Testing the Validity of Spatial Beta Convergence for the Countries of Southern Europe

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SUMMARY

Territorial economic and social disparities remain a major problem for the European Union today. No two regions have the same characteristics and starting conditions, resulting in significant disparities in their development path. The aim of this study is to analyse the impact of the economic and social shocks of the 2000s (economic and financial crisis of 2008-09 and COVID-19 pandemic) on the economies of four countries (Portugal, Spain, Italy and Greece) in Southern Europe by county-level gross value added. The methodology used is based on classical descriptive statistics, convergence analyses and spatial autocorrelation studies. The results show that the impact of the shocks of the 2000s varies across counties, with some areas being able to increase their gross value added even during the crisis period. In addition, the first and second waves of the economic and financial crisis and the pandemic had an uneven impact on the region's counties, which further increased territorial disparities.

Keywords: crises; gross value added; Southern Europe; spatial beta convergence; territorial inequalities.
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INTRODUCTION

Territorial economic and social disparities remain a major problem for the European Union. These differences are more critical in Southern Europe, where great dispersion is found not only in terms of GDP per capita but also in other economic and social indicators. Like other external shocks, crises tend to have a significant impact on the development of countries and regions and sometimes change their development paths. However, the effects can vary widely depending on the type of external shocks, and the resilience of regions in such circumstances is also not uniform.

The aim of this study is to analyse the impact of the economic and social shocks of the 2000s (the economic and financial crisis of 2008-09 and the COVID-19 pandemic) on the economies of the Southern European EU Member States. The study presents county-level differences in gross value added as a characteristic of development in the Southern European countries and their changes in response to external shocks. The methodology used is based on classical descriptive statistics, convergence analyses (sigma, beta, gamma) and spatial autocorrelation studies.

The structure of the article is as follows. The first section presents some theories of inequalities and the effects of crisis with special focus on the analysed area. The next section shows the methodology which can be adequate for checking the convergence processes of the South. The last section summarises the results of the study, while testing the extreme values, the different convergence processes across NUTS3 territorial units, and the role of space in connection with the convergence analysis.

THEORETICAL BACKGROUND

The study of convergence in economic growth theories is not a recent phenomenon; one of the main goals of the EU since the beginning of integration has been the convergence of peripheral regions. The importance of territorial cohesion was already mentioned in the preamble of the Treaty of Rome (1957), which laid the foundations for integration, and was formally confirmed in the Single European Act of 1986, which elevated regional policy to the level of European Community policy as a top priority of integration (Soós, 2020).

The analysis of territorial inequalities is not a recent phenomenon; several researchers have already investigated the positive convergence prospects and catching-up of peripheral regions (e.g., the convergence process of nation states in Barro & Sala-i-Martin, 1992; Sala-i-Martin, 1995; Quah, 1996). In the relation of Southern Europe, the European Commission states that some of the EU regions, primarily in southern Member States (e.g., Calabria and Sicily in Italy or Ipeiros and Dytiki Elláda in Greece) accompanied by others from Europe, are in a “development trap” or at risk of falling into one, with low or negative growth, weak productivity and low employment creation (European Commission, 2023a). Thus, the analysis of their convergence processes is a timely issue.

According to the European Commission's 8th Cohesion Report, since 2000 the impact of substantial structural and territorial funding has reduced disparities between EU Member States (i.e., convergence has accelerated), but internal regional disparities between regions have increased (European Commission, 2022). In 2021, the highest GDP per capita among EU Member States at NUTS3 region (county) level was in Wolfsburg (GER) with €172,100, while the lowest was in Silistra (BG) with €4,200, a 40-fold difference (Eurostat, 2023). Data for Southern Europe (Portugal, Spain, Italy, and Greece) are as follows. The highest value is linked to Milano (ITA) with per capita values of €53,000 and the lowest to the county of Xanthi (GRE) with €8,900. Here there is a six-fold difference. This indicates a rather large disparity for the Southern European region. Besides the economic differences, there are huge problems in the unemployment rate (high in the whole region, especially in case of youth unemployment), wage levels, innovation and productivity. The European Regional Competitiveness Index of 2022 shows large differences also in regional competitiveness. The least competitive regions are in the eastern Member States, followed by southern Member States. The level of R&D expenditure in the EU is highest in the north-western regions and lowest in the East and South (European Commission, 2023a).

Crises can have a major impact on the development of regions. Diermeier et al. examined the impact of the 2008-09 economic and financial crisis on territorial processes from the aspect of convergence. Based on their results, the crisis slowed down the convergence of Europe, as in Central-Eastern Europe there was a low growth rate during that two years, while Southern Europe was stagnating (Diermeier et al., 2018). Another issue in these countries that the countries “have experienced two parallel crises of different types—an economic crisis and a political one” (Zamora-Kapoor & Coller, 2014, p. 1511). The crisis had such consequences in the region as the emergence of protest parties, and the growth of Euroscepticism and political instability besides the economic downturns (Morlino & Sottilotta, 2019). Studies have also revealed that once the EU managed to overcome the crisis, earlier β-convergence returned and there are positive tendencies in decreasing inequalities (Kuruczleki et al., 2022). Looking at a crisis of a different nature, the OECD (2020) study finds that the COVID-19 crisis highlighted the widening of regional differences in economic growth in Europe. Palomino et al. (2020) measured the impact on poverty and wage inequality in Europe from the aspect of policies that emphasised social distancing during the pandemic and found that poverty increased, and wage losses occurred during the pandemic. Abrhám & Vošta (2022) checked the effects of the COVID-19 pandemic from the unemployment point of view and has described that the negative impact on unemployment level from the crisis was not equal across Europe; Greece and Spain suffered most, while in Ireland there was only a slight increase in unemployment figures.

From the above it is clear that the region, there was a strong negative effect of the 2008-09 economic and financial crisis, which developed further in the first wave of COVID-19. The effects are not equal among the territories; their extent is different based on region-specific factors. Thus, a deeper analysis is justified.

METHODOLOGY AND DATA

Scope and time frame of the analysis

There are various suggestions for and approaches to the economic division of Europe by geographical region. In this study, I have relied primarily on the UN methodological guide (UNSTAT, 2023), refining it based on an article by Manic et al. (2017). Accordingly, Southern Europe is the composition of four countries in the Mediterranean region: Portugal, Spain, Italy and Greece.

The above division is supported not only by the UN and the above-mentioned study, but also by a study carried out by VÁTI (Urban Development Ltd.) in 2011, which defines the main European Geographical Zones with a similar classification.

A difference can be verified in the so-called Mediterranean 2.0 model, which defines a broader area, including also Cyprus, Malta and Slovenia, and the analysis notes that these are “joining the ‘traditional’ Mediterranean cohort” of Italy, Spain, Portugal, and Greece. In these countries, the low level of investments and exports is the most problematic dimension (Kuruczleki et al., 2022). I have decided rather to exclude them, as Malta and Cyprus would be outliers in a spatial regression analysis, having no neighbours, while Slovenia is also an outlier based on a different development path and economic history.

The area covered in my analysis contains a sum of 245 NUTS3 regions in the four-country group, from which 27 are neighbourless[i]. The connections among the territories with queen contiguity are shown in Figure 1. Queen contiguity means that spatial units share a common edge or a common vertex (Gerkman, 2010).

Source: Own compilation

Figure 1. The NUTS3 regions of the analysed area and the connections among them

The time frame of the analysis was 16 years, from 2005 until 2020, which is long enough to check the tendencies of the gross value added. To explore the impact of the crises, I have created three different shorter time periods to review the impact of the different shocks on the region. The first period covers the first wave of the economic and financial crisis from 2008 to 2009 ('Period A'), the second covers the second wave of the economic and financial crisis from 2011 to 2012 ('Period B'), and the third covers the first wave of the COVID-19 pandemic from 2019 to 2020 ('Period C'). In the first two periods, my assumption was that the crisis had a W-shape nature with bounces and drops in a sequence (Molnár et al., 2021).

Applied methods

In the literature, different types of convergence analyses are used to detect trends in differences (e.g., sigma, beta, and gamma tests), which try to explain the development trajectories of given regions.

Sigma convergence examines the dispersion of GDP between regions, i.e., whether the dispersion of incomes decreases over time (Kocziszky & Szendi, 2020). Thus, it measures the narrowing of the variation between different economic indicators (Kuruczleki et al., 2022).

Sigma convergence is usually measured by trends in the coefficient of variation (CV) indicator. If the relative dispersion of gross value added relative to the average decreases over time, then the phenomenon of sigma convergence is fulfilled (Szendi, 2016). The indicator can be calculated as the ratio of the dispersion to the average value.

$$CV = \frac{standard\ deviation}{average} \qquad (1)$$

The basic idea of beta-convergence is related to Solow's neoclassical model, which assumes that the rate of economic growth depends essentially on the growth rates of capital stock and labour (Andrei et al., 2023) and accounts for the change in average GDP relative to the base period. If the beta-coefficient is negative and significant, then beta-convergence is satisfied (Ferkelt, 2005; Stanišić, 2012). There are two trends in the literature on this method: absolute and conditional beta convergence. The absolute convergence theory states that less developed countries tend to grow faster in absolute terms towards a future steady state. In this theory, all regions converge to the same steady state. In contrast, conditional beta-convergence assumes that there are significant differences between regions in terms of initial conditions, available factors, and characteristics, so that there is no common steady state for each region, but each region converges towards its own development path (Mankiw et al., 1992; Eckey & Türck, 2007; Szendi, 2016).

The concept of gamma convergence was introduced by Boyle & McCarthy (1997) in the context of economic analysis. The index measures the change in ranking, expressing how the ranking of each area has changed compared to the base year:

$$\gamma = \left(\frac{\mathrm{var}(\mathrm{RGDPC_{ti}+RGDPC_{t0}})}{\mathrm{var}(\mathrm{RGDPC_{t0}*2})}\right) \quad (2)$$

where $var(RGVAC)$ is GVA per capita (gross value added)[ii] variance, while t_i is the examined year, t_0 the base year.

RESULTS

After making the analyses for the Southern European region, my results are detailed below. I present the results in four subsections, covering the distribution of values, the impact of crises on inequalities in the region, the results of convergence tests, and the importance of neighbourhood connections.

Variation and magnitude of extreme values

First, I examined the changes in the extreme values (maximum and minimum) of the four-country region as a response to the crises. In total, I examined six time periods, with 2005 indicating the starting year and the others showing the changes in response to Waves 1 and 2 of the economic crisis and the effects of Wave 1 of the COVID-19 pandemic. In the analysis, I wanted to find out how much the differences in the extreme values changed as a result of the shocks, which area was associated with the highest and lowest values in the periods under study, and how stable the position of these areas was (Table 1).

Table 1

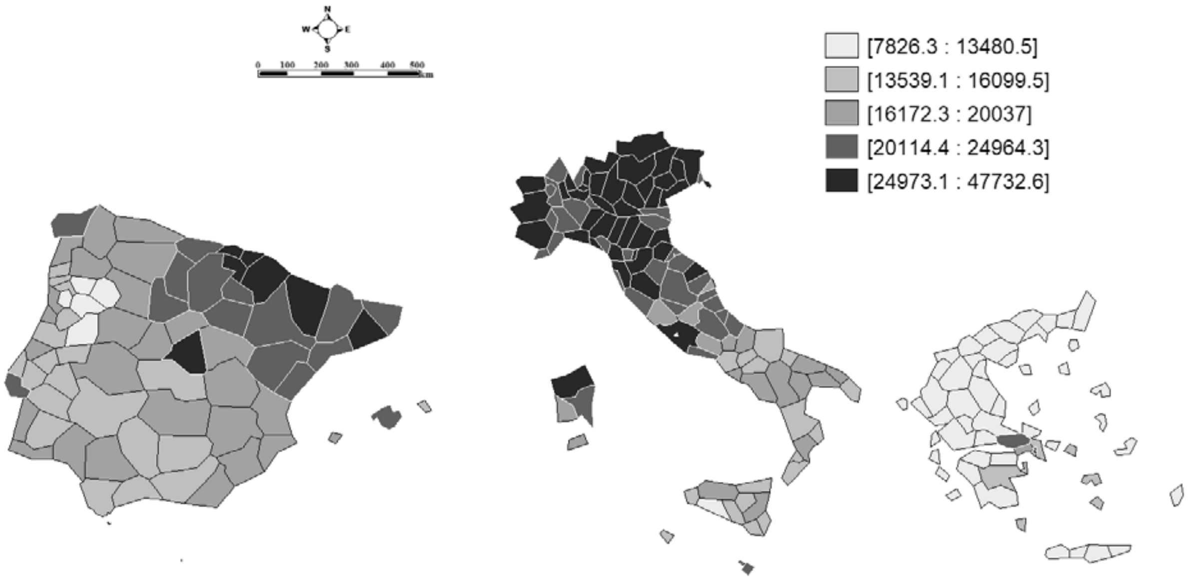
The variation of the extreme values in the GVA in Southern Europe

	Southern Europe			
	max	**region**	**min**	**region**
2005	39887.1	Milano (ITA)	7079.5	Tâmega e Sousa (POR)
2008	46379.2	Milano (ITA)	8374.6	Tâmega e Sousa (POR)
2010	47403.3	Milano (ITA)	8721.7	Tâmega e Sousa (POR)
2012	46853.9	Milano (ITA)	8402.6	Tâmega e Sousa (POR)
2019	50093.9	Milano (ITA)	8397.1	Xanthi (GRE)
2020	47732.5	Milano (ITA)	7826.2	Xanthi (GRE)

Source: Own compilation

There is a high degree of stability across the area in terms of the position of the best/worst areas, with few region swaps in the data. In Southern Europe, the maximum value is concentrated in the region of Milan in Northern Italy throughout the whole time frame, and the minimum value is driven by a Portuguese county until 2019, followed by a Greek region. In these regions the share of industrial GVA is quite low, mostly in the southern part of the area (in Southern Italy, Southern Spain, and almost the whole of Greece it is below 10%). Only some parts of Northern Italy and the Basque Country in Spain have high shares of industrial GVA (over 30%), which are in the top of the ranking (European Commission, 2023b). Differences in this geographical block increased from 5.6-fold to 6-fold, indicating divergence for the period.

When checking the dispersion of the GVA per capita in the Southern European region, we can see the lowest values concentrating in Greece and in some parts of Portugal, while the biggest hot spots are in Northern Italy (Lombardia, Veneto and Emilia-Romagna regions) and in the Basque Country and near Madrid (Figure 2).



Source: Own compilation

Figure 2. Dispersion of GVA in Southern Europe

These hot spots were also mentioned for the whole EU by Szendi (2022, p. 238), emphasising that central and north-eastern Spain (Segovia, Guadalajara, Toledo, Comunidad de Madrid, Avila, Cuenca, Girona and Tarragona), and northern and central Italy (in the larger area of Piemonte, Genova, Savona, Aosta and Rome) is one of the concentration areas, while Greece is a cold spot. For Europe as a whole, there is both an eastern-western and a northern-southern slope in the GVA distribution (similarly to GDP per capita), and the differences in the maximum values are the biggest in the western-eastern slope, while the minimum values appear in the northern-eastern relationship (European Commission, 2023b).

The country group has some other disadvantages compared to the western and northern part of the continent besides the economic data (GDP and GVA) and the previously mentioned unemployment rate. For example, if we check the latest edition of the Regional Innovation Scoreboard of the European Commission, low levels of competitiveness can also be verified. Only six NUTS2 regions of the countries examined have a higher competitiveness level than 100% of the EU average (Madrid, Catalonia, Comunidad Foral de Navarra in Spain, and Emilia-Romagna, Friuli-Venezia Giulia and Provincia Autonoma Trento in Italy). The most competitive, Madrid, is only 81st among the 239 regions covered. The worst positions are in the autonomous regions of Spain – Ceuta (231st of 239) and Melilla (223rd of 239 regions) – with 35% and 46%, respectively (European Commission, 2023c).

Impact of crises

The above results show that the four countries have followed a sometimes similar and sometimes very differentiated path during each of the crises studied. The different types of shocks have affected the areas differently (Table 2).

Table 2

Effects of the crisis periods on the NUTS3 areas by the degree of increase/decrease

%	2009	2012	2020
Above 0	15.9	13.5	1.6
Between the two thresholds (2009: 0 to -10; 2012, 2020: 0 to -5)	82.0	64.5	26.5
Below -10 (2009); below -5 (2012, 2020)	2.0	22.0	71.8

Source: Own compilation

When checking the three periods of the analysis (first wave of the economic and financial crisis from 2008 to 2009, second wave of the economic and financial crisis from 2011 to 2012, first wave of the COVID-19 pandemic from 2019 to 2020), the following can be verified. From 2008 to 2009, during the first wave of the economic and financial crisis, Southern and Western Europe showed significant similarities at the level of each NUTS3 territorial unit based on the extent of the downturns (World Bank, 2019). Their economies suffered the largest decreases in this period, although the recovery time in Southern Europe was much longer. Some regions in this geographical area reached the pre-crisis GDP level only in 2016 or 2017 (mainly in Southern Italy and Greece), while a huge part of the EU in 2010 or 2011 (Eurostat, 2019).

The share of regions with an increase in per capita value added was around 15%. Counties that showed a fall in value added of over 10% because of the crisis made up 2% of the 245 territories. At the same time, a continuous examination of the data shows that in Southern Europe this crisis was noticeable only one year later than in the rest of the continent (Zamora-Kapoor & Coller, 2014; the analysis of raw data). A further analysis of the consequences of the economic and financial crisis also shows the extent to which the W-shaped crisis curve (Molnár et al., 2021) can be supported. In the second wave of the crisis (2012), more serious problems are to be found in Southern Europe, where the later onset of the above-mentioned crisis, and the second fallback due to the W-nature caused serious problems. Only 13.5% of the counties managed to grow, while the remaining counties experienced a decline of varying degrees (most of them between 0 and 5%). The tendencies showed quite similar tendencies to Western Europe, as mentioned also above, as the GDP per capita relative to EU average changed similarly over the period between 2007 and 2011; in both areas there was a decrease (Southern Europe: GRE, ITA, ESP, POR; Western Europe NED, LUX, IRL, FRA) to a similar extent (Kolev, 2012). By 2020, the effects of the first wave of the COVID-19 pandemic were being felt in Europe. The trends of different economic data reflect the different ways in which the crisis has been handled (closures, restrictions, the resilience of the health system, more liberal solutions and their impact on economic growth). Southern Europe, perhaps one of the worst hit by the first and second waves of the epidemic, saw one of the largest declines in the EU, with more than 70% of counties showing a decline of more than 5%. The automotive sector was especially hard hit, where based on the data of the ACEA (European Automobile Manufacturers' Association), in 2020 22.9% of the total EU production was lost. In the EU, Southern Europe suffered the longest closures (in days), which resulted in a significant lack of vehicles, working days and employees (ITA: 41 days, 157,933 vehicle loss, 69,382 employees affected; ESP: 34 days, 452,155 vehicle loss, 60,000 employees affected; POR: 35 days, 41,525 vehicle loss, 20,000 employees affected). The biggest decline in employees took place in Portugal with 1.92 employees per 1000 inhabitants (this was 1.26 in Spain, and 1.17 in Italy) (ACEA, 2020).

Convergence analysis

Sigma convergence – Change in the value of the CV indicator

As mentioned in the methodological chapter, the analysis of sigma convergence examines whether the dispersion of gross value added (measured by the CV indicator) is decreasing over time, i.e., whether regional differences are narrowing. In examining this in the geographical area concerned, I have come to the following conclusions. Over the whole period, we find a non-balanced picture between territorial units showing both convergence and divergence. In total, one country's NUTS 3 regions converged (Portugal), while the three other countries' counties showed diverging trends (Table 3). Although in the whole period some countries behave similarly, there are some differences among the given countries from year to year. For instance, in Greece there was a sigma convergence in 2006-2010, and a stronger divergence from 2015 until 2020. In contrast, in Italy until 2018 the whole period was characterised by divergence, followed by a slight narrowing after it, while in Spain there was a slight divergence in the whole-time frame with some stagnating phases. The situation in Portugal was the most promising; until 2014 there was strong and rapid narrowing of the inequalities, and the same after 2018. However, it is also worth noting that in Portugal the sigma convergence was predominantly the effect of a negative catch-up, as the more developed regions showed bigger drops in their values, compared to the less developed ones in the different crisis periods.

Table 3

Summary of the sigma convergence analysis results

convergence	**divergence**
Portugal (0.24-0.15)	Greece (0.28-0.32)
	Italy (0.24-0.27)
	Spain (0.19-0.21)
	Southern Europe as a whole (0.32-0.35)

Note: value of CV indicator in the brackets
Source: own compilation

Southern Europe shows overall divergence. Of course, the overall picture over the whole period is nuanced by the differences and changes in each crisis period and it is worth running deeper analyses to test the validity of the analyses. Until 2010 the four-country area experienced sigma convergence, while after that a strong divergence happened, mainly due to the results of Greece and Italy.

Looking at the impact of crises in more detail, in Southern Europe, the 1st wave of the economic and financial crisis brought the sigma divergence a year later, yet the 2nd wave arrived at the expected time, here the COVID-19 crisis also indicated a slight divergence of the values.

Beta and gamma convergence

Sigma convergence alone is not sufficient to map convergence processes, because when it occurs, we can speak of convergence in both positive and negative senses. In other words, it also indicates convergence if the values of the initially more developed regions decrease and thus the overall regional differences decrease (negative convergence). It is therefore worthwhile to investigate convergence processes using additional methods. In the present study I have analysed both beta and gamma convergence to obtain a more complete picture of the changes in the differences. First, I review the results of beta convergence, which measures the regression of the initial GVA on the average annual growth rate of value added.

The results suggest that, in contrast to the sigma convergence examined earlier, several countries show convergent trends, and three of them achieved beta convergence of gross value added over the whole period (Table 4). One country in Southern Europe where convergence has not been achieved was Italy. Here, basically three counties have affected the divergent tendencies for the country, as Trieste, Bolzano and Milano are quasi-outliers, both in their initial GVA level, and because the growth rate is higher than the average.

The gamma convergence, which quantifies the positive changes in the ranking of regions, shows much more favourable results than before. Over the period, it shows convergence in all the countries and the geographical block studied, i.e., a positive shift in the ranking of the NUTS3 counties.

Table 4

Summary of the beta and gamma convergence analysis results

country/region	Beta convergence		Gamma convergence	
Portugal	✓	y = -0.0003x + 5.2001 $R^2 = 0.7953$	✓	2.23 – 2.14
Greece	✓	y = -2E-05x - 1.3291 $R^2 = 0.0083$	✓	2.22 – 2.10
Italy	×	y = 1E-05x + 0.1329 $R^2 = 0.0195$	✓	2.24 – 2.21
Spain	✓	y = -6E-05x + 1.7082 $R^2 = 0.0546$	✓	2.24 – 1.94
Southern Europe	✓	**y = -1E-05x + 0.5105** $\mathbf{R^2 = 0.0038}$	✓	**2.24 – 2.13**

Source: Own compilation

The gamma convergence' results highlight that the biggest position changes can be observed in Spain, while Italy showed the smallest ranking shifts. From a deeper analysis of the data, we can state that in Spain, compared to the base year, Huesca has improved by 12 positions, A Coruña by 13, and Ourense by 29 (these are tourism and trade centres of the country). Of course, huge negative change also took place in the country (e.g., the island region of Fuerteventura has lost 47 positions, while Menorca went down by 33 positions), but their extent (the number of affected territories) was smaller than that of the positive shifts. The changes in Italy were about maximum 20 positions in both directions (Trieste was positive, and Prato, among others, was negative).

Spatial autocorrelation analysis

The role of space in the analysis of spatial inequalities is significant based on the first law of geography: "Everything is connected to everything else. But near things are more connected than distant things" (Tobler, 1970, p. 236). Spatial autocorrelation is a method of studying spatial interactions by examining whether the spatial distribution of individual values of gross value added is random or follows some regular pattern (Dusek, 2004). Autocorrelation can be measured globally (using the Moran I index) and locally.

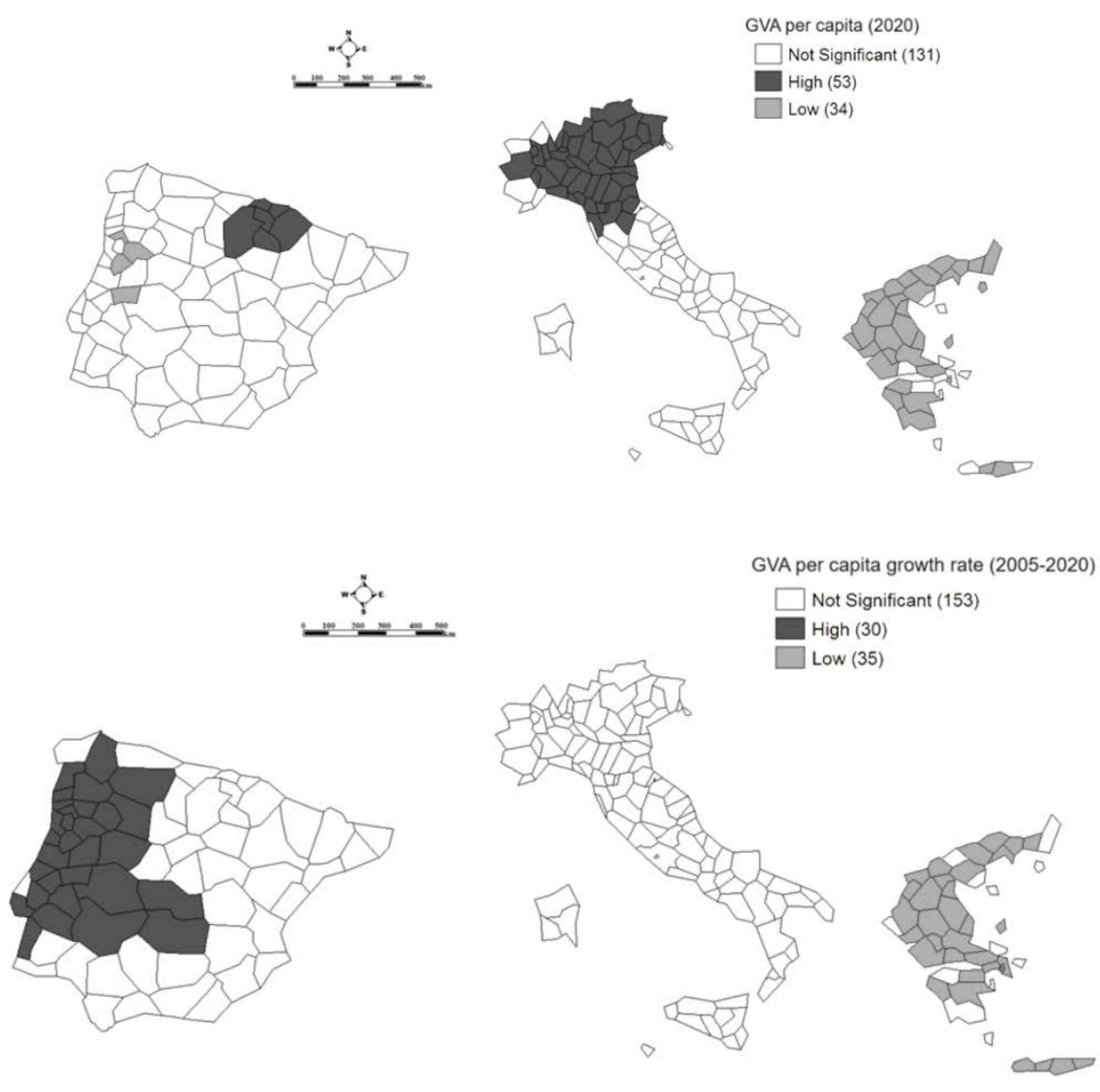
Among the tools of the local spatial econometric methods (LISA indicators such as Local Moran I, Local Geary C, Local G indicator), I chose the Local G_i^* indicator, which is an indicator of the local spatial autocorrelation of each data point. The indicator is not sensitive to spatial outliers and can be calculated using the following equation:

$$G_i^*(d) = \frac{\sum_{j=1}^{n} w_{ij} x_j}{\sum_{j=1}^{n} x_j}, \quad (3)$$

where d is the neighbourhood distance and w_{ij} is the weight matrix, which is a queen neighbourhood matrix (with symmetric distribution). Positive G_i^* represents local clustering of high values (hot spots), while negative G_i^* represents local clustering of low values (cold spots).

In Southern Europe the Moran I results suggest medium strong, positive spatial autocorrelation among the territories (0.5360 by significant pseudo-p value), which indicates that the neighbouring territories have similar values, so the high and low values of the GVA cluster together. That is why it is worth analysing the local clustering tendencies.

I checked the Local G_i^* indicator for the geographical area covered and observed the following. Based on the values of the GVA in 2020, Northern Italy (from Torino to Udine (west-east) and from Bolzano to Arezzo (north-south) containing also the Milan – Turin – Genova triangle) and the Basque Country are hot spots with continuous high levels of value added (Figure 3). The cold spots (with continuous lower GVA levels) can be found mainly in Greece (12 of the 52 territories are lower outliers) and some parts of Portugal (Ave, Douro, Viseu Dao Lafoes or Beira Baixa). In the case of hot and cold spots, the forming clusters underline the hypothesis stated by the dispersion of the specific GVA across the Southern European countries, as almost the whole Northern Italian region and some parts of Northern Spain are also mentioned here, while the concentration area of lower-value-added regions verifies the previously mentioned territories of Greece and Portugal.



Source: Own editing

Figure 3. Local G_i^* clusters of GVA per capita (above) and GVA per capita growth rate (below) in Southern Europe

The growth rate of GVA (checked along with the initial values) also indicates divergent processes, as Greece is a cold spot in both indicators, so a further widening of inequalities is expected. Based on the GVA growth rate from 2005–2020, a huge section of Portugal and Spain shows hot spot areas (76% of the Portugal areas and some Spanish territories like Lugo, León, Zamora, Salmanca, Caceres, Badajoz, Toledo or Ciudad Real). The South of Italy cannot be classified into a single cold spot cluster (although the initial values suggested that), as some NUTS3 regions from the Basilicata or Calabria region act as outliers.

As the spatial autocorrelation analysis suggests significant neighbourhood effects, it is worth expanding the analysis with spatial effects. I checked the validity of spatially lagged models in the β-convergence analysis, with the following results. In Southern Europe, the explanatory power of the OLS (Ordinary Least Squares) model is quite low, with the linear equation explaining only 0.37% of the dispersion of units, while the value and significance of the F statistic suggest that this model does not best explain the distribution of value added in the region (Table 5). The Jarque-Bera test for normality also rejects the null hypothesis at 1%.

However, as seen above, the spatial autocorrelation tests for Southern Europe, with a Moran I (0.5360), indicate a positive, moderately strong, and significant autocorrelation. In other words, in this case it is justified to extend the analysis to include neighbourhood effects. It also implies that gross value added of the Southern European counties is positively related to its neighbours. Therefore, I tested whether the spatial lag or the spatial error autocorrelation model seems to be correct for the region.

Table 5

OLS regression results for the GVA in Southern Europe

REGRESSION OLS METHOD **(SOUTH)**			
	Coefficient	Std. error	Prob.
Constant	0.510485	0.286499	0.07603**
Log of „base year”	-0.000144	0.000150	0.33822
R-squared		0.003775	
F-statistic		0.92079	
Prob(F-statistic)		0.33822	
Multicollinearity Condition Number		6.350066	
Jarque-Bera test		9.7353	0.00769
Breusch-Pagan test		45.0880	0.00000
Koenker-Bassett test		30.4667	0.00000
Log likelihood		-425.23	
Akaike info criterion		854.46	
Schwarz criterion		861.463	
	Moran I/ Degrees of Freedom	Value	Prob
Moran I (error)	0.5360	12.7042	0.00000
Lagrange Multiplier (lag)	1	157.4413	0.00000
Robust LM (lag)	**1**	**6.1161**	**0.01340**
Lagrange Multiplier (error)	1	152.8476	0.00000
Robust LM (error)	1	1.5224	0.21726
Lagrange Multiplier (SARMA)	2	158.9637	0.00000

Source: Own compilation

Two of the most common methods for econometric modelling of spatial autocorrelation are the spatial lag model and the spatial error model (Varga, 2002). The spatial lag is the weighted average of the neighbouring values of a given observation unit. The spatial error model (SEM) assumes that only the error terms are correlated in the regression, while the spatial lag model (SLM) examines how the GVA growth rate of regions depends on their own initial value-added level and how this is affected by the growth rates of neighbouring regions (Gerkman & Ahlgren, 2011; Andrei et al., 2023).

To select the appropriate spatial autocorrelation model, I used the classical procedure presented by Anselin (2005), which allows the user to decide between the SLM model and the SEM model based on Lagrange Multiplier tests.

Since both the LM-lag and the LM-error models are significant (p value 0.0000), robustness tests should be considered. As the significance of the lag model is lower among the robust tests, I decided to use it. This assumes that there is autocorrelation between different levels of the dependent variable.

Since the analysis of R^2 is not relevant in spatial regression models (Anselin, 2005), I considered the values of the Log- Likelihood, the Akaike Information Criterion (AIC) and the Schwarz Criterion (SC). By comparing the Log-Likelihood values of OLS (-425.23) and SLM (-360.671), a higher value is observed for SLM, i.e. the lag model fit is better. This is also supported by the Akaike Information Criterion (AIC) and the Schwarz Criterion (SC), which have lower values for the lag model.

The model estimates the spatial autoregressive coefficient to be 0.71, which is significant (0.0000) based on the p-value (Table 6). The spatial lag model and the classical OLS model of GVA differ slightly. However, the spatial lag model suggests a faster catch-up than the OLS estimate (based on the constant and log base values).

Table 6

Spatial lag model results for the GVA in Southern Europe

	Value
Mean dependent var	0.248872
S.D. dependent var	1.37518
Lag coeff. (Rho)	**0.712743**
R-squared	0.494473
Sigma-square	0.956015
Standard Error of regression	0.97776
Log likelihood	-360.671
Akaike information criterion	727.341
Schwarz criterion	737.845
W_log yearly average growth rate	0.712743 (0.0000)
Constant	0.261355 (0.20317)
Log of „base year”	-0,0001401 (0.19551)

Source: Own compilation

CONCLUSION

The aim of the study was to test the convergence and autocorrelation of gross value added in Southern Europe. The results show that the impact of the shocks of the 2000s varies from one region to another, with some areas being able to increase their level of value added even in times of crisis. Almost all areas were deeply affected by the first wave of the economic and financial crisis, but the second wave and the first wave of the pandemic had stronger impact for some areas. In general, Greece and Spain experienced the strongest downturns (with -1.8; -5.6; -8.9% and -3.3; -3.6, respectively, and a -10.5% average decrease in GVA in the different periods), followed by Italy (-4.2; -1.3; -6.1%) and Portugal (0.3; -3.4; -4.8%). Analyses of convergence at the intra- and inter-country level show that between 2005 and 2020, sigma convergence was only achieved in Portugal and in the other three countries and within the four-country region sigma divergence took place, while beta convergence was achieved in Portugal, Spain and Greece, and in an interregional context. This indicates that the ranking of areas within countries has also changed, as evidenced by the gamma convergence of values. The spatial autocorrelation is significant in the area, but there is no significant change in the pattern of hot and cold spots, indicating that the spatial patterns are not very sensitive to external shocks. The different nature of the areas and their initial conditions suggest that they have followed recovery paths of different intensities from crises. Thus, the first and second waves of the economic and financial crisis and the pandemic have had an uneven impact on the region's development path, which has widened spatial disparities. The Southern European NUTS3 regions’ convergence is best described by a spatial lag model.

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[i] Similarly to Malta and Cyprus, these territories are island areas, where neighbourhood connections cannot be interpreted.

[ii] Most researchers choose value added as the measure of economic activity. This has the advantage of including the contribution of capital and labour as well as changes in productivity, but is not sensitive to, for example, price levels between regions within Member States (Gorter - Van der Horst, 2005).