Journal of Applied Economics

ISSN: (Print) (Online) Journal homepage: www.tandfonline.com/journals/recs20

Economic convergence of Balkan regions towards EU

María A. González-Álvarez, Antonio Montañés, Esther Ruiz & Skender Uku

To cite this article: María A. González-Álvarez, Antonio Montañés, Esther Ruiz & Skender Uku (2025) Economic convergence of Balkan regions towards EU, Journal of Applied Economics, 28:1, 2460149, DOI: 10.1080/15140326.2025.2460149

To link to this article: https://doi.org/10.1080/15140326.2025.2460149

Published online: 15 Feb 2025.

JOURNAL OF APPLIED ECONOMICS
2025, VOL. 28, NO. 1, 2460149
https://doi.org/10.1080/15140326.2025.2460149

Routledge
Taylor & Francis Group

RESEARCH ARTICLE

OPEN ACCESS Check for updates

Economic convergence of Balkan regions towards EU

María A. González-Álvarez[a], Antonio Montañés[a], Esther Ruiz[b] and Skender Uku[c]

[a]Department of Economics, University of Zaragoza, Spain; [b]Department of Statistics, Universidad Carlos III de Madrid, Spain; [c]Department of Economics, Agricultural University of Tirana, Albania

ABSTRACT

This paper analyzes convergence of per capita Gross Domestic Product (GDP) of Balkan NUTS3 regions to average GDP of the EU27. Employing stochastic and β-convergence approaches, we find strong evidence supporting convergence across the panel, indicating a robust catch-up trend of the Balkans with EU GDP with a significant break around the Great Recession. However, this pattern is not uniform across all individual regions, with some of them exhibiting divergence (mainly Greece and some regions in Croatia, Albania and Serbia). We also categorize groups of economies sharing similar divergence patterns. Additionally, among the regions that converge, convergence rates vary, with some regions progressing faster (Bulgaria, Montenegro and North Macedonia). Our results suggest the critical necessity for policy interventions to hasten the convergence process by encouraging substantial reforms. If regional disparities are addressed and balanced development is promoted, Balkan countries can achieve more robust integration into the European economic framework.

ARTICLE HISTORY
Received 17 August 2024
Accepted 24 January 2025

KEYWORDS
β-convergence; common factors; dynamic factor models; stochastic convergence; unit roots

1. Introduction

The creation of the European Union (EU) aimed to promote peace, stability, and prosperity in Europe after the devastating wars that took place in the continent during the 20th century. In addition, the EU sought to foster economic and political cooperation among European nations to ensure common economic growth and improve the living standards of its inhabitants.

Access to the EU is open to all European countries that respect the fundamental principles of the rule of law, as well as the values of liberty, democracy, human rights and basic freedoms. The EU was initially formed by the six signatory countries of the Treaty of Rome in 1959, and today is composed of 27 member countries and known as EU27. Currently, nine additional countries are candidates for membership, namely, Albania, Bosnia and Herzegovina, Georgia, Moldova, Montenegro, North Macedonia, Republic of Serbia, Turkey, and Ukraine, whilst the Republic of Kosovo is considered a potential candidate.

CONTACT Antonio Montañés amontane@unizar.es Department of Economics, University of Zaragoza, Spain

Among the candidate countries, all but Georgia, Moldova, and Ukraine, are located in the Balkan Peninsula, a geographical and cultural region in southeastern Europe that includes Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Greece, Kosovo, Montenegro, North Macedonia, Serbia, Slovenia, and parts of Romania and Turkey. This region, a vital part of European civilization with significant geostrategic relevance, seeks to regain its social and economic importance.

Most Balkan countries have recently sought to join structures such as the EU as part of their efforts to stabilize the region and promote economic and democratic development. This integration represents a significant milestone in the history of Europe. In particular, Greece has been a full member of the EU since 1981, Slovenia since 2004, Bulgaria and Romania since 2007, and Croatia since 2013. The remaining countries (Albania, Bosnia and Herzegovina, Kosovo, North Macedonia, Montenegro, Serbia, and Turkey), which are candidates for membership, must meet several convergence criteria, including the achievement of a relative equilibrium among their macroeconomic indicators and those of the EU27. In particular, income convergence is crucial for their integration into the EU due to its impact on the overall economic development and alignment with EU standards. Convergence in GDP is essential for creating a stronger and more cohesive union, enhancing the competitiveness of new members and strengthening the European single market, providing mutual benefits in terms of stability, growth, and development. To this end, in November 2023, the EU presented an aid plan to promote and accelerate the growth of Western Balkan economies and their convergence toward European standards.[1]

Most existing studies on the economic convergence of Balkan economies toward the EU use national-level data, examining convergence from an aggregate perspective; see, for example, the works by El Ouardighi and Somun-Kapetanovic (2007, 2009). However, aggregate data may obscure differences between various regions or provinces within a given country, a factor that should be considered since internal imbalances can affect the evolution of candidate countries and hinder their convergence toward the EU. Therefore, it is appropriate to analyze not only the behavior of each candidate country as a whole but also to assess whether convergence occurs uniformly across all regions or provinces within each country; see Le Pen (2011), Azomahou et al. (2011), and Montañés et al. (2018) for the importance of geographical disaggregation.

Against this background, this paper analyzes the convergence of *per capita* GDP of countries in the Balkan Peninsula toward average GDP of the EU27, using a panel of annual data disaggregated at the NUTS 3 level, as provided by Eurostat, from 2000 to 2021. The analysis is based on the concepts of stochastic and β-convergence proposed by Bernard and Durlauf (1995) and G. A. Carlino and Mills (1993, 1996). We provide strong evidence of convergence within the overall panel, highlighting a noticeable catching-up process of Balkan GDP with that of the EU27. However, when analyzing different regions or provinces separately, the results are not unanimous, with some economies displaying diverging patterns. Additionally, the pace of convergence varies, with some regions or provinces converging more slowly than others toward EU27 GDP average.

[1]Details of this Growth Plan for the Western Balkans can be found in the following e-address: https://neighbourhood-enlargement.ec.europa.eu/enlargement-policy/enhanced-eu-engagement-western-balkans_en.

Moreover, we find that differences between the GDP of various regions and the average GDP of the EU27 are cross-correlated, indicating the presence of common movements. Using Dynamic Factor Models (DFMs), we extract common factors from the panel of divergences, allowing us to identify groups of economies sharing similar patterns. By doing so, we can discern not only common patterns among regions but also whether all regions or provinces within a given country exhibit similar convergence behavior or display heterogeneous patterns of convergence.

The rest of this paper is organized as follows. Section 2 brief reviews the related literature. Sections 3 and 4 describe the methodology and the data, respectively. Section 5 is devoted to the empirical analysis of convergence. Section 6 concludes the paper with the most relevant conclusions and their policy implications.

2. A brief review of the related literature

Since the influential works of Barro and Sala-i-Martí (R. J. Barro & Sala-I-Martin, 1992; 1991), the literature on economic growth convergence has attracted a great deal of attention. In the case of Europe, Cuestas et al. (2021), Cartone et al. (2021), and Lähdemäki (2024), are recent important works analyzing economic growth convergence; see also Johnson and Papageorgiou (2020) and Tomal (2024) for detailed surveys of the literature. Evidence tends in general to support the presence of convergence among member states, with significant differences in the pace of this process; see, for example, Monfort et al. (2013).

In the specific case of the Balkan countries, the analysis of economic convergence has also attracted some interest among researchers. However, the volume of studies on the convergence between these countries and the European Union remains comparatively limited. Among the works that stand out for analyzing GDP convergence of Balkan countries towards the European Union average, El Ouardighi and Somun-Kapetanovic (2007, 2009) analyze β and σ-convergence, considering only a small group of countries observed over a sample period that ends before the Great Recession. They conclude that there is a certain degree of convergence, albeit with temporal variations. Similarly, Szeles and Marinescu (2010) and Eftimoski (2020) examine convergence in a large number Central, Eastern, and Southeastern European (CESEE) countries, that include some Balkan countries. They show that countries such as Albania, Belarus, Bulgaria, Croatia, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Macedonia, Moldova, Montenegro, Poland, Romania, Russia, Serbia, Slovakia, Slovenia, Turkey, and Ukraine have converged toward European standards during the period 1997–2016, highlighting factors such as democracy and foreign direct investment (FDI) as key drivers of this process; see also Gockov and Antoska (2019), who emphasize the need for Balkan countries to prioritize reforms in the agricultural and banking sectors to accelerate convergence, and Silak and Nagy (2002), who suggest greater trade openness and a reduction in negative indicators such as inflation, unemployment, public debt, and corruption. Finally, Grodzicki and Jankiewicz (2024) analyze the period 1997–2020, finding evidence in favor to the existence of slow convergence towards the EU.

The works on convergence described above are based on the standard concepts of β and σ-convergence, which may have inherent methodological limitations, casting doubts on some of their conclusions. In order to overcome these limitations, other studies use alternative econometric techniques as stochastic convergence, which is grounded in using unit root tests. In this regard, Tsanana et al. (2012) and Tsanana and Katrakilidis (2014), who analyze a sample including eight Balkan countries (Albania, Bulgaria, Croatia, North Macedonia, Greece, Romania, Serbia, and Slovenia) over a period spanning from the late 1990s to the years immediately following the Great Recession, conclude about a slow process of convergence toward the European average.

Conversely, the study by Kollias and Messis (2020), along with earlier works such as that of 'Estrin et al. (2001), do not find conclusive evidence of economic convergence between countries aspiring to join the European Union (Albania, Bosnia and Herzegovina, Georgia, Moldova, Serbia, North Macedonia, Turkey, Montenegro, and Ukraine) and the European average. However, they do identify a high degree of in-group convergence. Additionally, they emphasize the need to incorporate a structural break around 2008 to capture the effects of the Great Recession, as well as a marked heterogeneity in the behavior of the Balkan countries.[2]

In summary, the literature reveals a high degree of heterogeneity in the results. The lack of studies that disaggregate information territorially also stands out, limiting the identification of regional differences within the same country.

3. Methodology

In this section, we describe the methodology used to analyze convergence and the DFMs used to find common patterns of convergence.

3.1. Stochastic and β-convergence

The concept of convergence has received significant attention from economists. Since the pioneering works of Baumol (1986) and R. Barro et al. (1991), a vast literature has attempted to measure whether two or more economies converge. Among the most popular procedures for analyzing convergence are those based on stochastic and β-convergence, as proposed by Bernard and Durlauf (1995) and G. A. Carlino and Mills (1993, 1996); see Islam (2003), Johnson and Papageorgiou (2020), and Tomal (2024) for comprehensive reviews of the literature on convergence.

Define $y_{it} = \ln(GDP_{it})$, where GDP_{it} is the *per capita* GDP of the i-th region, for $i = 1, \ldots, N$, at period $t = 1, \ldots, T$, $y_t^* = \ln\left(GDP_t^*\right)$, where GDP_t^* is the benchmark GDP at time t, and $\delta_{it} = y_{it} - y_t^*$, the difference between them. G. A. Carlino and Mills (1993, 1996) suggest modelling this difference as follows

$$\delta_{it} = \alpha_i + \beta_i t + u_{it}. \tag{1}$$

Stochastic convergence occurs if u_{it} is a stationary zero mean noise. A particular case is the one of β-convergence. This occurs when a region that is initially above the benchmark grows more slowly than it or when this region is below the benchmark and grows faster

[2]See also Kollias and Messis (2022) for an analysis of political convergence of Balkan countries with similar conclusions. In particular, they analyse convergence of the Liberal democracy and the Civil liberties indexes.

than it.[3] If we take into account the specification presented in (1), β-convergence implies that either $\alpha_i < 0$ and $\beta_i > 0$, meaning the i-th region is growing faster than the benchmark GDP, or $\alpha_i > 0$ and $\beta_i < 0$, meaning the i-th region is growing slower than the benchmark GDP. We refer to these cases as C^+ and C^-, respectively. By contrast, when $\alpha_i < 0$ and $\beta_i < 0$, or $\alpha_i > 0$ and $\beta_i > 0$, the i-th region does not compensate its initial difference with respect to the benchmark GDP, resulting in divergence. We refer to these latter cases as D^- and D^+, respectively. Finally, $\beta_i = 0$ implies that the distance with respect to the benchmark GDP remains unchanged over time. This latter case can be understood as a weak case of conditional convergence and will be referred to as WC^+ and WC^-, when $\alpha_i > 0$ and $\alpha_i < 0$, respectively; see Bernard and Durlauf (1995) for the concept of conditional convergence.[4]

Testing for convergence requires first testing for stochastic convergence, i.e., whether u_{it} is I(1) against the alternative of being I(0). Two alternative procedures can be used for testing for unit roots in this context. First, one can test for unit roots individually in each region by using the residuals $\hat{u}_{it}$ of the regression of δ_{it} on a constant and a deterministic trend. For this, we consider the GLS version of the standard Dickey–Fuller test as proposed by Elliott et al. (1996). To account for the potential effect of structural breaks on the GLS unit root test, we also use the test proposed by Carrion-I-Silvestre et al. (2009).

Second, if there is cross-sectional dependence among u_{it}, it is more efficient to test for unit roots using panel data unit root statistics; see, for example, Carrion-I-Silvestre and Soto (2007). In this case, we initially test for the presence of cross-sectional dependence using the tests proposed by Pesaran (2015, 2021), denoted as CD, Juodis and Reese (2022), denoted as CDw, and Fan et al. (2015), denoted as CDw+. If evidence against the null hypothesis of no cross-sectional dependence is found, we test for panel unit roots using the test proposed by Pesaran (2007). Finally, to consider the possible consequences of omitting breaks in the trend, we also use the test proposed by Karavias and Tzavalis (2014).[5]

After testing for stochastic convergence, one should analyse the presence of β-convergence by considering the signs of the estimated $\hat{\alpha}_i$ and $\hat{\beta}_i$ parameters according to the descriptions above. To that end, we estimate model (1) in each NUTS 3 region using the method proposed by Prais and Winsten (1954) to account for the potential presence of correlation in the perturbation.[6]

3.2. Common factors

The analysis of convergence described above can determine whether a given region converges to the benchmark GDP. Additionally, rejecting the null hypothesis of no

[3]See Barro and Sala-i-Martin (R. J. Barro & Sala-I-Martin, 1992; 1991) for the concepts of β-convergence, and catching-up.
[4]Alternatively, Carvalho and Harvey (2005) propose a model for convergence based on assuming stochastic instead of deterministic trends for the differences between ln(GDP) in a given regions and the benchmark ln(GDP). The convergence mechanism operates on both the gap in the level, α_i, and the gap in the growth rate, β_i; see also the discussion by Carvalho et al. (2007). However, in this paper, given that the data is annual and observed over a relatively short span of time, assuming deterministic trends may be a close enough approximation.
[5]Alternatively, one can use the test by Bai and Carrion-I-Silvestre (2009).
[6]Following Kiefer and Vogelsang (2005), we also consider HAR methods to estimate model (1). These results are not reported given that they are qualitatively similar to those presented in this paper.

cross-sectional dependence suggests common movements among different NUTS 3 regions. In this case, it is also of interest to analyse whether groups of regions share the same pattern of convergence. To this end, we fit DFMs to the system $D_t = (\delta_{1t}, \ldots, \delta_{Nt})$ and extract the common factors using Principal Components (PC); see Bai and Ng (2008) and Stock and Watson (2011) for useful surveys on DFMs and PC. The existence of common factors can help understanding the similarities and differences between the patterns of the convergence of the NUTS 3 regions.

Consider the following DFM for the variables in D_t

$$D_t = \Lambda F_t + \varepsilon_t, \qquad (2)$$

where Λ is the $N \times r$ matrix of factor loadings, $F_t = (F_{1t}, \ldots, F_{rt})$ is the $r \times 1$ vector of underlying unobserved factors at time t, and ε_t is the $N \times 1$ vector of idiosyncratic components, which are allowed to be weakly cross-sectionally correlated but uncorrelated with the factors, F_t. The idiosyncratic components are assumed to be white noise with covariance matrix Σ_ε.To uniquely identify the factors and loadings, we assume, as usual in this literature, that $\frac{FF}{T} = I_r$, where $F = (F_1, \ldots, F_T)$ is an $r \times T$ matrix, and $\Lambda\Lambda$ is diagonal with its elements ordered from largest to smallest. The number of factors, r, is determined using the procedure proposed by Alessi et al. (2010). The PC factors, $\hat{f}_t$ are given by $\sqrt{T}$ times the eigenvectors corresponding to the r largest eigenvalues of DD arranged in decreasing order while the loadings are estimated as $\hat{\Lambda} = \frac{1}{T}\hat{f}D$, with $D = (D_1, \ldots, D_T)$. The asymptotic distribution of the loadings is derived by Bai (2003) as follows

$$\sqrt{T}\left(\hat{\lambda}_i - \lambda_i\right) \sim N(0, \Omega_i), \qquad (3)$$

where λ_i is the i'th row of Λ and $\hat{\lambda}_i$ is its corresponding PC estimator. Furthermore, if the idiosyncratic components are serially homoscedastic and uncorrelated, then $\Omega_i = \sigma_i^2 I_r$ with I_r being the $r \times r$identity matrix, and σ_i^2 being the i'th element of the main diagonal of Σ_ε.

4. Data

Annual *per capita* GDP of the EU27 (GDP_t^*), measured in Purchasing Power Standards (PPS), with 2020 as the reference year is collected from Eurostat from 2000 to 2021. Additionally, we obtain annual *per capita* GDP (GDP_{it}) for the 157 NUTS 3 regions considered as a part of the Balkan area, also measured in 2020 PPS. Specifically, the database comprises the 28 Bulgarian (BG) oblasts, 52 Greek (GR) prefectures, 21 Croatian (HR) counties, 12 Slovenian (SI) statistical regions, the single Montenegrin (ME) NUTS 3, 8 North Macedonian (MK) statistical regions, 18 Serbian (RS) districts (including the region that incorporates the city of Belgrade), and 12 Albanian (AL) counties. We have also included two Romanian (RO) counties and three Turkish (TR) provinces, as they are clearly part of the Balkan region. Since these areas constitute a very small portion of their respective countries (less than 7%), we have opted to exclude the remaining NUTS 3 regions of Romania and Turkey. Table A1 provides a detailed list of the NUTS 3 regions included.[7]

Table 1 reports some descriptive statistics for GDP_t^* and GDP_{it}, for three particular years, namely, 2000, 2010 and 2021. Furthermore, descriptive statistics for annual average growth rates, calculated as $\left(\frac{GDP_{T_1}}{GDP_{T_0}}\right)^{(T_1-T_0)^{-1}} - 1$, where T_0 and T_1 are the initial and final years of the period considered, respectively, are also reported for the full sample (years 2000 to 2021), the periods before the Great Recession (years 2000 to 2009), and after the Great Recession (years 2010 to 2019), and the last 2 years in the sample (years 2019 to 2020); see also Table A1 in the Appendix for disaggregated information of the NUTS 3 regions in the sample.

The results reported in Table 1 offer some interesting insights. First, we observe that the GDP in the Balkans over the full sample period from 2000 to 2021 exhibits an average annual growth rate of 3.3%, which is slightly greater than that of the EU (2.8%). However, this growth has not been stable across time, with average growth rates of 4.6% and 2.3% for the periods before and after the Great Recession, respectively. Furthermore, when considering the distribution of the average growth rate among the NUTS 3 regions, there is considerable heterogeneity, with the average growth rate of the lowest percentile being much lower than that of the uppermost one. Additionally, the average growth rates of the uppermost percentiles (50%, 75%, and 95%) are consistently higher than those of the EU27 across all periods considered, whereas the growth rates of the lower percentiles (5% and 25%) are always below those of the EU27.

Comparing the percentiles with the average GDP value of the EU27, we see that the GDP of the 5% and 25% percentiles represent 17% and 24% of the EU GDP at the beginning of the sample period, respectively, increasing to 23% and 35% by the end of the sample period. Conversely, the GDP of the 75% and 95% percentiles decreased from 68% to 101% at the beginning of the sample period to 57% and 84%, respectively.

Table 1. Descriptive statistics of GDP in Balkan regions/provinces.

	GDP			Growth			
	2000	2010	2021	00–21	00–09	10–19	19–21
Average	9,045	13,074	16,079	3.3%	4.6%	2.3%	3.8%
CV	60	55	43	62	43	100	125
$p_{0.05}$	3,163	4,675	7,500	0.3%	2.0%	−1.5%	−2.7%
$p_{0.25}$	4,350	6,700	11,475	1.2%	3.3%	0.1%	0.7%
$p_{0.50}$	7,230	12,250	14,550	3.7%	4.3%	2.9%	3.5%
$p_{0.75}$	12,525	17,725	18,500	5.0%	5.9%	4.1%	5.9%
$p_{0.95}$	18,575	26,200	27,600	5.9%	7.5%	5.3%	11.0%
min	2,420	3,900	6,100	−1.0%	−1.0%	−2.5%	−5.5%
max	25,400	41,300	43,100	8.9%	11.5%	7.0%	32.3%
Average EU	18,400	24,100	32,700	2.8%	3.0%	2.6%	2.2%

This Table reports descriptive statistics of *per capita* GDP (PPS from 2020) of the 157 Balkan NUTS 3 (columns 2 to 4) at years 2000, 2010 and 2021, and of average annual growth for the periods 2000–2021 (00–21), 2000–2009 (00–09), 2010–2019 (10–19), and 2019–2021 (19–21): Average, coefficient of variation (CV), 5% percentile ($p_{0.05}$), 25% percentile ($p_{0.25}$), 50% percentile ($p_{0.50}$), 75% percentile ($p_{0.75}$), and 95% percentile ($p_{0.95}$).

[7]Data of the NUTS 3 incorporated in the region of Vojvodina and the ones of the Kosovo Republic are not included due to the absence of information about them. Furthermore, data for the Albanian regions from 2000 to 2007, for Montenegro in 2001, and for the Turkish provinces from 2000 to 2003 have been estimated using the evolution of the corresponding national GDP.

Finally, the median GDP of the Balkan NUTS 3 regions/provinces increased from 39% to 44% of the EU GDP, while the coefficient of variation decreased from 59.6% to 43.5%, suggesting some degree of convergence of the Balkan NUTS 3 GDP towards the average EU GDP.

5. Empirical analysis

In this section, stochastic and β-convergence is analyzed using both aggregate and disaggregate data on GDP in the Balkan Peninsula. We also analyze the commonality of the convergence in different regions/provinces by using DFMs.

5.1. Stochastic convergence in the Balkan NUTS 3

To analyze the possible existence of stochastic convergence, we begin by testing for the presence of unit roots around a deterministic trend in δ_{it}.[8]

Table 2 reports the statistics of the tests proposed by Pesaran (2015), CD, Juodis and Reese (2022), CDw, and Fan et al. (2015), CDw+, for testing the null hypothesis of no cross-sectional dependence in the residuals obtained using Dickey–Fuller regressions with fixed effects and 1 and 2 lags. The evidence overwhelmingly rejects the null hypothesis of no cross-dependence, particularly when using the CDw+ test. Therefore, we also test for stationarity of u_{it} using the panel data unit root tests.

Table 3 reports the tests proposed by Pesaran (2007), CIPS, for $l = 0, 1,$ and 2 lags, and by Karavias and Tzavalis (2014), KT, when allowing for one structural break, $M = 1$.[9] When considering all NUTS 3 jointly, the CIPS statistics cannot reject the null hypothesis of unit root. However, if we account for a break in the deterministic trend, the evidence against the null hypothesis is very strong regardless of whether the test includes a constant or a deterministic trend. The results are qualitatively very similar when

Table 2. Cross-sectional dependence.

	N	CD	CDw	CDw+	CD	CDw	CDw+
		I			II		
Total Panel	156	54.1***	0.9	1,242***	56.8***	1.4	1,292***
Bulgaria	28	2.0*	0.6	35.6***	2.0**	0.6	36.5***
Greece	52	27.6***	−0.1	300.0***	22.5***	0.0	249.7***
Croatia	21	2.9***	0.7	31.1***	2.8***	0.6	31.6***
Romania	2						
Slovenia	12	1.3	−0.0	13.6***	1.1	−0.0	12.4***
Montenegro	1						
North Macedonia	8	0.1	0.1	2.9***	0.1	0.0	2.7***
Albania	12	1.1	−0.2	11.4***	0.9	−0.1	9.3***
Serbia	17	0.9	0.2	11.9***	0.8	0.2	12.0***
Turkey	3						

This table reports statistics for testing for the null hypothesis of lack of weak cross-dependence: CD, CDw, and CDw+. N is the number of NUTS 3 in each country. Panels I and II use the residuals of a panel Dickey–Fuller with fixed effects and 1 and 2 lags, respectively. *points the statistics significant at the 10% significance level and ** those significant at the 5% level, and *** those significant at the 1% level.

[8]The computations in this paper have been carried out by using the software programme Stata.
[9]The test proposed by Perron and Yabu (2009) offers evidence in favour of the presence of a break in the trend with the estimated timing of this break consistently occurring around 2008. We omit it for the sake of brevity.

Table 3. Testing for stochastic convergence using panel data unit root statistics.

	CIPS			KT
	L = 0	L = 1	L = 2	*M* = 1
No trend				
Total Panel	−1.06	−1.21	−0.83	−6.74***
Bulgaria	−2.58***	−2.00	−2.17**	−21.37***
Greece	−2.07*	−1.90	−1.47	−37.79***
Croatia	−2.18**	−1.78	−1.29	−11.28***
Romania	−1.72	−0.35	−1.19	−8.08***
Slovenia	−1.85	−2.06	−1.64	−8.86***
Montenegro				
N.Macedonia	−3.32	−2.07	−1.58	−14.13***
Albania	−3.00	−3.58***	−3.13***	−13.20***
Serbia	−2.11*	−2.27**	−2.07	−10.31***
Turkey	−0.85	−0.33	−0.62	−9.78***
Trend				
Total Panel	−2.42	−2.18	−1.88	−10.41***
Bulgaria	−2.73**	−2.25	−2.30	−6.08***
Greece	−2.37	−2.00	−1.52	−15.07***
Croatia	−2.76***	−2.34	−1.96	−8.71***
Romania	−4.22***	−3.06***	−5.03***	−3.44***
Slovenia	−2.32	−2.77**	−2.52	−6.45***
Montenegro				
N.Macedonia	−3.58***	−2.54	−1.89	−6.50
Albania	−3.05***	−3.32***	−2.46	−5.78
Serbia	−1.90	−20.0	−1.62	−2.78
Turkey	−1.10	−0.81	−0.71	−3.82

This table reports the CIPS and KT statistics for testing the panel data unit root null hypothesis, with L lags, and with M breaks, respectively. *points the statistics significant at the 10% significance level and ** those significant at the 5% level, and *** those significant at the 1% level.

grouping the NUTS 3 regions by country. However, note that, when considering the KT test with a deterministic trend, the null hypothesis cannot be rejected.

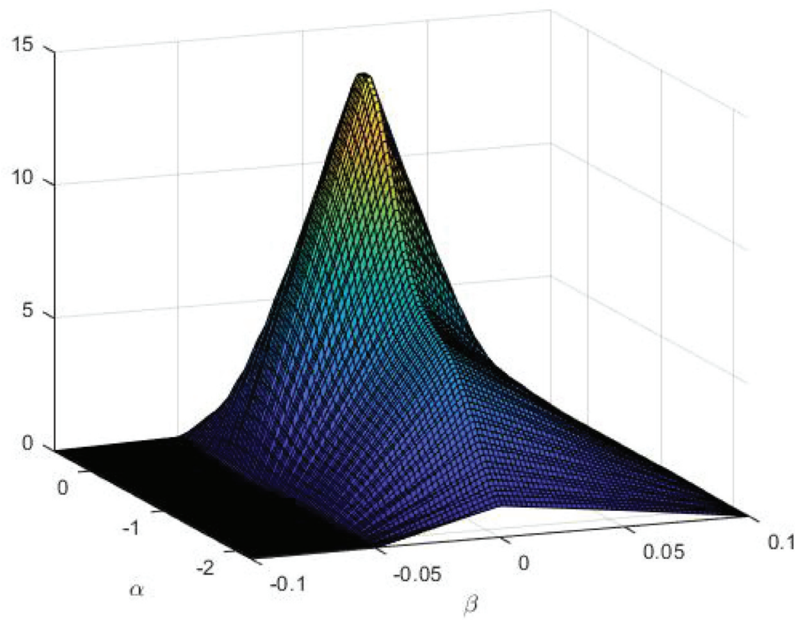
Additionally, the results of the unit root tests for each NUTS 3 region separately are reported in Table A2 in the Appendix. The unit root null hypothesis is mostly rejected for the NUTS 3 regions when accounting for a single break. Moreover, if we include a second break, the null hypothesis is almost unanimously rejected, except in the NUTS 3 regions of Jugozapaden (MK003) and Beogradski (RS100). Therefore, the evidence in favor of stochastic convergence is overwhelmed.

This initial analysis provides strong evidence of the existence of stochastic convergence in the Balkan regions/provinces. Next, we test for the existence of β-convergence by analyzing the signs of the estimation of the parameters of model (1). Given the presence of a break clearly related to the Great Recession (GR), we split the sample into two periods. The estimates $\hat{\alpha}_i$ and $\hat{\beta}_i$corresponding to the pre-GR sample and to the post-GR sample are reported in Table A2 of the Appendix for each region. Figure 1 plots bivariate kernel estimates of their empirical densities for the pre- and post GR periods.

The results differ significantly between the pre- and post-GR periods. In the pre-GR period, most of the estimated values of the parameter α_i are negative. By contrast, the estimates of the slope are more heterogeneous: 58% are positive, 11% are negative, and the remaining 31% are not statistically different from zero.[10] This implies that most of the

[10]Note that we employ the 10% significance level to report the results of this Section. Qualitatively similar results are obtained using the 5% significance level.

Panel a.2000-2009.



Panel b. 2010-2021.

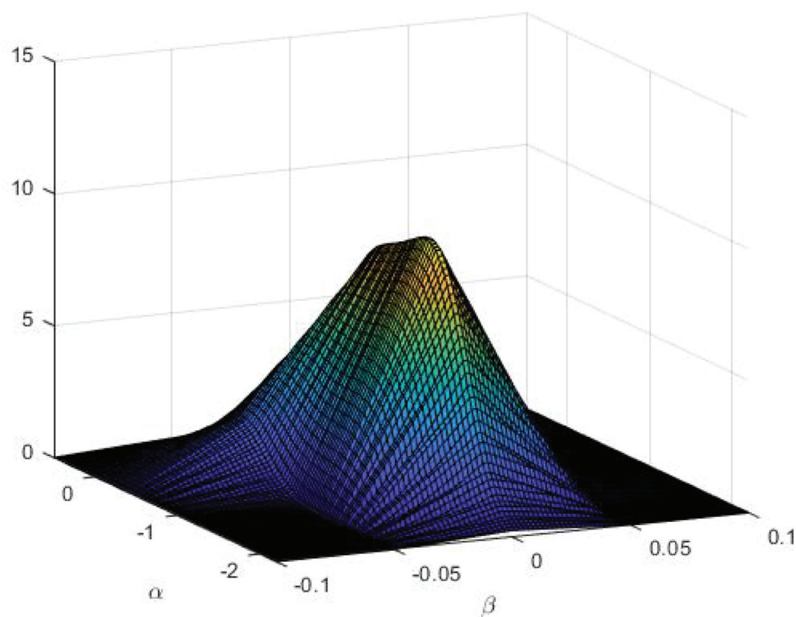


Figure 1. Bivariate Kernel of the estimates of the parameters of the time trend regression.

NUTS 3 regions follow either a C+ convergence process (53.5%) or a CA- one (28.7%), reflecting the fact that the GDP of the Balkan NUTS 3 is lower than that of the EU27 in this period. Notably, 16 NUTS 3 regions follow a D- process, with most located in Greece. Conversely, seven NUTS 3 regions exhibit a D+ process, around the Athens area (EL301, EL303, EL304, EL305 and EL306), the Greek prefecture that contains the Cyclades (EL422) and the Slovenia capital region (SI041).

In the post-GR period, there is a leftward shift in the estimated $\hat{\alpha}_i$ and $\hat{\beta}_i$ parameters, indicating that the GR has slowed the convergence toward the EU standards. This is further confirmed by the increased number of NUTS 3 regions with negative values of $\hat{\beta}_i$ estimates (55 compared to 18 in the pre-GR period). Consequently, the number of regions showing positive catching-up process ($\hat{\alpha}_i < 0$ and $\hat{\beta}_i > 0$) slightly decreases, as does the number showing absolute convergence. Conversely, the number of regions exhibiting negative divergence ($\hat{\alpha}_i < 0$ and $\hat{\beta}_i < 0$) increases. These shifts are largely driven by Greek NUTS 3 regions, which have transitioned massively from convergence to negative divergence, highlighting the impact of the GR on the Greek economy.

The final picture from this analysis is as follows: Bulgaria, Montenegro, North Macedonia, and the Balkan NUTS 3 regions of Romania and Turkey show a clear convergence process toward the EU27, while Greece clearly diverges. Croatia, Albania, and Serbia display heterogeneous behavior, with similar number of convergent and non-convergent NUTS 3 regions. On the other hand, most NUTS 3 regions in Slovenia clearly converge toward EU27 standards, although Central Sava (SI035) and Coastal – Karst (SI044) diverge, and Central Slovenia (SI041), which includes the capital, shows a WC+ process; see Figure 2 for a map with a summary of the convergence results in all NUTS 3 considered.

In summary, there is a generalized process of slow convergence of the Balkan NUTS 3 GDP toward the EU level, as highlighted by previous studies. However, it is crucial to note that these studies often use aggregate data, overlooking the heterogeneous behavior within each country. Our results suggest that understanding these internal differences is vital. Economic policies should consider these disparities and design incentives to ensure that no NUTS 3 regions lag behind in the convergence process.

5.2. Commonality and heterogeneity in the convergence of Balkan NUTS 3

The previous results show that the GDP of most Balkan NUTS 3 seems to converge towards the average EU27 GDP with this convergence changing somehow after the GR. Furthermore, there is significant cross-sectional correlation among δ_{it} in different regions, implying some commonality in their evolution. Additionally, there is noticeable heterogeneity among the NUTS 3 regions. To disentangle the common and heterogeneous movements in δ_{it}, we extract common factors from the system of all NUTS 3 regions. By doing so, we are able to detect whether the convergence process is similar in all NUTS 3 regions or if it follows different routes in different groups of regions/provinces. Furthermore, we can analyze whether the convergence is common or heterogeneous within a given country.

The number of common factors was selected using the procedure proposed by Alessi et al. (2010). Figure 3, which plots the S_C and $r^{*T}_{c,N}$ statistics, suggests 3 common factors. The estimated three PC factors, which explain 88.3% of the total variability, are plotted in Figure 4.

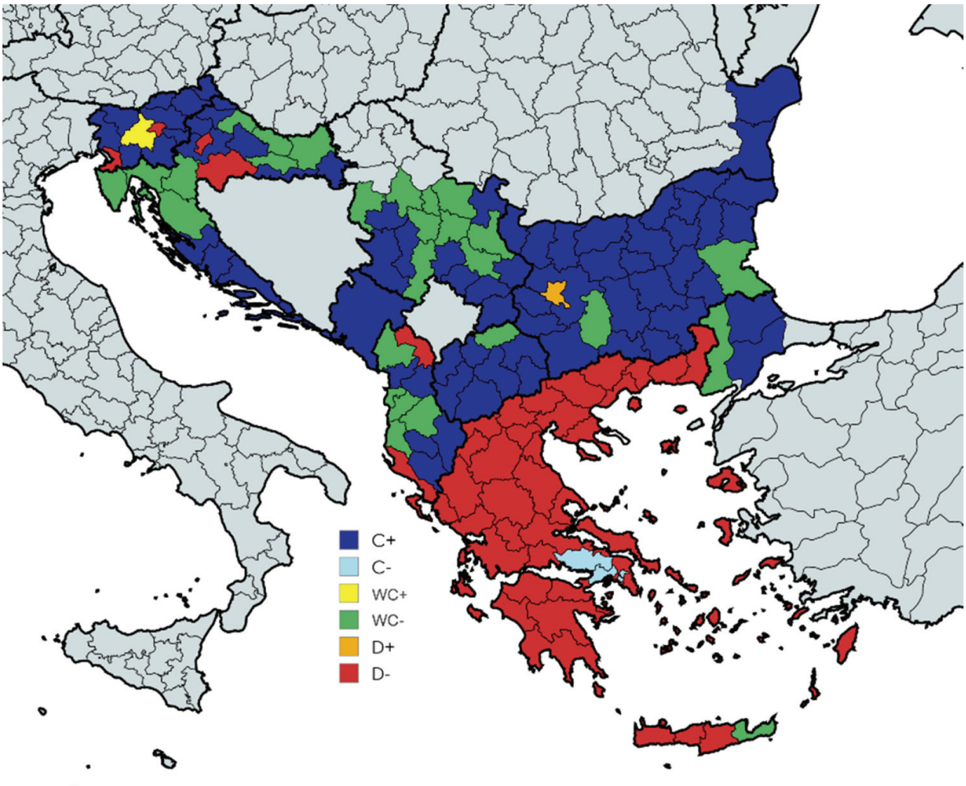


Figure 2. Convergence map of NUTS 3 regions in the Balkan Peninsula. C^+ and C^- means that $\alpha_i < 0$ and $\beta_i > 0$ and $\alpha_i > 0$ and $\beta_i < 0$ in (1), respectively. D^+ and D^- implies that $\alpha_i < 0$ and $\beta_i < 0$ and $\alpha_i > 0$ and $\beta_i > 0$ in (1), respectively. WC^+ and WC^- means the case where $\beta_i = 0$ and, additionally, $\alpha_i > 0$ and $\alpha_i < 0 in(1)$, respectively.

The first factor, F_{1t}, shows an upward trend with an approximately constant slope and a break after the GR. We can also observe an increase in the most recent years following the COVID-19 pandemic, which can be associated with a positive convergence process. The temporal evolution of the second factor, F_{2t}, is more erratic. It increases until 2008 with a slope that is larger than that of F_{1t}. However, between 2008 and 2016, it decreases, suggesting some divergence. Finally, after 2016, F_{2t} again shows a positive increase. The third factor, F_{3t}, has a strong positive trend until the GR, after which it decreases. The GR clearly affects the convergence patterns of the GDP of the NUTS 3 towards the average GDP of the EU27.

Figure 5 plots the estimated PC loadings for each of the three factors that are significant at the 10% level, according to the asymptotic distribution in (4), with σ_i^2 estimated using the sample variance of the idiosyncratic components, $\hat{\varepsilon}_{it} = \delta_{it} - \sum_{j=1}^{3} \hat{\lambda}_{ji}\hat{f}_{jt}$.[11]

The main conclusion is that a large percentage of NUTS 3 regions load positively only on the first factor, with the corresponding estimated loadings being close to 1.

[11]Note that we employ the 10% significance level to report the results of this Section. Qualitatively similar results are obtained using the 5% significance level.

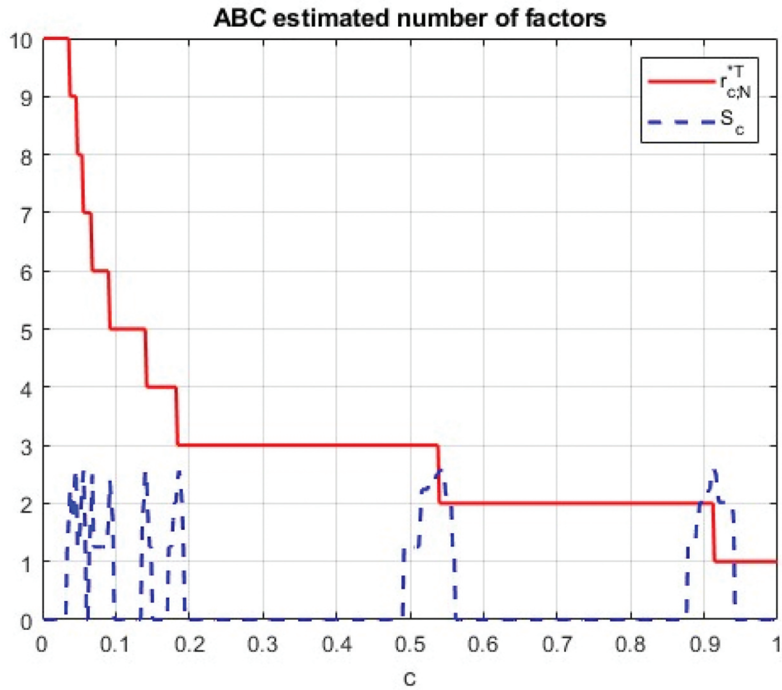


Figure 3. ABC criteria. This figure plots the statistics proposed by Alessi et al. (2010) to determine the number of common factors.

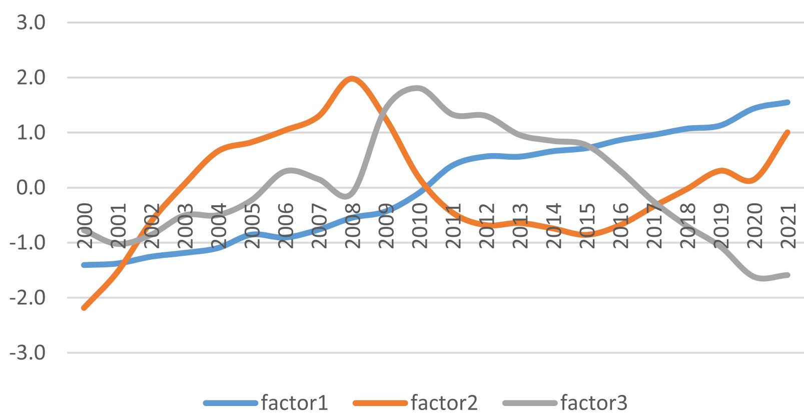


Figure 4. Estimated PC factors for δ_{it}.

Therefore, they have a positive catching-up process, as concluded in the previous section. In particular, all NUTS 3 regions in Montenegro, North Macedonia, Romania, and Turkey load only on the first factor, with convergence patterns closely following this factor; see Figure 6, which plots the common components estimated for each NUTS 3 region within these countries. Even though some NUTS 3 regions in Bulgaria also have significant loads on the second and third factors, their convergence paths are similar to that observed when the convergence depends only on the first

a) First factor

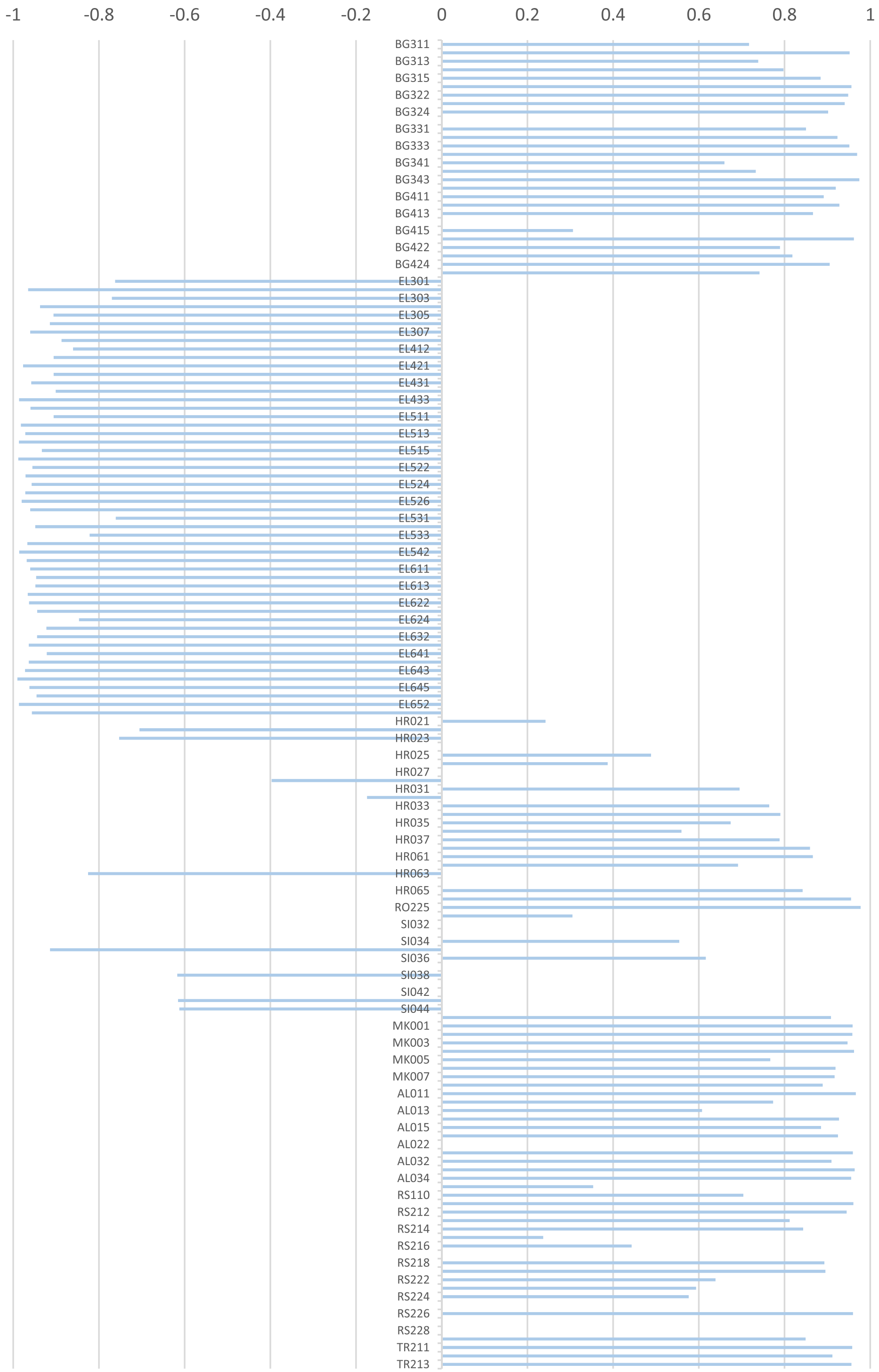


Figure 5. Factor loadings.

b) Second factor

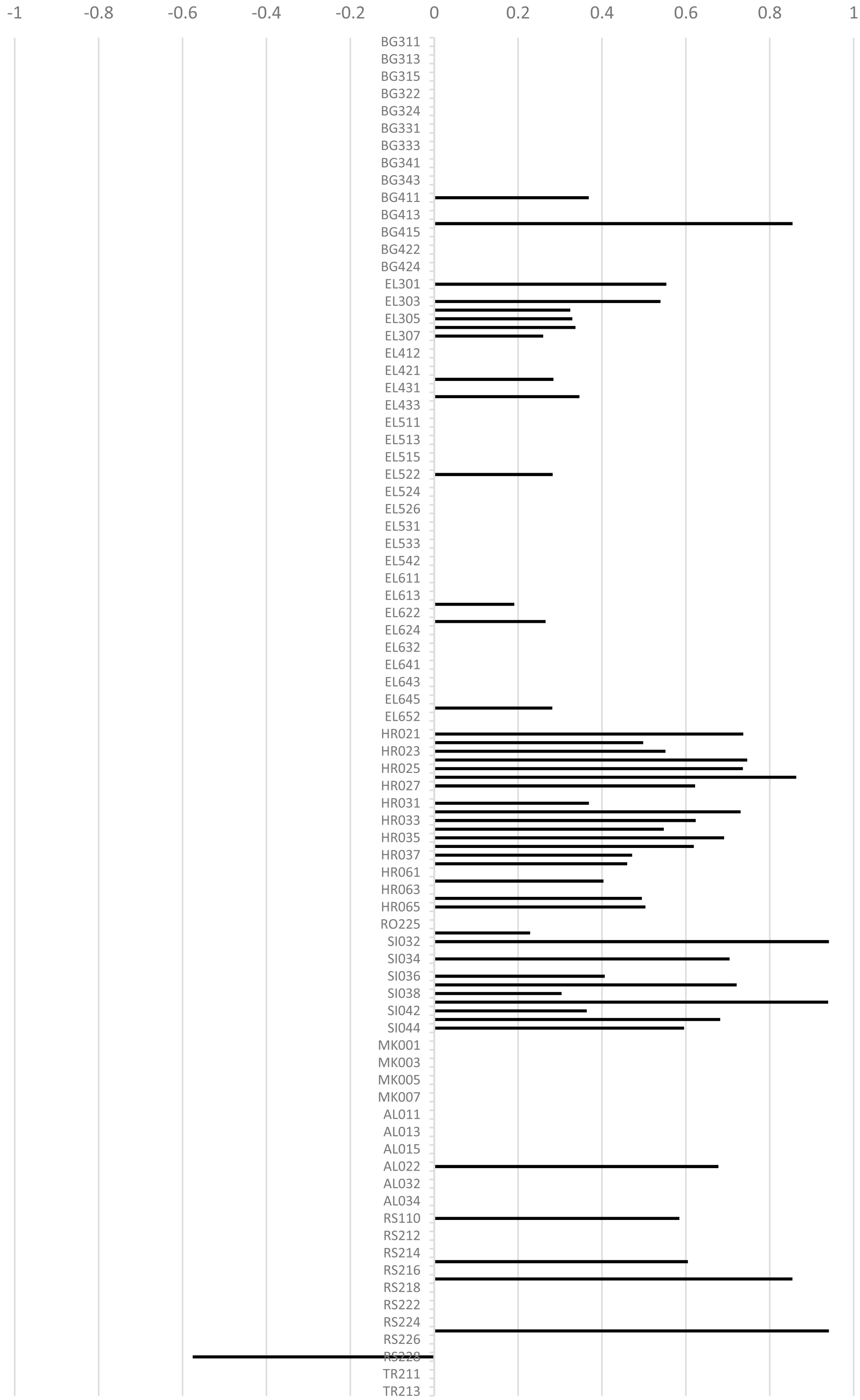


Figure 5. (Continued).

c) Third factor

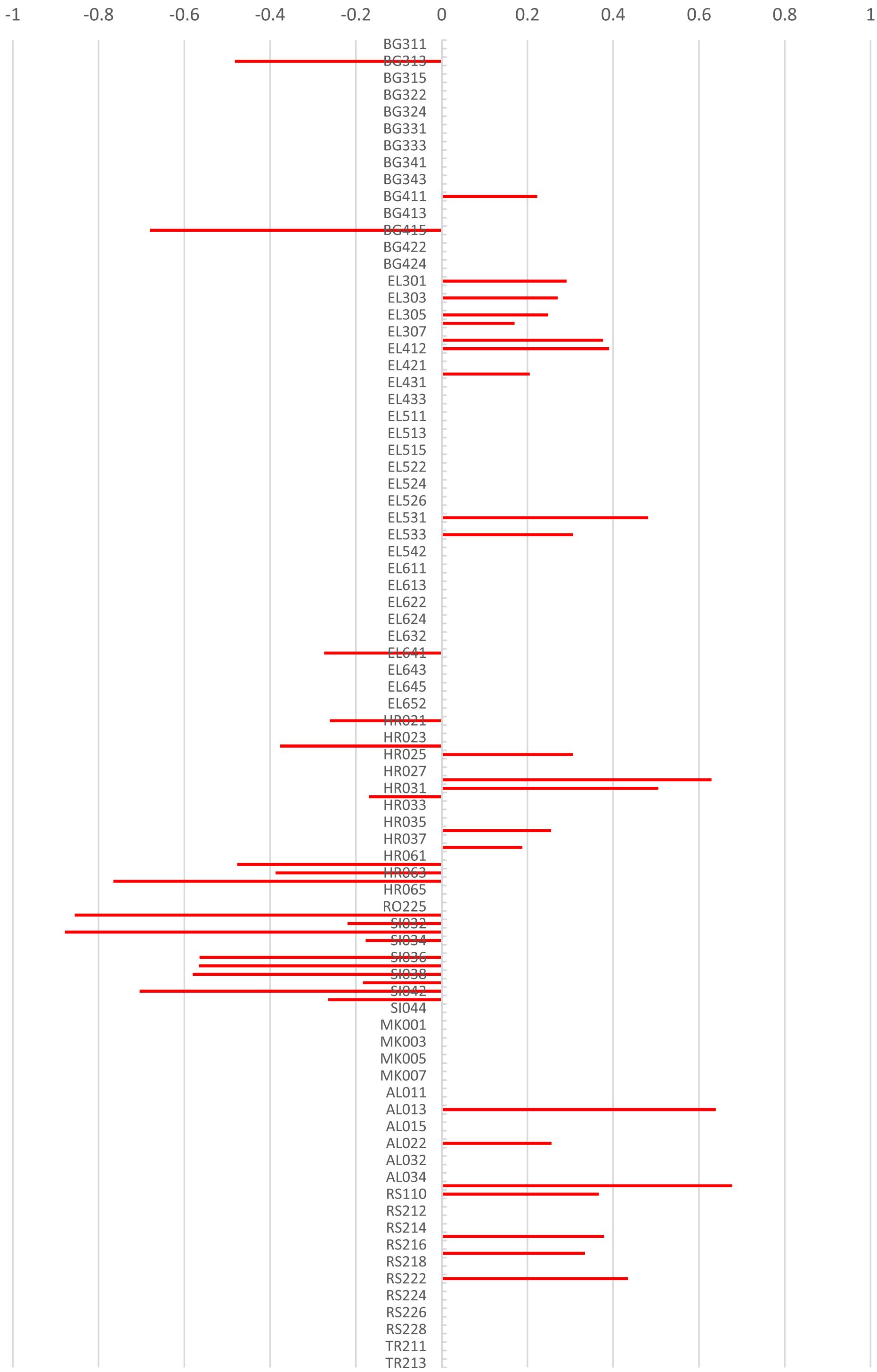
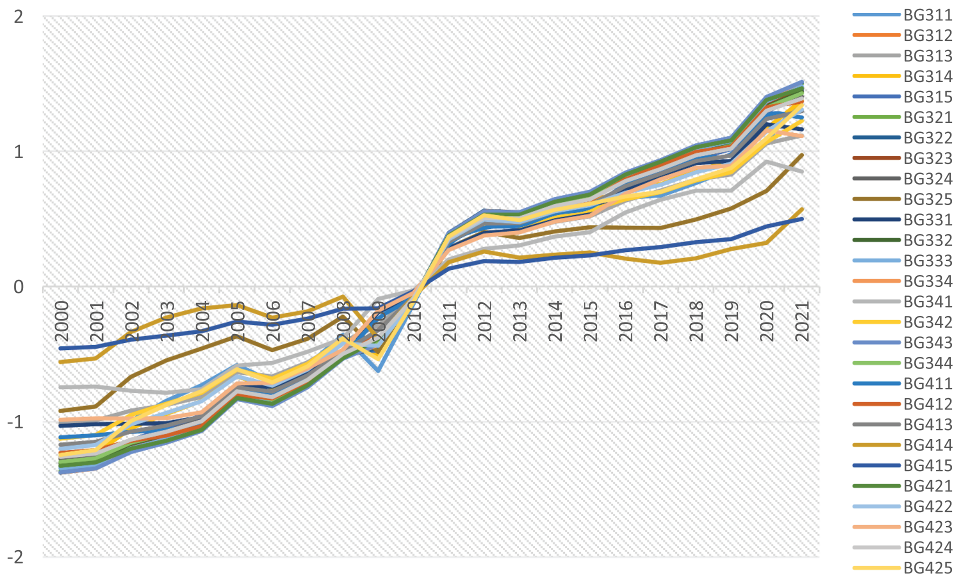


Figure 5. (Continued).

(a) Bulgaria



(b) Greece

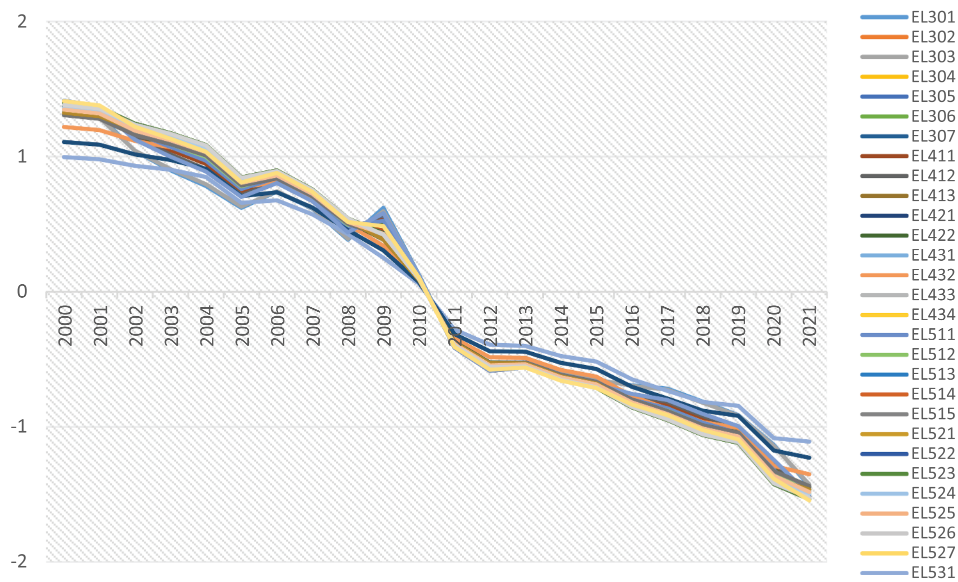
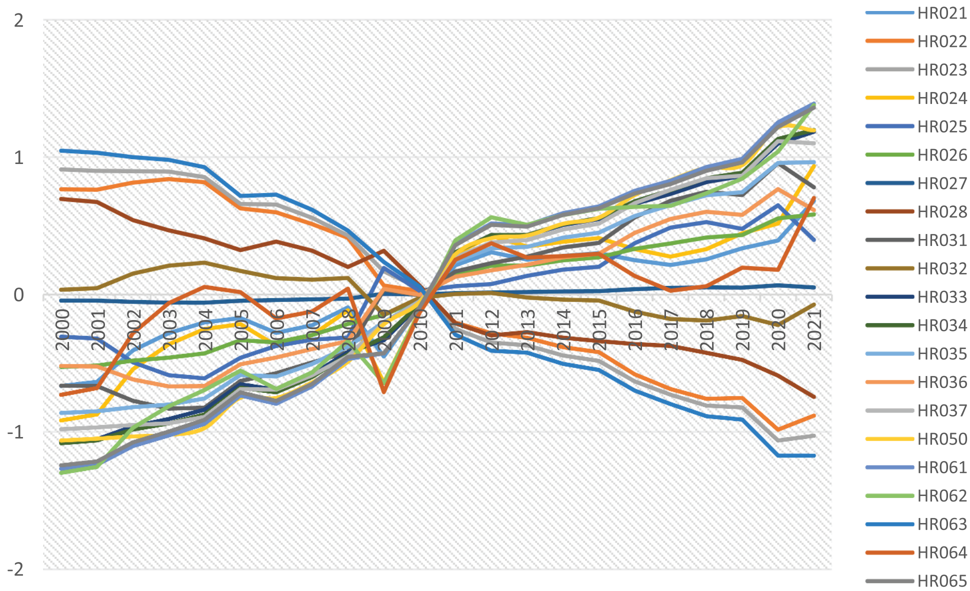


Figure 6. Common components for different NUTS 3 in a given country.

factor, although with slightly more heterogeneity in the rates of convergence (see panel (a) of Figure 6).

A remarkable case is that of Greece. Figure 5 shows that all Greek NUTS 3 regions load mainly on the first factor but with negative loadings. Therefore, it seems that the GDPs of Greek NUTS 3 are diverging from the average EU GDP. This pattern is confirmed in

(c) Croatia



(d) Romania

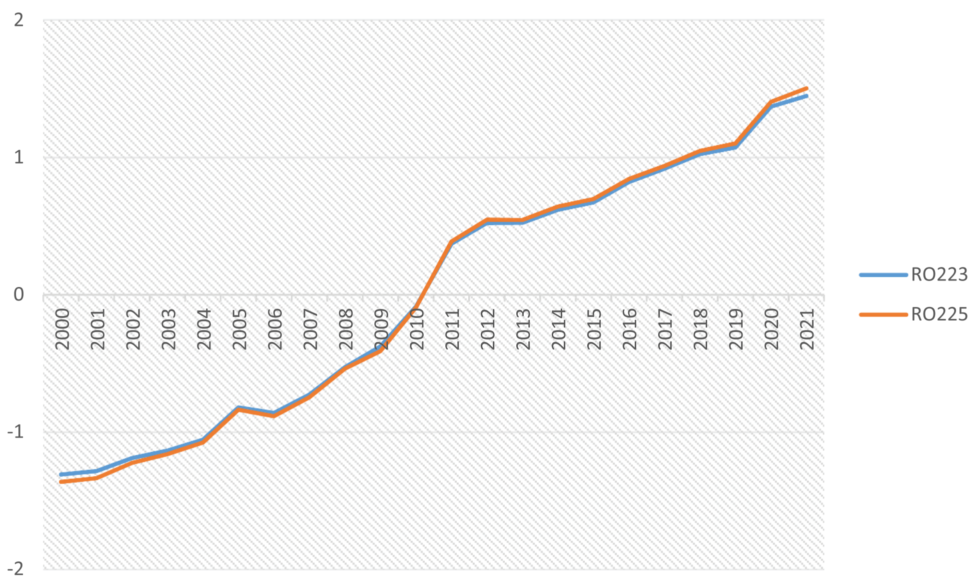
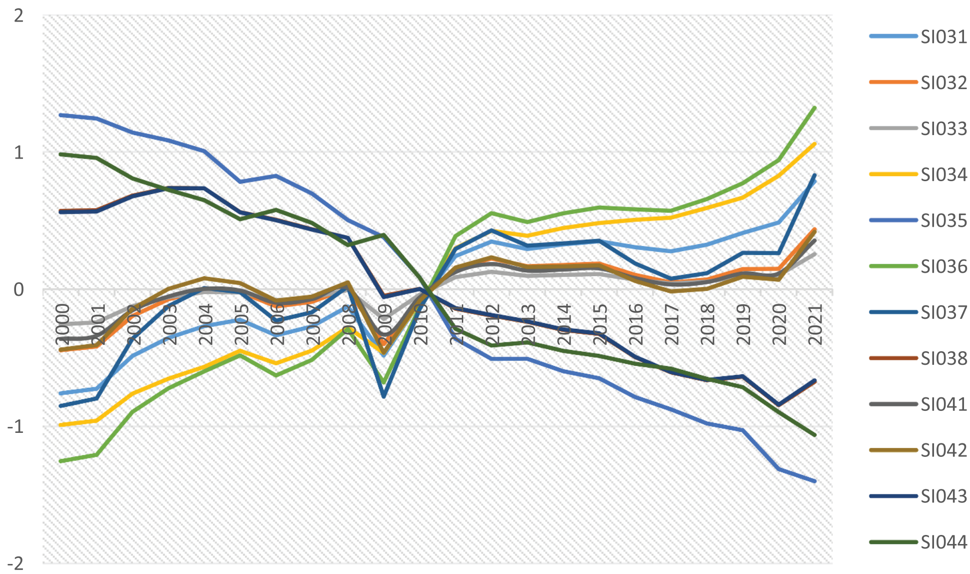


Figure 6. (Continued).

panel (b) of Figure 6, where we can observe that the estimated common components of the Greek NUTS 3 regions show a very clear downward trend.

Finally, Figure 5 shows significant heterogeneity in the convergence of NUTS 3 regions in Croatia, Slovenia, Albania, and Serbia; see panels (c), (e), (h) and (i) of Figure 6, which plot the corresponding common factors. The analysis of these

(e) Slovenia



(f) Montenegro

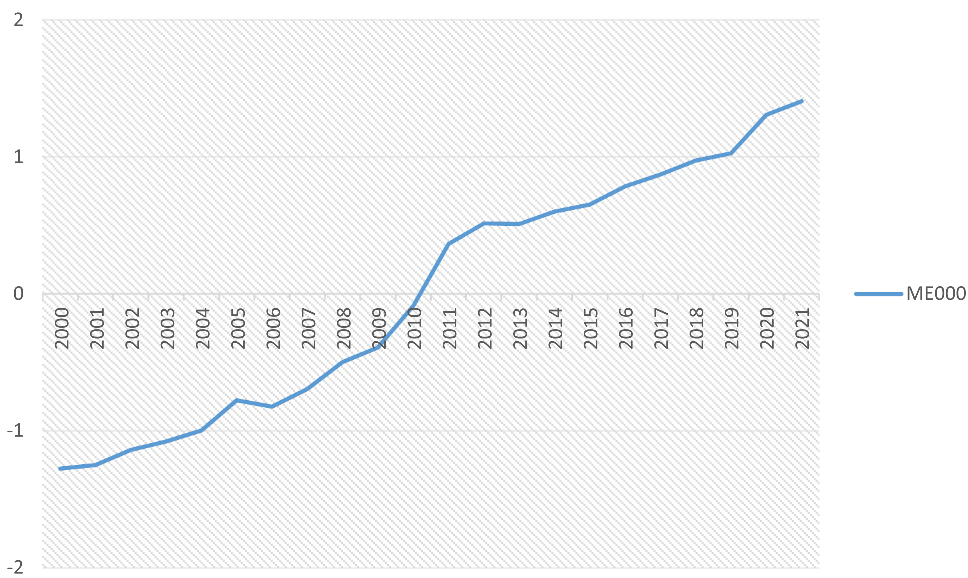


Figure 6. (Continued).

panels reveals that the paths of GDP convergence in the NUTS 3 regions of these countries are not similar, a point also raised in the previous section. This heterogeneity confirms the usefulness of this disaggregated analysis. For instance, it allows us to observe a “capital effect”, where regions including the national capital

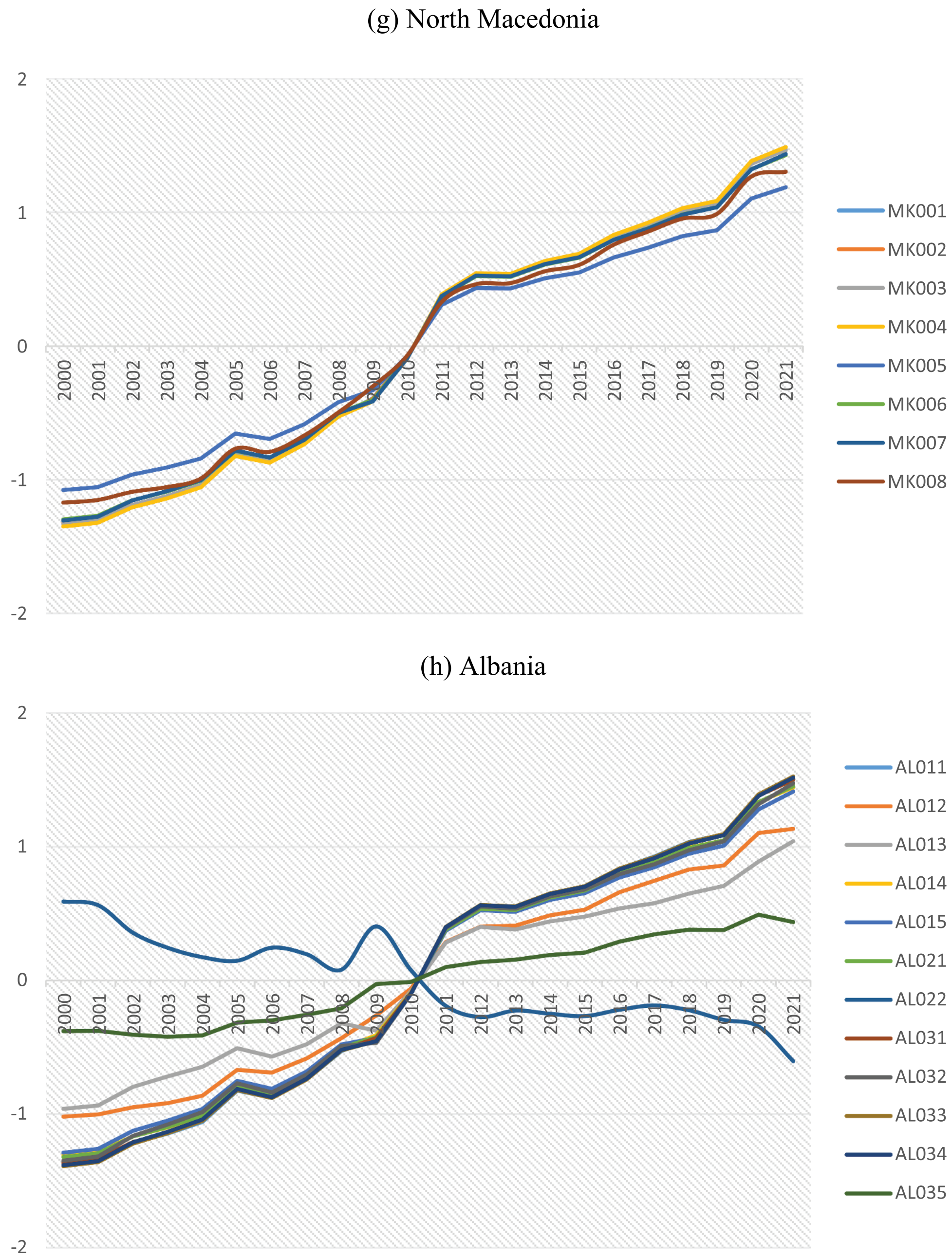


Figure 6. (Continued).

show better convergence outcomes compared to others. Additionally, we can also see that the NUTS 3 regions showing divergence in Figure 6 are generally not placed near their respective capital regions. Therefore, appropriate measures should be taken to ensure that these regions do not lag behind and adhere to the convergence path. This conclusion is not valid for the case of Albania, given

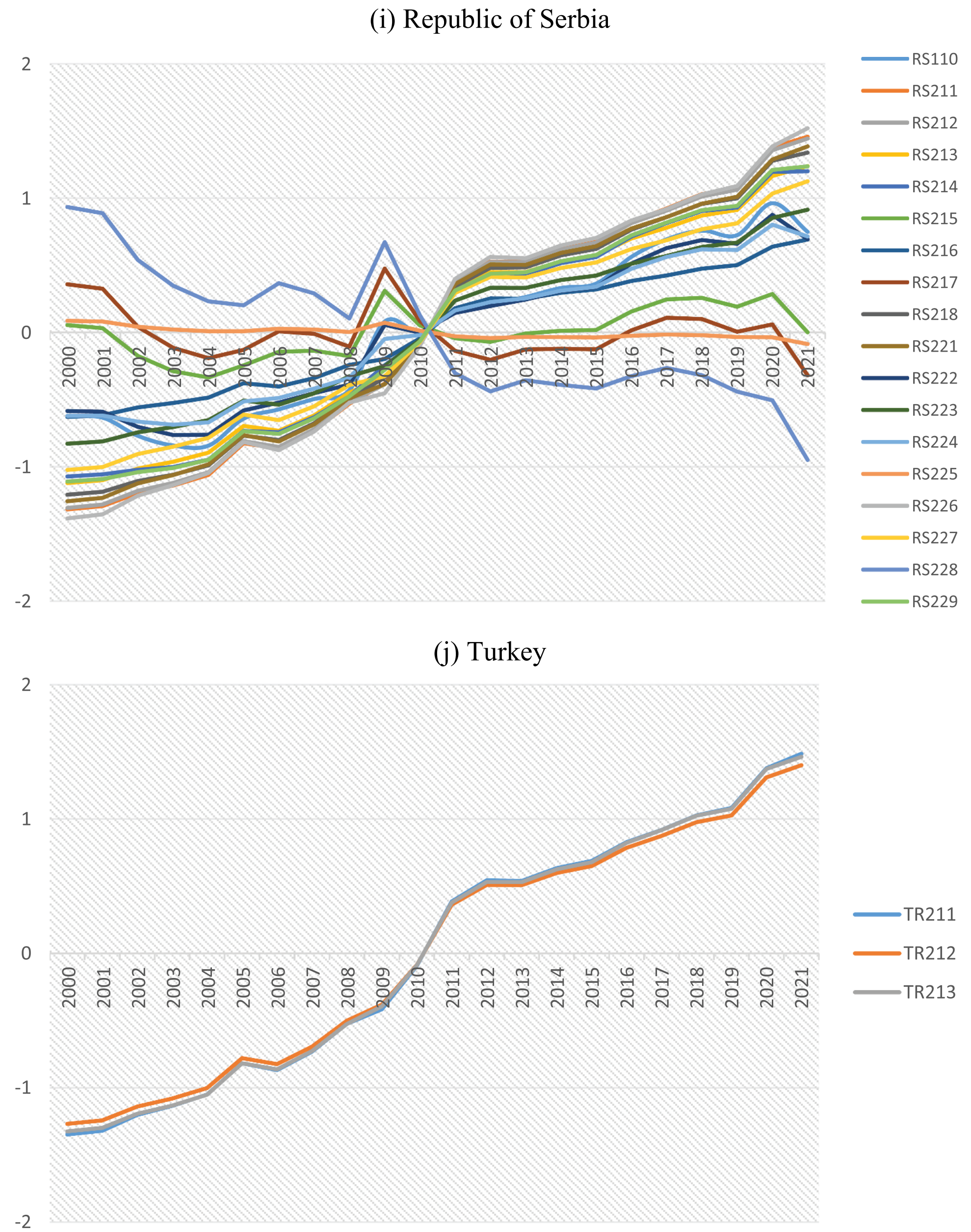


Figure 6. (Continued).

that the county of Tiranë (AL022) includes the national capital but exhibits a clear divergence path, in opposition with the rest of the Albanian counties.

Finally, note that the convergence trends plotted in Figure 6 do not show any apparent breaks in the years of accession of the actual member states (Slovenia, 2004, Bulgaria and Romania, 2007, and Croatia 2013). Furthermore, as commented above, when testing for broken trends, we only find strong evidence supporting the presence of a broken trend break around 2008 (the Great Recession). With respect to the years acquiring the EU candidate status (Albania, 2020, Bosnia and Herzegovina, 2022, Montenegro, 2014, North Macedonia, 2020, Republic of Serbia, 2012, and Turkey, not clear year according to the information available in the EU documents), they are mostly happening close or outside of either the Great recession or the end of the observation sample period and, consequently, the assessment of the effect of the acquisition of the candidate status is impossible or very challenging. The strong effect of the Great Recession could potentially mask any real influence that the signing of EU agreements may have had on the evolution of the GDP of Balkan regions, given that many of them occurred around this date. Finally, the cases of Montenegro and the Republic of Serbia are similar to those of the actual members in the sense that no significant break in their trends can be found.

6. Conclusions and policy implications

This paper examines the relationship between the GDP of the Balkan NUTS 3 regions and the GDP of the EU27. Our findings indicate a general trend of slow convergence, which is neither homogeneous across the Balkan countries nor within each individual country.

Our results are particularly noteworthy in highlighting that countries such as Bulgaria, Montenegro, and North Macedonia are converging towards the EU GDP in a very homogeneous manner. Conversely, Greece exhibits the opposite behavior. Especially since the GR, the Greek GDP has been diverging from the European average. For the remaining countries – Slovenia, Croatia, Albania, and the Republic of Serbia – our results reveal a high degree of heterogeneity. The disaggregated analysis shows that distinct patterns of behavior coexist in these countries, with some NUTS 3 regions clearly converging towards European levels while others either fail to converge or even diverge.

The findings of this study suggest several important policy implications. For countries like Bulgaria, Montenegro, and North Macedonia, economic policies should focus on maintaining and enhancing the current convergence momentum. Ensuring sustainable growth and further integration with EU economic standards will be key. By contrast, Greece requires targeted interventions to reverse its divergence trend. Policies should aim at structural reforms, enhancing productivity, and attracting investment to stimulate growth and convergence.

For countries with internal heterogeneous convergence patterns, such as Slovenia, Croatia, Albania, and Serbia, policies must address regional disparities. Economic strategies should promote balanced regional development to prevent internal economic divisions. Investing in infrastructure to connect less developed regions with economic hubs can facilitate more uniform growth. Enhancing education and skill development in lagging regions can boost their economic potential and promote more cohesive growth.

Ensuring that economic growth is not only aimed at converging with the European GDP average but also fostering internal cohesion is crucial. Disparities in growth within these countries could generate internal tensions and skepticism towards EU accession.

The EU could provide incentives and support for regional development projects aimed at promoting convergence within these countries.

Continuous monitoring of regional economic performance is essential. Developing metrics to assess the effectiveness of implemented policies will help in fine-tuning strategies and ensuring that regions are on the right path towards convergence. By addressing regional disparities and promoting balanced development, these countries can achieve more robust integration into the European economic framework.

In conclusion, while the Balkan NUTS 3 regions are generally on a path towards GDP convergence with the EU27, the process is uneven. Policymakers need to adopt a dual approach that not only targets convergence with the EU but also ensures internal cohesion to foster stable and inclusive economic growth.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

Financial support of the Spanish Government contract grants [PID2020-114646RB-C44, PID2022-139614NB-C2, and PID2023-150095NB-C44 (MINECO/FEDER)] are gratefully acknowledged by the second and third authors, respectively. They also gratefully acknowledge the hospitality of the Department of Economics of the Università di Bologna and financial support of the Salvador Madariaga grants PRX22/00396 and PRX22-00195, respectively. The first and second authors also acknowledge the financial support of the Government of Aragón (Cassetem).

Notes on contributors

María A. González-Álvarez is a senior lecturer at the University of Zaragoza (Spain).

Antonio Montañés is a full professor at the University of Zaragoza (Spain).

Esther Ruiz is a full professor at the University Carlos III, Madrid (Spain).

Skender Uku is an associate professor at the Agricultural University of Tirana (Albania).

ORCID

Esther Ruiz http://orcid.org/0000-0002-5944-9449

References

Alessi, L., Barigozzi, M., & Capasso, M. (2010). Improved penalization for determining the number of factors in approximate factor models. *Statistics & Probability Letters*, *80*(23–24), 1806–1813. https://doi.org/10.1016/j.spl.2010.08.005

Azomahou, T. T., Pham, P., Nguyen-Van, T. K. C., & Pham, T. K. C. (2011). Testing convergence of European regions: A semiparametric approach. *Economic Modelling*, *28*(3), 1202–1210. https://doi.org/10.1016/j.econmod.2010.12.010

Bai, J. (2003). Inferential theory for factor models of large dimensions. *Econometrica*, *71*(1), 135–171. https://doi.org/10.1111/1468-0262.00392

Bai, J., & Carrion-I-Silvestre, J. L. (2009). Structural changes, common stochastic trends, and unit roots in panel data. *Review of Economic Studies*, *76*(2), 471–501. https://doi.org/10.1111/j.1467-937X.2008.00530.x

Bai, J., & Ng, S. (2008). Large dimensional factor analysis. *Foundations and Trends® in Econometrics*, *3*(2), 89–163. https://doi.org/10.1561/0800000002

Barro, R. J., & Sala-I-Martin, X. (1992). Convergence. *Journal of Political Economy*, *100*(2), 223–251. https://doi.org/10.1086/261816

Barro, R., Sala-I-Martin, X., Blanchard, O. J., & Hall, R. E. (1991). Convergence across states and regions. *Brookings Papers on Economic Activity*, *1991*(1), 107–182. https://doi.org/10.2307/2534639

Baumol, W. J. (1986). Productivity growth, convergence, and welfare: What the long-run data show. *The American Economic Review*, *76*(5), 1072–1085.

Bernard, A. B., & Durlauf, S. N. (1995). Convergence in international output. *Journal of Applied Econometrics*, *10*(2), 97–108. https://doi.org/10.1002/jae.3950100202

Carlino, G. A., & Mills, L. O. (1993). Are US regional incomes converging?: A time series analysis. *Journal of Monetary Economics*, *32*(2), 335–346. https://doi.org/10.1016/0304-3932(93)90009-5

Carlino, G., & Mills, L. (1996). Convergence and the US states: A time-series analysis. *Journal of Regional Science*, *36*(4), 597–616. https://doi.org/10.1111/j.1467-9787.1996.tb01120.x

Carrion-I-Silvestre, J. L., Kim, D., & Perron, P. (2009). Gls-based unit root tests with multiple structural breaks under both the null and the alternative hypotheses. *Econometric Theory*, *25*(6), 1754–1792. https://doi.org/10.1017/S0266466609990326

Carrion-I-Silvestre, J. L., & Soto, V. (2007). Stochastic convergence amongst Mexican states. *Regional Studies*, *41*(4), 531–541. https://doi.org/10.1080/00343400601120221

Cartone, A., Postiglione, P., & Hewings, G. J. (2021). Does economic convergence hold? A spatial quantile analysis on European regions. *Economic Modelling*, *95*, 408–417. https://doi.org/10.1016/j.econmod.2020.03.008

Carvalho, V. M., & Harvey, A. C. (2005). Growth, cycles and convergence in US regional time series. *International Journal of Forecasting*, *21*(4), 667–686. https://doi.org/10.1016/j.ijforecast.2005.04.017

Carvalho, V. M., Harvey, A. C., & Trimbur, T. (2007). A note on common cycles, common trends, and convergence. *Journal of Business & Economic Statistics*, *25*(1), 12–20. https://doi.org/10.1198/073500106000000431

Cuestas, J. C., Monfort, M., & Ordóñez, J. (2021). Stochastic convergence in real personal disposable income in the EU: A note. *International Journal of Finance & Economics*, *26*(4), 6390–6394. https://doi.org/10.1002/ijfe.2125

Eftimoski, D. (2020). Some new insights on economic convergence and growth in Central, Eastern, and Southeastern Europe. *Empirica*, *47*(4), 863–884.

Elliott, G., Rothenberg, T. J., & Stock, J. H. (1996). Efficient tests for an autoregressive unit root. *Econometrica*, *64*(4), 813–836. https://doi.org/10.2307/2171846

El Ouardighi, J., & Somun-Kapetanovic, R. (2007). Do Balkan countries have a European future? An analysis of real economic convergence, 1989-2005. *South East European Journal of Economics and Business*, *2*(2), 23–30. https://doi.org/10.2478/v10033-007-0002-4

Estrin, S., Urga, G., & Lazarova, S. (2001). Testing for ongoing convergence in transition economies, 1970 to 1998. *Journal of Comparative Economics*, *29*(4), 677–691.

Fan, J., Liao, Y., & Yao, J. (2015). Power enhancement in high-dimensional cross-sectional tests. *Econometrica*, *83*(4), 1497–1541. https://doi.org/10.3982/ECTA12749

Gockov, G., & Antovska, A. (2019). Western Balkans countries income convergence in the context of EU membership–dynamics and determinants. *Journal Transition Studies Review*, *26*(2), 69–84.

Grodzicki, T., & Jankiewicz, M. (2024). Economic growth in the Balkan area: An analysis of economic β-convergence. *Acta Geographica Slovenica*, *64*(1), 91–105. https://doi.org/10.3986/AGS.12797

Islam, N. (2003). What have we learnt from the convergence debate? *Journal of Economic Surveys*, *17*(3), 309–362. https://doi.org/10.1111/1467-6419.00197

Johnson, P., & Papageorgiou, C. (2020). What remains of cross-country convergence? *Journal of Economic Literature*, *58*(1), 129–175. https://doi.org/10.1257/jel.20181207

Juodis, A., & Reese, S. (2022). The incidental parameters problem in testing for remaining cross-section correlation. *Journal of Business & Economic Statistics*, *40*(3), 1191–1203. https://doi.org/10.1080/07350015.2021.1906687

Karavias, Y., & Tzavalis, E. (2014). Testing for unit roots in short panels allowing for a structural break. *Computational Statistics & Data Analysis*, *76*, 391–407. https://doi.org/10.1016/j.csda.2012.10.014

Kiefer, N. M., & Vogelsang, T. J. (2005). A new asymptotic theory for heteroskedasticity-autocorrelation robust tests. *Econometric Theory*, *21*(6), 1130–1164. https://doi.org/10.1017/S0266466605050565

Kollias, C., & Messis, P. (2020). Are future enlargement candidate countries converging with the EU? *Empirica*, *47*(3), 453–473. https://doi.org/10.1007/s10663-019-09442-9

Kollias, C., & Messis, P. (2022). Are candidate countries converging with the EU in terms of the Copenhagen political criteria? *European Politics and Society*, *23*(5), 639–659. https://doi.org/10.1080/23745118.2021.1927374

Lähdemäki, S. (2024). Cross-country convergence: To be or not to be, that is the question. *Empirical Economics*, *67*, 839–875. https://doi.org/10.1007/s00181-024-02561-8

Le Pen, Y. (2011). A pair-wise approach to output convergence between European regions. *Economic Modelling*, *28*(3), 955–964. https://doi.org/10.1016/j.econmod.2010.11.006

Monfort, M., Cuestas, J. C., & Ordonez, J. (2013). Real convergence in Europe: A cluster analysis. *Economic Modelling*, *33*, 689–694. https://doi.org/10.1016/j.econmod.2013.05.015

Montañés, A., Olmos, L., & Reyes, M. (2018). Has the Great Recession affected the convergence process? The case of Spanish provinces. *Economic Modelling*, *68*, 360–371. https://doi.org/10.1016/j.econmod.2017.08.006

Perron, P., & Yabu, T. (2009). Estimating deterministic trends with an integrated or stationary noise component. *Journal of Econometrics*, *151*(1), 56–69. https://doi.org/10.1016/j.jeconom.2009.03.011

Pesaran, M. H. (2007). A simple panel unit root test in the presence of cross-section dependence. *Journal of Applied Econometrics*, *22*(2), 265–312. https://doi.org/10.1002/jae.951

Pesaran, M. H. (2015). Testing weak cross-sectional dependence in large panels. *Econometric Reviews*, *34*(6–10), 1089–1117. https://doi.org/10.1080/07474938.2014.956623

Pesaran, M. H. (2021). General diagnostic tests for cross-sectional dependence in panels. *Empirical Economics*, *60*(1), 13–50. https://doi.org/10.1007/s00181-020-01875-7

Prais, S. J., & Winsten, C. B. (1954). *Trend estimators and serial correlation*. Cowles Commission discussion paper.

Šiljak, D., & Nagy, S. G. (2023). Patterns of the Western Balkans' convergence toward the EU since 2004. *Regional Statistics*, *13*(6), 1145–1168.

Stock, J. H., & Watson, M. W. (2011). Dynamic factor models. In *The Oxford handbook of economic forecasting*. Oxford University Press, 35–60.

Szeles, M. R., & Marinescu, N. (2010). Real convergence in the CEECs, euro area accession and the role of Romania. *The European Journal of Comparative Economics*, *7*(1), 181.

Tomal, M. (2024). A review of Phillips-Sul approach-based club convergence tests. *Journal of Economic Surveys*, *38*(3), 899–930. https://doi.org/10.1111/joes.12563

Tsanana, E., & Katrakilidis, C. (2014). Do Balkan economies catch up with EU? New evidence from panel unit root analysis. *Empirica*, *41*(4), 641–662. https://doi.org/10.1007/s10663-013-9222-2

Tsanana, E., Katrakilidis, C., & Pantelidis, P. (2012). Balkan area and EU-15: An empirical investigation of income convergence. In *Balkan and Eastern European Countries in the Midst of the global economic crisis* (pp. 23–33). Heidelberg: Physica-Verlag HD.

Appendix

Table A1. Description of the NUTS 3.

			Per capita GDP			growth			
Nomenclature	Code	Country	2000	2010	2021	00–21	00–09	10–19	19–21
Vidin	BG311	BG	3,700	5,900	10,400	5.0%	5.3%	4.4%	11.3%
Montana	BG312	BG	3,600	6,000	10,900	5.4%	5.8%	4.5%	8.8%
Vratsa	BG313	BG	6,600	8,200	16,200	4.4%	2.4%	4.1%	12.1%
Pleven	BG314	BG	4,400	6,100	11,700	4.8%	3.7%	5.2%	11.0%
Lovech	BG315	BG	4,500	6,800	12,500	5.0%	4.7%	4.0%	11.8%
Veliko Tarnovo	BG321	BG	4,400	6,800	12,500	5.1%	5.0%	4.2%	8.1%
Gabrovo	BG322	BG	5,000	8,600	15,200	5.4%	6.2%	5.4%	4.2%
Ruse	BG323	BG	4,600	8,200	13,800	5.4%	6.6%	5.6%	5.5%
Razgrad	BG324	BG	3,700	5,900	11,900	5.7%	5.3%	4.7%	8.5%
Silistra	BG325	BG	3,800	5,400	9,200	4.3%	4.0%	3.6%	11.5%
Varna	BG331	BG	6,200	11,300	16,500	4.8%	6.9%	3.9%	2.2%
Dobrich	BG332	BG	4,900	6,400	11,400	4.1%	3.0%	2.7%	8.4%
Shumen	BG333	BG	3,900	6,300	11,000	5.1%	5.5%	4.5%	5.9%
Targovishte	BG334	BG	3,800	6,000	11,500	5.4%	5.2%	5.0%	6.7%
Burgas	BG341	BG	6,700	9,600	14,500	3.7%	4.1%	3.0%	5.6%
Sliven	BG342	BG	3,700	5,500	9,600	4.6%	4.5%	3.3%	10.2%
Yambol	BG343	BG	3,700	6,200	11,600	5.6%	5.9%	4.0%	8.8%
Stara Zagora	BG344	BG	6,000	10,600	18,500	5.5%	6.5%	4.2%	8.2%
City of Sofia	BG411	BG	9,200	24,500	41,500	7.4%	11.5%	3.8%	5.5%
Sofia	BG412	BG	5,200	11,100	17,700	6.0%	8.8%	5.7%	3.6%
Blagoevgrad	BG413	BG	4,100	7,100	11,600	5.1%	6.3%	4.0%	7.7%
Pernik	BG414	BG	4,000	6,400	10,200	4.6%	5.4%	2.5%	6.5%
Kyustendil	BG415	BG	4,900	6,000	10,600	3.7%	2.3%	3.4%	7.3%
Plovdiv	BG421	BG	4,400	8,500	14,300	5.8%	7.6%	5.2%	1.1%
Haskovo	BG422	BG	3,900	6,100	9,000	4.1%	5.1%	4.4%	1.7%
Pazardzhik	BG423	BG	3,600	6,300	10,700	5.3%	6.4%	2.8%	5.6%
Smolyan	BG424	BG	4,000	7,400	11,600	5.2%	7.1%	4.2%	1.3%
Kardzhali	BG425	BG	3,300	6,000	10,800	5.8%	6.9%	5.0%	7.8%
Northern Athens	EL301	GR	21,000	34,500	34,400	2.4%	5.7%	0.7%	0.9%
Western Athens	EL302	GR	12,000	16,200	14,800	1.0%	3.4%	0.0%	0.7%
Central Athens	EL303	GR	25,400	41,300	40,600	2.3%	5.5%	0.8%	0.1%
Southern Athens	EL304	GR	18,100	25,800	24,100	1.4%	4.0%	0.1%	0.0%
Eastern Attica	EL305	GR	18,100	28,600	21,700	0.9%	5.2%	−2.0%	−0.7%
Western Attica	EL306	GR	24,800	38,500	27,400	0.5%	5.0%	−2.4%	−1.4%
Piraeus, Islands	EL307	GR	19,800	26,100	24,000	0.9%	3.1%	0.0%	0.0%
Lesbos, Lemnos	EL411	GR	11,800	18,000	12,800	0.4%	4.8%	−2.2%	−2.6%
Ikaria, Samos	EL412	GR	12,000	19,100	12,800	0.3%	5.3%	−2.5%	−3.0%
Chios	EL413	GR	12,200	17,800	13,200	0.4%	4.3%	−2.2%	−0.7%
former Dodekanisos	EL421	GR	18,200	21,500	17,500	−0.2%	1.9%	−0.2%	−5.3%
Former Kyklades	EL422	GR	21,100	29,400	24,800	0.8%	3.8%	−0.2%	−3.4%
Heraklion	EL431	GR	14,300	20,000	16,300	0.6%	3.8%	−1.1%	−1.2%
Lasithi	EL432	GR	14,400	20,100	21,100	1.8%	3.8%	1.5%	0.5%
Rethymno	EL433	GR	16,900	18,400	15,800	−0.3%	0.9%	0.1%	−3.3%
Chania	EL434	GR	14,900	20,400	16,900	0.6%	3.6%	−0.5%	−2.3%
Evros	EL511	GR	11,600	16,800	15,300	1.3%	4.2%	−1.5%	1.7%
Xanthi	EL512	GR	12,300	14,900	12,000	−0.1%	2.2%	−2.5%	1.3%
Rhodope	EL513	GR	13,000	15,700	14,400	0.5%	2.1%	−1.3%	6.9%
Drama	EL514	GR	11,800	14,300	13,400	0.6%	2.2%	−0.6%	2.3%
Thasos, Kavala	EL515	GR	13,700	19,100	16,800	1.0%	3.8%	−0.8%	0.3%
Imathia	EL521	GR	13,000	15,800	14,400	0.5%	2.2%	−0.8%	2.2%
Thessaloniki	EL522	GR	14,500	20,300	17,800	1.0%	3.8%	−0.4%	0.9%
Kilkis	EL523	GR	12,000	15,500	14,400	0.9%	2.9%	−0.5%	2.2%
Pella	EL524	GR	11,300	15,200	14,200	1.1%	3.3%	0.5%	−2.4%
Pieria	EL525	GR	11,600	15,300	13,700	0.8%	3.1%	−0.5%	0.7%
Serres	EL526	GR	10,000	12,000	13,200	1.3%	2.0%	0.6%	3.2%
Chalkidiki	EL527	GR	13,600	17,700	16,200	0.8%	3.0%	0.3%	−1.5%

(*Continued*)

Table A1. (Continued).

			Per capita GDP			growth			
Nomenclature	Code	Country	2000	2010	2021	00–21	00–09	10–19	19–21
Grevena, Kozani	EL531	GR	14,600	19,700	18,000	1.0%	3.4%	−0.9%	−0.8%
Kastoria	EL532	GR	10,000	13,900	12,800	1.2%	3.7%	−0.5%	1.2%
Florina	EL533	GR	16,100	20,600	18,400	0.6%	2.8%	0.2%	−4.8%
Arta, Preveza	EL541	GR	11,200	14,400	14,400	1.2%	2.8%	−0.2%	1.8%
Thesprotia	EL542	GR	17,900	17,600	14,500	−1.0%	−0.2%	−1.6%	−1.4%
Ioannina	EL543	GR	12,000	16,000	14,600	0.9%	3.2%	−0.5%	0.7%
Karditsa, Trikala	EL611	GR	10,400	14,100	13,500	1.3%	3.4%	0.8%	0.0%
Larissa	EL612	GR	14,000	18,700	18,500	1.3%	3.3%	0.4%	3.1%
Magnesia	EL613	GR	13,100	17,900	16,200	1.0%	3.5%	0.0%	1.6%
Zakynthos	EL621	GR	19,700	25,300	20,700	0.2%	2.8%	−0.1%	−5.5%
Corfu	EL622	GR	16,100	20,800	17,100	0.3%	2.9%	0.0%	−4.4%
Ithaca, Cephalonia	EL623	GR	16,800	22,800	17,300	0.1%	3.5%	−1.8%	−2.8%
Lefkada	EL624	GR	10,700	16,600	14,900	1.6%	5.0%	−0.8%	−2.3%
Aetolia-Acarnania	EL631	GR	10,800	15,400	15,200	1.6%	4.0%	−0.3%	4.2%
Achaea	EL632	GR	13,700	19,100	16,100	0.8%	3.8%	−1.4%	0.3%
Elis	EL633	GR	10,600	14,500	13,000	1.0%	3.5%	0.0%	−2.2%
Boeotia	EL641	GR	25,300	26,500	32,400	1.2%	0.5%	0.8%	7.6%
Euboea	EL642	GR	15,600	18,700	18,500	0.8%	2.0%	−0.3%	5.6%
Evrytania	EL643	GR	10,900	14,100	12,500	0.7%	2.9%	−0.6%	0.8%
Phthiotis	EL644	GR	15,700	18,500	16,100	0.1%	1.8%	−1.0%	0.6%
Phocis	EL645	GR	12,400	16,100	14,500	0.7%	2.9%	−0.9%	3.6%
Argolis, Arcadia	EL651	GR	14,800	20,400	21,600	1.8%	3.6%	0.6%	3.4%
Korinthia	EL652	GR	15,100	18,200	17,100	0.6%	2.1%	0.1%	0.0%
Laconia, Messenia	EL653	GR	11,700	16,300	14,700	1.1%	3.8%	0.0%	−2.0%
Bjelovar-Bilogora	HR021	HR	7,000	11,000	15,600	3.9%	5.2%	3.1%	8.7%
Virovitica-Podravina	HR022	HR	6,800	9,300	12,800	3.1%	3.5%	2.7%	7.4%
Požega-Slavonia	HR023	HR	6,800	9,300	12,000	2.7%	3.5%	2.5%	2.6%
Brod-Posavina	HR024	HR	5,700	8,700	12,700	3.9%	4.8%	3.8%	5.1%
Osijek-Baranja	HR025	HR	7,200	12,500	17,100	4.2%	6.3%	2.5%	7.5%
Vukovar-Srijem	HR026	HR	5,600	9,400	13,200	4.2%	5.9%	3.3%	5.8%
Karlovac	HR027	HR	7,400	11,400	16,200	3.8%	4.9%	2.6%	8.0%
Sisak-Moslavina	HR028	HR	8,700	12,000	14,500	2.5%	3.6%	1.2%	4.0%
Primorje-Gorski Kotar	HR031	HR	11,500	18,700	25,200	3.8%	5.6%	2.7%	4.0%
Lika-Senj	HR032	HR	7,500	12,300	18,200	4.3%	5.7%	3.1%	9.1%
Zadar	HR033	HR	6,000	12,800	20,100	5.9%	8.8%	4.8%	4.8%
Šibenik-Knin	HR034	HR	6,300	10,600	18,200	5.2%	6.0%	4.4%	4.1%
Split-Dalmatia	HR035	HR	6,800	12,200	18,100	4.8%	6.7%	3.9%	3.2%
Istria	HR036	HR	11,000	19,300	26,500	4.3%	6.4%	3.4%	1.5%
Dubrovnik-Neretva	HR037	HR	7,600	15,100	22,900	5.4%	7.9%	5.3%	−0.9%
City of Zagreb	HR050	HR	14,200	27,200	42,300	5.3%	7.5%	3.5%	4.3%
Medimurje	HR061	HR	7,200	12,500	20,300	5.1%	6.3%	4.7%	7.1%
Varaždin	HR062	HR	8,200	12,800	20,200	4.4%	5.1%	4.9%	4.8%
Koprivnica-Križevci	HR063	HR	10,100	12,400	16,500	2.4%	2.3%	2.9%	4.9%
Krapina-Zagorje	HR064	HR	6,900	9,400	14,600	3.6%	3.5%	5.0%	4.0%
Zagreb	HR065	HR	6,500	11,800	19,500	5.4%	6.8%	4.9%	8.1%
Constanța	RO223	RO	6,300	14,000	26,500	7.1%	9.3%	5.6%	5.3%
Tulcea	RO225	RO	3,300	8,000	19,700	8.9%	10.3%	7.0%	8.3%
Mura	SI031	SI	10,500	13,400	20,000	3.1%	2.7%	3.7%	3.1%
Drava	SI032	SI	12,300	17,300	24,100	3.3%	3.9%	3.0%	3.0%
Carinthia	SI033	SI	12,600	15,400	22,700	2.8%	2.3%	4.0%	0.7%
Savinja	SI034	SI	13,500	18,400	26,100	3.2%	3.5%	3.1%	2.0%
Central Sava	SI035	SI	11,000	12,600	15,700	1.7%	1.5%	1.5%	3.3%
Lower Sava	SI036	SI	12,500	16,900	25,000	3.4%	3.4%	3.6%	3.1%
Southeast Slovenia	SI037	SI	14,700	19,700	28,200	3.2%	3.3%	3.7%	0.7%
Littoral – Inner Carniola	SI038	SI	12,200	15,200	20,900	2.6%	2.5%	2.9%	3.8%
Central Slovenia	SI041	SI	20,900	30,500	43,100	3.5%	4.3%	2.8%	5.0%
Upper Carniola	SI042	SI	13,300	16,900	24,300	2.9%	2.7%	4.1%	−1.2%
Gorizia	SI043	SI	14,600	19,600	25,800	2.7%	3.3%	2.6%	2.0%
Coastal – Karst	SI044	SI	15,900	22,400	26,400	2.4%	3.9%	2.0%	−1.8%
Crna Gora	ME000	ME	5,989	9,800	15,500	4.6%	5.6%	4.8%	−0.6%

(*Continued*)

Table A1. (Continued).

			Per capita GDP			growth			
Nomenclature	Code	Country	2000	2010	2021	00–21	00–09	10–19	19–21
Vardarski	MK001	MK	4,100	8,000	14,600	6.2%	7.7%	5.2%	3.2%
Istočen	MK002	MK	4,000	7,600	14,300	6.3%	7.4%	4.0%	5.7%
Jugozapaden	MK003	MK	4,400	6,100	12,700	5.2%	3.7%	5.1%	8.4%
Jugoistočen	MK004	MK	4,400	8,400	14,900	6.0%	7.4%	4.8%	0.3%
Pelagoniski	MK005	MK	6,100	9,300	12,900	3.6%	4.8%	3.2%	0.4%
Pološki	MK006	MK	2,700	4,400	7,500	5.0%	5.6%	4.6%	4.3%
Severoistočen	MK007	MK	3,400	4,900	8,100	4.2%	4.1%	4.6%	3.9%
Skopski	MK008	MK	7,600	13,400	18,900	4.4%	6.5%	3.3%	3.3%
Dibër	AL011	AL	2,420	3,900	7,400	5.5%	5.4%	5.0%	2.8%
Durrës	AL012	AL	4,701	7,100	9,900	3.6%	4.7%	1.8%	2.1%
Kukës	AL013	AL	2,973	4,600	6,100	3.5%	5.0%	1.2%	2.6%
Lezhë	AL014	AL	3,042	4,700	7,200	4.2%	5.0%	3.9%	2.2%
Shkodër	AL015	AL	3,111	4,900	7,300	4.1%	5.2%	2.2%	3.6%
Elbasan	AL021	AL	2,973	4,600	7,400	4.4%	5.0%	2.0%	5.9%
Tiranë	AL022	AL	7,259	10,700	13,800	3.1%	4.4%	1.9%	3.4%
Berat	AL031	AL	3,180	5,000	8,200	4.6%	5.2%	3.1%	4.6%
Fier	AL032	AL	3,941	5,700	11,100	5.1%	4.2%	4.7%	3.8%
Gjirokastër	AL033	AL	3,318	5,200	10,600	5.7%	5.1%	5.8%	4.0%
Korçë	AL034	AL	3,042	4,700	7,500	4.4%	5.0%	3.6%	3.5%
Vlorë	AL035	AL	4,425	6,700	8,800	3.3%	4.7%	1.7%	5.5%
Beogradska	RS110	RS	5,900	17,300	23,100	6.7%	12.7%	2.6%	2.2%
Zlatiborska	RS211	RS	3,600	6,600	10,700	5.3%	7.0%	4.1%	5.6%
Kolubarska	RS212	RS	3,900	7,000	10,400	4.8%	6.7%	3.6%	4.1%
Macvanska	RS213	RS	3,500	6,000	8,400	4.3%	6.2%	2.0%	5.8%
Moravicka	RS214	RS	5,100	8,200	11,800	4.1%	5.4%	2.9%	5.5%
Pomoravska	RS215	RS	4,200	7,100	9,600	4.0%	6.0%	1.6%	8.9%
Rasinska	RS216	RS	4,900	6,000	9,600	3.3%	2.3%	2.9%	9.5%
Raska	RS217	RS	3,200	6,000	7,600	4.2%	7.2%	0.9%	9.8%
Sumadijska	RS218	RS	3,600	6,700	10,900	5.4%	7.1%	4.4%	4.4%
Borska	RS221	RS	4,500	6,500	24,500	8.4%	4.2%	6.1%	32.3%
Branicevska	RS222	RS	4,600	8,500	11,100	4.3%	7.1%	1.2%	7.5%
Zajecarska	RS223	RS	4,000	4,900	8,100	3.4%	2.3%	3.2%	12.5%
Jablanicka	RS224	RS	3,400	4,100	7,400	3.8%	2.1%	4.9%	8.4%
Nisavska	RS225	RS	4,700	8,200	11,000	4.1%	6.4%	2.1%	5.9%
Pirotska	RS226	RS	3,600	6,600	11,000	5.5%	7.0%	4.7%	1.4%
Podunavska	RS227	RS	3,100	4,400	8,400	4.9%	4.0%	1.7%	21.4%
Pcinjska	RS228	RS	4,600	4,200	6,700	1.8%	−1.0%	4.3%	5.7%
Toplicka	RS229	RS	3,400	4,500	8,100	4.2%	3.2%	6.1%	3.9%
Tekirdağ	TR211	TR	10,834	15,400	30,900	5.1%	4.0%	3.9%	11.6%
Edirne	TR212	TR	6,247	10,800	16,200	4.6%	6.3%	2.9%	0.6%
Kırklareli	TR213	TR	7,987	13,500	22,600	5.1%	6.0%	3.5%	5.5%
EU			18,400	24,100	32,700	2.8%	3.0%	2.6%	2.2%

This table presents the NUTS 3 employed in the study, together with their Eurostat codes and per capita GDP in 2000, 2010 and 2021. It also reflects the growth of per capita GDP between 2000 and 2021 (00–21), 2000 and 2009 (00–09), 2010 and 2019 (10–19), and 2019 and 2021 (19–21).

Table A2. Testing for unit roots and estimation of model (1).

Code	DF_{I}^{GLS}	CKP_{1}^{I}	CKP_{2}^{I}	DF_{II}^{GLS}	CKP_{1}^{II}	CKP_{2}^{II}	$\hat{\alpha}_i$	$\hat{\beta}_i$	TC	$\hat{\alpha}_i$	$\hat{\beta}_i$	TC
							Pre-GC			Post-GC		
BG311	−0.16	−4.20	−4.40	−1.77	−4.27	−4.39	−1.55	0.02	C+	−1.52	0.02	C+
BG312	−0.37	−4.25	−5.20	−2.05	−4.82	−5.13	−1.59	0.02	C+	−1.40	0.02	C+
BG313	−0.18	−5.06	−6.41	−1.34	−4.98	−2.99	−1.03	–	WC–	−1.11	0.03	C+
BG314	0.72	−5.17	−5.70	−1.26	−5.18	−5.64	−1.41	–	WC–	−1.45	0.03	C+
BG315	−0.23	−3.89	−4.53	−2.78	−4.09	−5.52	−1.38	0.02	C+	−1.26	0.02	C+
BG321	0.84	−3.68	−3.47	−2.97	−2.42	−3.07	−1.39	0.01	C+	−1.24	0.02	C+
BG322	−0.59	−1.70	−6.89	−1.84	−1.91	−7.54	−1.25	0.02	C+	−1.06	0.03	C+
BG323	−0.64	−3.79	−3.50	−3.00	−3.21	−5.99	−1.43	0.04	C+	−1.13	0.02	C+
BG324	−1.13	−2.60	−3.27	−3.30	−2.14	−2.74	−1.49	–	WC–	−1.27	0.02	C+
BG325	0.30	−1.54	−1.98	−1.21	−1.58	−6.75	−1.50	–	WC–	−1.53	0.01	C+
BG331	−1.46	−3.86	−4.71	−1.35	−4.92	−6.05	−1.19	0.05	C+	−0.79	0.01	C+
BG332	−0.79	−3.13	−4.15	−3.51	−3.95	−4.04	−1.38	–	WC–	−1.20	0.01	C+
BG333	−0.74	−5.98	−5.98	−2.51	−4.73	−4.99	−1.54	0.03	C+	−1.31	0.02	C+
BG334	−0.23	−3.76	−4.20	−3.73	−4.64	−6.06	−1.58	0.03	C+	−1.33	0.02	C+
BG341	−1.86	−5.26	−6.11	−3.08	−5.36	−6.11	−1.23	0.04	C+	−0.92	–	WC–
BG342	−1.17	−3.90	−4.06	−2.67	−3.77	−5.30	−1.54	–	WC–	−1.47	0.01	C+
BG343	−0.22	−2.36	−3.81	−2.30	−3.66	−5.76	−1.58	0.02	C+	−1.29	0.02	C+
BG344	−1.00	−3.72	−5.22	−2.63	−4.25	−6.44	−1.13	0.03	C+	−0.78	0.02	C+
BG411	−0.02	−1.62	−4.53	−1.61	−3.00	−4.06	−0.74	0.08	C+	–	0.02	D+
BG412	−0.91	−5.71	−7.03	−1.77	−5.49	−5.66	−1.42	0.06	C+	−0.80	0.02	C+
BG413	−0.79	−3.64	−4.77	−2.39	−3.59	−4.87	−1.51	0.03	C+	−1.26	0.02	C+
BG414	−1.71	−1.79	−6.31	−1.95	−2.55	−5.74	−1.51	0.04	C+	−1.41	0.02	C+
BG415	−1.04	−4.03	−6.42	−1.49	−4.38	−5.23	−1.22	−0.01	D–	−1.36	0.02	C+
BG421	−0.58	−3.99	−4.34	−2.36	−3.81	−4.32	−1.45	0.04	C+	−1.04	0.02	C+
BG422	−0.77	−1.42	−5.57	−2.37	−4.66	−7.02	−1.51	0.02	C+	−1.40	0.01	C+
BG423	−1.25	−4.54	−5.44	−2.16	−4.25	−5.68	−1.68	0.05	C+	−1.22	–	WC–
BG424	−1.41	−5.43	−6.61	−1.61	−5.15	−6.01	−1.48	0.03	C+	−1.22	0.02	C+
BG425	−1.07	−2.07	−6.24	−2.34	−2.56	−7.52	−1.65	0.03	C+	−1.48	0.03	C+
EL301	−0.77	−2.36	−3.66	−2.17	−4.38	−3.84	0.14	0.02	C–	0.19	−0.01	C–
EL302	−0.14	−1.80	−3.06	−2.18	−4.25	−5.97	−0.37	–	WC–	−0.60	−0.02	D–
EL303	−0.72	−2.40	−3.03	−2.09	−3.85	−3.05	0.33	0.02	C–	0.36	−0.01	C–
EL304	−0.84	−1.83	−3.50	−2.04	−3.84	−6.28	–	0.01	C–	−0.11	−0.02	D–
EL305	0.14	−2.11	−4.16	−2.19	−3.46	−2.54	–	0.02	C–	–	−0.04	D–
EL306	−0.19	−2.38	−4.33	−2.28	−3.83	−4.05	0.37	0.02	C–	0.26	−0.04	C–
EL307	−0.73	−1.71	−4.56	−1.86	−2.57	−4.57	0.09	–	WC+	−0.13	−0.02	D–
EL411	−0.17	−3.29	−2.93	−1.83	−3.42	−3.18	−0.43	0.02	C+	−0.38	−0.05	D–
EL412	−0.84	−3.14	−3.32	−1.59	−3.65	−5.65	−0.45	0.03	C+	−0.35	−0.05	D–
EL413	−0.31	−3.24	−3.25	−1.77	−3.99	−4.86	−0.42	0.01	C+	−0.41	−0.04	D–
EL421	0.06	−3.86	−4.72	−2.86	−5.17	−7.60	–	−0.01	D–	−0.22	−0.03	D–
EL422	−0.42	−3.37	−4.08	−2.29	−4.15	−5.04	0.13	0.01	C–	–	−0.03	D–
EL431	−0.08	−2.37	−4.51	−2.40	−2.74	−4.86	−0.19	–	WC–	−0.39	−0.03	D–
EL432	−0.85	−1.95	−3.72	−2.06	−4.31	−4.94	−0.22	–	WC–	−0.40	–	WC–
EL433	−0.15	−2.44	−3.86	−2.40	−3.58	−4.76	–	−0.02	D–	−0.43	−0.02	D–
EL434	0.02	−2.50	−3.59	−2.38	−3.81	−4.82	−0.16	–	WC–	−0.34	−0.03	D–
EL511	−0.89	−1.98	−3.73	−1.88	−3.32	−4.81	−0.45	–	WC–	−0.45	−0.03	D–
EL512	0.13	−2.32	−5.78	−2.37	−2.48	−2.09	−0.35	−0.01	D–	−0.62	−0.04	D–
EL513	−1.13	−2.79	−4.04	−1.69	−4.67	−4.05	−0.27	−0.02	D–	−0.65	−0.02	D–
EL514	−0.29	−2.19	−4.57	−2.61	−3.38	−4.48	−0.36	−0.02	D–	−0.69	−0.02	D–
EL515	−0.35	−2.70	−5.55	−2.17	−4.69	−5.36	−0.31	0.01	C+	−0.42	−0.02	D–
EL521	−0.89	−1.61	−3.83	−2.08	−2.32	−3.88	−0.29	−0.01	D–	−0.57	−0.03	D–
EL522	−0.91	−1.59	−3.44	−1.97	−3.93	−3.32	−0.20	–	WC–	−0.40	−0.02	D–
EL523	−0.98	−1.87	−5.42	−2.20	−4.61	−5.14	−0.39	–	WC–	−0.61	−0.02	D–
EL524	−0.14	−2.52	−6.31	−2.75	−5.23	−6.12	−0.44	–	WC–	−0.62	−0.01	D–
EL525	0.08	−2.27	−5.17	−2.17	−4.09	−5.05	−0.44	–	WC–	−0.61	−0.02	D–
EL526	−0.49	−2.67	−3.64	−2.19	−3.35	−4.17	−0.57	−0.01	D–	−0.81	−0.01	D–
EL527	−0.09	−3.44	−4.75	−2.44	−4.58	−5.62	−0.28	–	WC–	−0.43	−0.02	D–
EL531	0.01	−3.11	−3.15	−1.83	−3.15	−4.43	−0.18	–	WC–	–	−0.04	D–
EL532	−0.76	−2.88	−3.29	−2.77	−2.79	−4.78	−0.56	–	WC–	−0.63	−0.03	D–
EL533	0.25	−2.69	−2.65	−1.93	−2.75	−5.78	–	–	CT	–	−0.03	D–
EL541	−0.11	−3.89	−3.96	−1.96	−3.78	−4.36	−0.45	–	WC–	−0.58	−0.02	D–

(*Continued*)

Table A2. (Continued).

Code	DF_I^{GLS}	CKP_1^I	CKP_2^I	DF_{II}^{GLS}	CKP_1^{II}	CKP_2^{II}	$\hat{\alpha}_i$	$\hat{\beta}_i$	TC	$\hat{\alpha}_i$	$\hat{\beta}_i$	TC
							Pre-GC			Post-GC		
EL542	−0.73	−1.15	−3.62	−1.44	−2.77	−5.44	0.10	−0.04	D−	−0.40	−0.04	D−
EL543	−0.85	−1.67	−3.20	−2.16	−3.74	−7.70	−0.37	–	WC−	−0.56	−0.02	D−
EL611	−0.63	−2.21	−3.22	−2.50	−3.81	−4.45	−0.51	–	WC−	−0.72	−0.01	D−
EL612	−0.54	−1.69	−3.32	−2.02	−4.07	−5.18	−0.22	–	WC−	−0.47	−0.01	D−
EL613	−0.21	−1.48	−3.69	−2.07	−2.97	−3.14	−0.27	–	WC−	−0.51	−0.02	D−
EL621	−0.33	−2.96	−5.10	−2.77	−4.36	−5.30	0.11	–	WC+	−0.15	−0.03	D−
EL622	−0.08	−2.50	−3.80	−2.33	−4.38	−5.12	−0.09	–	WC−	−0.34	−0.02	D−
EL623	−0.06	−2.77	−5.07	−2.15	−3.36	−5.29	−0.08	0.01	C+	−0.24	−0.04	D−
EL624	−0.61	−4.90	−5.11	−1.75	−4.79	−6.81	−0.52	0.01	C+	−0.46	−0.03	D−
EL631	−0.36	−2.16	−4.03	−2.35	−2.16	−4.16	−0.47	–	WC−	−0.57	−0.02	D−
EL632	−0.57	−1.40	−4.71	−2.01	−2.68	−5.17	−0.25	–	WC−	−0.40	−0.03	D−
EL633	−0.64	−2.01	−3.44	−2.37	−4.02	−3.73	−0.49	–	WC−	−0.65	−0.02	D−
EL641	−0.97	−4.43	−4.33	−0.85	−4.03	−4.96	0.40	−0.03	C−	–	–	CT
EL642	−1.19	−1.87	−3.50	−1.69	−3.87	−4.04	−0.13	–	WC−	−0.48	−0.01	D-
EL643	−0.31	−2.71	−3.85	−2.79	−4.61	−5.24	−0.50	−0.01	D−	−0.71	−0.02	D−
EL644	−0.74	−1.72	−3.78	−2.12	−2.35	−5.69	−0.10	−0.02	D−	−0.41	−0.03	D−
EL645	−0.32	−1.51	−3.18	−1.83	−3.72	−6.26	−0.35	–	WC−	−0.62	−0.02	D−
EL651	−0.54	−2.08	−3.73	−2.28	−2.87	−4.91	−0.18	–	WC−	−0.32	−0.01	D−
EL652	−0.57	−2.29	−5.98	−1.98	−5.53	−6.51	−0.18	−0.01	D−	−0.45	−0.02	D−
EL653	−0.40	−2.64	−3.43	−2.29	−4.15	−3.73	−0.42	–	WC−	−0.51	−0.02	D−
HR021	−2.19	−3.44	−4.78	−2.52	−2.34	−3.09	−0.96	0.02	C+	−0.95	0.01	C+
HR022	−1.40	−3.15	−4.49	−1.77	−3.30	−5.88	−0.94	–	WC−	−1.07	–	WC−
HR023	−1.17	−1.43	−4.63	−1.93	−2.43	−4.52	−0.95	–	WC−	−1.02	–	WC−
HR024	−1.72	−3.43	−4.78	−2.19	−3.13	−5.27	−1.15	0.01	C+	−1.14	0.01	C+
HR025	−1.37	−1.91	−3.50	−1.86	−3.15	−5.07	−0.97	0.03	C+	−0.75	-	WC-
HR026	−1.48	−1.64	−4.57	−1.99	−2.11	−6.24	−1.19	0.03	C+	−1.07	0.01	C+
HR027	−0.85	−2.48	−3.57	−3.16	−3.67	−4.59	−0.86	0.02	C+	−0.80	–	WC−
HR028	−1.35	−1.94	−2.73	−1.73	−4.55	−6.31	−0.81	–	WC−	−0.71	−0.02	D−
HR031	−1.43	−5.25	−5.17	−1.88	−5.11	−4.86	−0.55	0.03	C+	−0.25	–	WC−
HR032	−2.22	−1.03	−4.83	−2.45	−2.07	−5.31	−0.80	–	WC−	−0.78	–	WC−
HR033	−0.48	−1.66	−3.87	−2.20	−3.88	−3.97	−1.11	0.05	C+	−0.80	0.02	C+
HR034	−1.01	−2.96	−4.71	−2.16	−3.39	−4.18	−1.08	0.04	C+	−0.81	0.02	C+
HR035	−1.20	−1.73	−6.58	−2.12	−4.91	−7.59	−1.02	0.04	C+	−0.80	0.01	C+
HR036	−1.58	−4.55	−2.58	−2.25	−2.68	−2.83	−0.48	0.03	C+	−0.28	–	WC−
HR037	−1.16	−2.41	−5.15	−1.87	−5.10	−7.58	−0.94	0.05	C+	−0.56	0.02	C+
HR050	−0.29	−1.84	−5.05	−2.03	−1.80	−6.03	−0.27	0.04	C+	0.09	0.01	D+
HR061	−0.87	−3.72	−4.93	−3.65	−4.53	−4.55	−0.95	0.03	C+	−0.77	0.02	C+
HR062	−0.47	−3.43	−3.04	−1.66	−2.91	−1.96	−0.79	0.01	C+	−0.78	0.02	C+
HR063	−1.46	−3.00	−4.07	−1.87	−4.02	−3.47	−0.58	−0.01	D-	−0.78	–	WC−
HR064	−1.35	−2.93	−7.49	−1.51	−5.71	−7.74	−0.93	0.01	C+	−1.08	0.02	C+
HR065	−0.31	−2.49	−5.40	−2.13	−3.68	−6.04	−1.09	0.04	C+	−0.88	0.02	C+
RO223	−0.31	−4.56	−5.59	−1.20	−4.89	−6.97	−1.15	0.06	C+	−0.42	0.02	C+
RO225	0.22	−3.81	−2.92	−2.12	−3.28	−7.79	−1.73	0.07	C+	−1.02	0.04	C+
SI031	−0.85	−2.73	−3.54	−1.27	−3.17	−3.34	−0.55	–	WC−	−0.62	0.01	C+
SI032	−1.44	−1.35	−3.02	−1.65	−1.99	−4.35	−0.40	0.01	C+	−0.38	–	C+
SI033	−1.89	−3.33	−4.03	−1.93	−3.77	−5.31	−0.36	–	WC−	−0.46	0.01	C+
SI034	−1.98	−1.39	−6.52	−1.77	−3.73	−3.84	−0.32	0.01	C+	−0.28	–	C+
SI035	−1.08	−2.00	−4.95	−1.46	−3.63	−5.49	−0.51	−0.02	D−	−0.68	−0.01	D−
SI036	−0.98	−1.69	−5.43	−1.99	−1.70	−6.34	−0.39	–	C+	−0.40	0.01	C+
SI037	−1.45	−2.01	−3.99	−1.56	−2.33	−4.16	−0.22	0.01	C+	−0.26	0.01	C+
SI038	−1.56	−2.28	−4.18	−1.50	−4.45	−4.40	−0.42	–	WC−	−0.54	0.01	C+
SI041	−2.23	−1.41	−3.82	−2.49	−1.73	−4.05	0.14	0.01	C−	0.18	–	WC+
SI042	−1.84	−2.49	−3.18	−1.85	−2.41	−3.38	−0.29	–	WC−	−0.36	0.01	C+
SI043	−1.38	−2.06	−4.27	−1.74	−2.15	−3.74	−0.23	0.01	C+	−0.27	–	C+
SI044	−0.92	−1.89	−1.94	−1.73	−2.36	−3.58	−0.14	0.01	C+	−0.11	−0.01	D−
ME000	−0.81	−3.42	−3.84	−3.10	−3.58	−5.53	−1.16	0.03	C+	−0.93	0.02	C+
MK001	−0.74	−4.26	−4.41	−2.47	−4.41	−5.89	−1.53	0.04	C+	−1.03	0.02	C+
MK002	−1.17	−4.56	−5.02	−2.01	−5.05	−5.36	−1.71	0.05	C+	−1.11	0.02	C+
MK003	−0.86	−2.07	−3.02	−2.07	−2.84	−3.03	−1.58	0.02	C+	−1.36	0.03	C+
MK004	−0.64	−4.39	−4.41	−1.55	−4.31	−4.72	−1.55	0.04	C+	−0.92	0.02	C+

(*Continued*)

Table A2. (Continued).

Code	DF_I^{GLS}	CKP_1^I	CKP_2^I	DF_{II}^{GLS}	CKP_1^{II}	CKP_2^{II}	$\hat{\alpha}_i$	$\hat{\beta}_i$	TC	$\hat{\alpha}_i$	$\hat{\beta}_i$	TC
							Pre-GC			Post-GC		
MK005	−0.67	−5.03	−5.26	−5.03	−4.13	−6.91	−1.13	–	WC–	−1.02	0.01	C+
MK006	−0.57	−2.06	−2.18	−1.94	−3.65	−3.28	−2.07	0.03	C+	−1.79	0.03	C+
MK007	−0.95	−1.14	−6.46	−1.41	−4.63	−4.58	−1.87	0.02	C+	−1.51	–	WC–
MK008	−0.68	−3.42	−4.90	−1.67	−3.86	−4.36	−0.99	0.03	C+	−0.67	0.01	C+
AL011	−0.44	−2.66	−5.20	−2.18	−2.91	−3.78	−2.03	0.01	C+	−1.71	0.02	C+
AL012	−1.80	−3.72	−4.13	−2.81	−4.15	−3.57	−1.35	0.01	C+	−1.17	–	WC–
AL013	−1.47	−2.27	−2.63	−1.39	−3.40	−3.75	−1.82	0.01	C+	−1.51	−0.02	D-
AL014	−0.64	−2.55	−5.96	−2.10	−5.02	−4.35	−1.79	0.01	C+	−1.62	0.01	C+
AL015	−0.90	−2.49	−3.29	−1.80	−4.27	−3.51	−1.77	0.01	C+	−1.49	–	WC–
AL021	−0.85	−2.82	−3.17	−2.31	−3.53	−3.06	−1.82	0.01	C+	−1.55	–	WC–
AL022	−1.70	−3.45	−2.73	−2.90	−4.34	−4.83	−0.91	0.01	C+	−0.87	–	WC–
AL031	−0.51	−2.74	−3.23	−2.33	−3.20	−3.29	−1.75	0.01	C+	−1.50	0.01	C+
AL032	−1.28	−1.71	−2.55	−1.40	−3.45	−4.13	−1.54	–	WC–	−1.19	–	WC-
AL033	−0.87	−1.85	−3.10	−1.48	−3.67	−3.63	−1.71	0.01	C+	−1.29	0.01	C+
AL034	−0.71	−2.31	−3.92	−1.64	−3.69	−4.06	−1.79	0.01	C+	−1.53	0.01	C+
AL035	−1.85	−3.56	−4.17	−2.01	−3.11	−3.76	−1.41	0.01	C+	−1.23	−0.01	D–
RS110	−0.66	−2.77	−2.31	−1.82	−2.56	−3.18	−1.14	0.09	C+	−0.35	–	WC–
RS211	−0.63	−4.39	−5.24	−1.94	−4.89	−5.29	−1.66	0.03	C+	−1.27	0.01	C+
RS212	−0.52	−3.37	−4.95	−1.83	−4.30	−4.83	−1.64	0.03	C+	−1.27	0.01	C+
RS213	−1.21	−3.06	−4.44	−1.96	−4.55	−4.28	−1.74	0.03	C+	−1.36	–	WC–
RS214	−0.67	−3.51	−3.87	−1.92	−3.65	−8.12	−1.38	0.03	C+	−1.15	0.01	C+
RS215	−1.50	−1.60	−6.85	−1.73	−3.20	−7.69	−1.49	0.02	C+	−1.32	–	WC–
RS216	−1.15	−3.37	−2.15	−2.06	−3.37	−2.08	−1.37	–	WC–	−1.49	0.02	C+
RS217	−1.80	−2.18	−3.06	−2.10	−3.67	−1.90	−1.75	0.03	C+	−1.54	–	WC–
RS218	−1.28	−2.71	−3.16	−1.29	−3.24	−4.27	−1.69	0.05	C+	−1.23	–	WC–
RS221	−0.08	−2.26	−2.72	−1.41	−2.29	−5.29	−1.46	–	WC–	−1.31	0.07	C+
RS222	−1.96	−3.73	−4.63	−2.76	−4.00	−4.55	−1.38	0.03	C+	−1.11	–	WC–
RS223	−2.11	−3.17	−4.62	−2.92	−3.63	−3.94	−1.53	–	WC–	−1.51	–	WC-
RS224	−1.15	−2.61	−2.19	−1.85	−2.26	−4.77	−1.64	−0.02	D–	−1.73	0.01	C+
RS225	−1.52	−1.34	−4.32	−1.75	−2.86	−2.10	−1.36	0.03	C+	−1.26	–	WC–
RS226	−0.59	−2.47	−4.35	−1.40	−1.70	−8.11	−1.69	0.03	C+	−1.20	0.01	C+
RS227	−1.00	−2.95	−5.66	−2.48	−4.38	−6.46	−1.86	–	WC–	−1.72	–	WC–
RS228	−2.06	−4.48	−5.55	−2.27	−4.24	−5.87	−1.43	−0.04	D–	−1.77	0.01	C+
RS229	−1.07	−1.76	−3.84	−1.66	−4.70	−6.44	−1.68	−0.02	D–	−1.62	0.02	C+
TR211	−0.31	−2.71	−3.52	−2.51	−2.59	−4.18	−0.52	0.01	C+	−0.30	0.02	C+
TR212	−1.29	−2.90	−5.51	−0.52	−3.01	−5.94	−1.13	0.03	C+	−0.66	–	WC–
TR213	−0.67	−3.95	−4.83	−1.05	−4.04	−6.88	−0.87	0.03	C+	−0.49	0.01	C+

This table reports the unit root test inference of the 157 NUTS 3. means the statistics proposed by Elliott et al. (1996), with i=I, II meaning the use of an intercept and intercept and trend, respectively. CKPji reports the statistic proposed in Carrion-I-Silvestre et al. (2009), with j=1,2 meaning the inclusion of 1 and two breaks. and are the estimation of the parameters of model (1), pre-GR and the post-GR period. The two segments are estimated by using the method proposed in Prais and Winsten (1954) in order to account for the possible presence of correlation in the perturbation. The values denoted by "-"imply that the corresponding estimated parameter is not statistically different to 0 when using a 10% significance level. TC means the type of β-convergence, as defined in G. A. Carlino and Mills (1993, 1996). C + and C- means that αi<0 and βi>0 and αi>0 and βi<0 in (1), respectively. D+ and D- implies that αi<0 and βi<0 and αi>0 and βi>0 in (1), respectively. WC+ and WC- means the case where βi=0 and, additionally, αi>0 and αi<0 in (1), respectively.