional unconditional β-convergence equation with additional regression terms. As population density data cannot be applied due to differences in region delineation (see, for example, in the case of Bratislava and Warszawa), we use the urban–rural types as dummy variables, the RUR group forming the reference group.

The coefficient of the initial level is still negative and significant in each period, i.e., a lower level of development is accompanied by higher growth, indicating significant convergence (Table 4). By the inclusion of the urban–rural dimension, the speed of convergence accelerates in each case compared to the basic model, and it is especially apparent in the period of 2000–2008, where the speed of convergence increases by over half. In addition, the fit of the model explaining convergence also clearly improves, i.e., the inclusion of new variables substantively contributes to the explanation of convergence.

Table 4 Convergence analysis completed with typing

	2000–2008	2010–2019	2000–2019
Initial level	-0.044***	-0.014***	-0.023***
	(0.004)	(0.003)	(0.002)
CAP	0.069***	0.009	0.030***
	(0.010)	(0.007)	(0.005)
URB	0.021***	0.001	0.011***
	(0.006)	(0.004)	(0.004)
INT	-0.003	-0.004*	-0.001
	(0.003)	(0.002)	(0.002)
Intercept	0.456***	0.179***	0.256***
	(0.035)	(0.029)	(0.019)
Observations	185	185	185
AIC	-914.8	-1073.1	-1134.9
LogL	462.4	541.5	572.43
R^2 Adjusted	0.41	0.142	0.399
Speed of convergence (%)	5.42	1.50	3.02
Half-life (year)	12.79	46.32	22.95

The brackets contain the standard error of the estimation. Significance: * $p < 0.05$, * * $p < 0.01$, * * * $p < 0.001$

The significant dummy variables of the types show that there is differentiation between the types in terms of growth in the studied period. CAP and URB regions are characterised by significantly higher growth compared to RUR in the period of 2000–2008, as well as in the entire period of 2000–2019. The regression coefficient of CAP is nearly three times that of URB in both periods, i.e., capitals have a substantial effect on the growth and catch-up of the CEE6. INT regions obstruct the growth of CEE6 regions compared to rural (RUR) regions; they emerge significantly only after the crisis, even though all 6 countries received substantial EU cohesion funding over this period.

In the models extended with urban–rural typology, increasing speed of convergence entail a considerable decrease of half-lives. The half of the time required for convergence drops nearly by half in the period of 2000–2008, decreases by 15% following the crisis, while it drops by one-third (11 years) in the entire period.

Conclusions

In our study, we analysed the convergence of the NUTS3 regions of the CCE6 countries and the catch-up of region types to EU14 average over the period of 2000–2019. We formulated three research questions and applied the methodologies used in convergence literature to address them.

The first question referred to the economic growth of the 185 regions of the CEE6 over the period of 2000–2019. The analyses showed that there was weak convergence on average in the pre-COVID-19 period, spatial disparities decreased

moderately and the catch-up of the regions to the EU14 average is contained. Out of the results we emphasise that we can confirm Barro and Sala-i-Martin's (1995) finding that β-convergence is not accompanied by sigma-convergence.

The second question addressed whether the convergence processes before and after the 2008 crisis can be considered identical or different. In the two periods, both the sigma- and beta-convergence clearly differ in the NUTS3 regions of the CEE6. Although considering the entire period spatial disparities did not decrease significantly, the two periods are distinct; until the 2008 crisis the disparities within countries substantially increased, followed by stagnation. Unconditional β-convergence shows a rapid convergence rate until the crisis, while the speed significantly slows down afterwards, not even reaching its half.

The third question covered whether the catch-up of the regions of the CEE6 countries depend on urban–rural typology. Based on our study, the growth of types is different, we maintain that the region types can also be interpreted as convergence clubs. Of the 4 region types, the economic growth of capital regions (CAP) was dynamic, reaching the EU14 average as early as in 2004, and achieving its one and a half times in 2019. Urban areas (URB) also catch up gradually, slightly behind the EU14 average in 2019. The development of the other two region types, INT and RUR is slow, reaching roughly the half of the EU14 average, even though 80% of the population live here. In the CEE6 countries, economic growth is closely linked to the economy of the capital regions, however, the catch-up of less developed regions is rather slow despite cohesion funding.

The growth of second-tier cities significantly differs from the growth of the capitals as first-tier cities, which shows a substantial difference from the processes observed in the EU14 member states. The faster development of the capitals can probably be explained by the concentration of EU resources, besides urbanisation agglomeration economies.

The unconditional β-convergence analyses indicate that although the catch-up of less developed regions (INT, RUR) is an existing phenomenon, its extent appears to be rather small in both pre- and post-crisis periods. The analysis of the entire period does not show a substantial improvement for these types, either. Nevertheless, the β-convergence results completed with an urban–rural typology are accompanied by an evident acceleration of the convergence speed. The results of the regression calculations overall support the findings of Cardoso and Meijers (2016) and Camagni et al. (2015) on different economic growth paths.

Several studies deal with the analysis of the different development trajectories of the regions of CEE countries. According to Rodríguez-Pose and Ketterer (2020), government quality matters for regional growth, and one-size-fits-all policies for lagging regions are not the solution. Rodríguez-Pose (2020) suggests several ways to improve how a better understanding of the regional development form of institutions can lead to more effective development policies. Based on an empirical study by Capello and Cerisola (2023), it was found that the reallocation of resources towards higher value-added sectors in CEE countries can actually lead to greater regional inequalities, as the competitiveness of the capital cities' economies improves. Using evolutionary economic geography analyses, Simone (2022) demonstrates that the possibility of unrelated diversification is narrower for lagging regions.

We believe that the inclusion of urban–rural types in convergence analysis contribute to understanding the catch-up and convergence of the CEE6 regions with relevant information and highlight the diverse effects of each type in space and time. Using these results is advised for regional policymakers as various region types indicate the necessity of different development strategies.

Appendix

Table 5 NUTS3 regions of the CEE6 countries

Code	Types	Name	Population, thousand		GDP cap, PPS, EU14 = 100	
			2000	2019	2000	2019
Bulgaria						
BG311	RUR	Vidin	138	84	17	25
BG312	INT	Montana	190	128	16	27
BG313	INT	Vratsa	254	161	30	38
BG314	INT	Pleven	317	238	20	28
BG315	INT	Lovech	175	124	21	30
BG321	INT	Veliko Tarnovo	300	234	20	32
BG322	INT	Gabrovo	153	108	23	41
BG323	INT	Ruse	274	217	21	37
BG324	RUR	Razgrad	164	112	17	30
BG325	RUR	Silistra	152	109	18	22
BG331	INT	Varna	438	471	29	47
BG332	INT	Dobrich	225	173	23	29
BG333	INT	Shumen	214	172	18	29
BG334	RUR	Targovishte	144	111	17	30
BG341	INT	Burgas	426	410	31	39
BG342	INT	Sliven	229	185	17	23
BG343	INT	Yambol	167	118	17	29
BG344	INT	Stara Zagora	384	315	28	47
BG411	URB/CAP	Sofia	1217	1328	42	111
BG412	RUR	Sofia	259	228	24	49
BG413	INT	Blagoevgrad	345	304	19	30
BG414	INT	Pernik	153	120	19	27
BG415	INT	Kyustendil	170	118	23	27
BG421	INT	Plovdiv	729	668	20	42
BG422	INT	Haskovo	291	227	18	26
BG423	INT	Pazardzhik	315	254	17	29
BG424	RUR	Smolyan	145	104	18	34
BG425	RUR	Kardzhali	201	156	15	28

Table 5 (continued)

Code	Types	Name	Population, thousand		GDP cap, PPS, EU14 = 100	
			2000	2019	2000	2019
Czechia						
CZ010	URB/CAP	Praha	1184	1315	122	191
CZ020	URB	Strední Cechy	1113	1378	62	79
CZ031	RUR	Jihocecký	626	643	58	69
CZ032	RUR	Plzenský	552	588	58	76
CZ041	INT	Karlovarský	305	295	53	54
CZ042	INT	Ústecký	827	821	51	61
CZ051	INT	Liberecký	429	443	56	65
CZ052	INT	Královéhradecký	551	551	57	76
CZ053	RUR	Pardubický	509	521	53	68
CZ063	RUR	Vysocina	521	509	51	69
CZ064	INT	Jihomoravský	1137	1190	56	81
CZ071	INT	Olomoucký	642	632	49	67
CZ072	INT	Zlínský	598	583	50	73
CZ080	INT	Moravskoslezský	1280	1201	48	67
Hungary						
HU110	URB/CAP	Budapest	1775	1751	89	140
HU120	INT	Pest	1063	1288	37	54
HU211	INT	Fejér	427	418	52	67
HU212	INT	Komárom-Esztergom	317	300	37	68
HU213	INT	Veszprém	376	341	39	52
HU221	INT	Győr-Moson-Sopron	434	470	61	77
HU222	INT	Vas	269	254	51	60
HU223	RUR	Zala	301	268	39	50
HU231	INT	Baranya	409	360	33	46
HU232	RUR	Somogy	338	301	31	42
HU233	RUR	Tolna	252	216	37	51
HU311	INT	Borsod-Abaúj-Zemplén	754	640	28	47
HU312	RUR	Heves	328	294	32	51
HU313	RUR	Nógrád	222	189	24	30
HU321	INT	Hajdú-Bihar	553	527	35	48
HU322	INT	Jász-Nagykun-Szolnok	421	368	29	43
HU323	RUR	Szabolcs-Szatmár-Bereg	590	551	26	39
HU331	INT	Bács-Kiskun	548	503	32	55
HU332	INT	Békés	403	332	30	39
HU333	INT	Csongrád-Csanád	431	399	37	50
Poland						
PL841	INT	Bialostocki	755	775	63	114
PL811	RUR	Bialski	643	732	25	51
PL225	INT	Bielski	448	462	28	42

Table 5 (continued)

Code	Types	Name	Population, thousand		GDP cap, PPS, EU14 = 100	
			2000	2019	2000	2019
PL613	URB	Bydgosko-torunski	497	541	27	43
PL228	URB	Bytomski	323	344	25	39
PL812	RUR	Chelmsko-zamojski	557	550	35	50
PL637	RUR	Chojnicki	545	512	36	59
PL922	RUR	Ciechanowski	641	667	45	69
PL213	URB	City of Krakow	649	633	35	59
PL711	URB	City of Lódz	476	438	32	49
PL415	URB	City of Poznan	523	467	43	81
PL424	INT	City of Szczecin	813	730	57	91
PL911	URB/CAP	City of Warszawa	740	679	41	61
PL514	URB	City of Wroclaw	382	397	53	79
PL224	INT	Czestochowski	404	410	34	49
PL621	INT	Elblaski	647	657	32	53
PL623	INT	Elcki	583	536	80	136
PL634	INT	Gdanski	666	669	32	60
PL229	URB	Gliwicki	532	558	34	60
PL431	INT	Gorzowski	510	666	48	80
PL616	RUR	Grudziadzki	417	402	60	79
PL617	RUR	Inowroclawski	353	357	36	54
PL515	INT	Jeleniogórski	401	426	32	39
PL416	RUR	Kaliski	527	513	34	52
PL22A	URB	Katowicki	379	385	38	54
PL721	INT	Kielecki	629	628	35	55
PL414	RUR	Koninski	643	642	59	117
PL426	INT	Koszalinski	593	560	36	51
PL214	INT	Krakowski	453	448	53	84
PL821	RUR	Krosnienski	705	650	31	48
PL516	INT	Legnicko-glogowski	521	600	32	68
PL417	RUR	Leszczynski	401	370	28	40
PL712	URB	Lódzki	672	614	38	61
PL842	RUR	Lomzynski	756	776	48	68
PL814	INT	Lubelski	389	389	28	45
PL218	RUR	Nowosadecki	367	363	30	43
PL219	RUR	Nowotarski	184	189	33	52
PL523	RUR	Nyski	373	358	30	43
PL622	INT	Olsztynski	532	525	29	44
PL524	INT	Opolski	610	613	36	52
PL924	RUR	Ostrolecki	284	288	26	37
PL21A	INT	Oswiecimski	760	750	58	101
PL411	RUR	Pilski	455	594	29	49

Table 5 (continued)

Code	Types	Name	Population, thousand		GDP cap, PPS, EU14 = 100	
			2000	2019	2000	2019
PL713	RUR	Piotrkowski	329	335	31	50
PL923	RUR	Plocki	211	226	28	43
PL418	INT	Poznanski	414	432	32	51
PL822	RUR	Przemyski	802	683	46	88
PL815	RUR	Pulawski	374	388	32	56
PL921	INT	Radomski	607	584	35	62
PL227	URB	Rybnicki	463	446	30	46
PL823	RUR	Rzeszowski	386	360	29	48
PL722	RUR	Sandomiersko-jedrzejowski	790	760	34	52
PL925	RUR	Siedlecki	513	477	28	42
PL714	RUR	Sieradzki	316	301	25	40
PL715	RUR	Skierniewicki	672	622	25	35
PL636	INT	Slupski	716	712	36	61
PL22B	URB	Sosnowiecki	505	477	26	41
PL638	INT	Starogardzki	489	481	28	39
PL843	RUR	Suwalski	398	389	26	35
PL618	RUR	Swiecki	598	643	32	60
PL427	RUR	Szczecinecko-pyrzyki	615	614	30	50
PL428	INT	Szczecinski	504	513	36	56
PL824	RUR	Tarnobrzeski	426	395	25	44
PL217	RUR	Tarnowski	281	272	27	41
PL633	URB	Trójmiejski	1676	1783	116	200
PL22C	URB	Tyski	547	643	35	56
PL517	INT	Walbrzyski	498	643	54	96
PL912	INT	Warszawski wschodni	631	610	29	46
PL913	INT	Warszawski zachodni	347	340	32	51
PL619	RUR	Wloclawski	336	328	48	107
PL518	INT	Wroclawski	386	385	28	49
PL432	INT	Zielonogórski	425	419	27	51
PL926	RUR	Zyrardowski	265	259	33	57
Romania						
RO111	RUR	Bihor	621	561	21	51
RO112	RUR	Bistrita-Nasaud	326	278	18	46
RO113	INT	Cluj	720	708	26	88
RO114	RUR	Maramures	531	460	16	46
RO115	RUR	Satu Mare	390	332	17	49
RO116	RUR	Salaj	256	211	16	51
RO121	RUR	Alba	396	325	20	62
RO122	INT	Brasov	629	553	27	75
RO123	RUR	Covasna	231	202	24	46

Table 5 (continued)

Code	Types	Name	Population, thousand		GDP cap, PPS, EU14 = 100	
			2000	2019	2000	2019
RO124	RUR	Harghita	342	302	21	48
RO125	RUR	Mures	602	534	22	50
RO126	INT	Sibiu	444	401	23	69
RO211	RUR	Bacau	753	583	17	41
RO212	RUR	Botosani	464	378	13	33
RO213	INT	Iasi	837	793	18	51
RO214	RUR	Neamt	586	440	15	39
RO215	RUR	Suceava	717	624	16	38
RO216	RUR	Vaslui	467	373	10	29
RO221	INT	Braila	386	288	16	48
RO222	RUR	Buzau	505	412	16	43
RO223	INT	Constanta	746	673	29	69
RO224	INT	Galati	644	502	19	44
RO225	RUR	Tulcea	263	193	15	48
RO226	RUR	Vrancea	391	319	18	40
RO311	RUR	Arges	672	578	22	58
RO312	RUR	Calarasi	332	282	13	39
RO313	RUR	Dâmbovita	551	489	16	44
RO314	RUR	Giurgiu	294	265	12	30
RO315	RUR	Ialomita	304	255	16	48
RO316	INT	Prahova	856	715	22	60
RO317	RUR	Teleorman	457	332	15	38
RO321	URB/CAP	Bucuresti	2009	1833	52	168
RO322	URB	Ilfov	276	486	30	72
RO411	INT	Dolj	744	624	17	50
RO412	RUR	Gorj	395	314	23	68
RO413	RUR	Mehedinti	322	240	15	38
RO414	RUR	Olt	508	392	17	42
RO415	RUR	Vâlcea	431	349	19	51
RO421	INT	Arad	476	417	24	65
RO422	RUR	Caras-Severin	353	271	18	48
RO423	INT	Hunedoara	523	382	20	51
RO424	INT	Timis	689	706	27	82
Slovakia						
SK010	URB/CAP	Bratislavský	617	664	98	148
SK021	RUR	Trnavský	551	564	44	73
SK022	INT	Trenciansky	609	585	41	52
SK023	INT	Nitriansky	715	675	36	55

Table 5 (continued)

Code	Types	Name	Population, thousand		GDP cap, PPS, EU14 = 100	
			2000	2019	2000	2019
SK031	INT	Zilinský	693	691	35	57
SK032	RUR	Banskobystrický	662	646	35	46
SK041	RUR	Presovský	786	825	26	39
SK042	INT	Kosický	766	801	39	51

Source: Eurostat (2018)
CAP – capital; URB – predominantly urban (except capitals); INT – intermediate; RUR – predominantly rural.

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Data Availability The data used in this study was collected from publicly available sources.

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CORRECTION

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