Territorial Data Aggregation and Trends of Regional Economic Convergence in Europe

A Geo-statistical Analysis for the 2003–2014 Period

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Not only the starting level of the convergence process will have an explanatory role, but also the geographical and economic context of the proximity.

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Introduction

IN THIS paper we explore the link between the geographical scale of analysis and the economic beta-convergence process in the European Union and FYROM, for the period 2003–2014. Our main hypothesis is that the economic convergence takes place differently, if one addresses its mechanism at NUTS3, NUTS2 or NUTS1 scale. In order to test this hypothesis, we will deploy several ordinary least squares regression models (OLS), for different periods of economic accumulation and for different territorial scales. The first stage in our research process consisted in the data quality check of the indicators and geometries retained for the analysis, mainly the datasets provided by the EUROSTAT, including the GDP for the 2003–2014 period. In a second stage, we developed a methodological frame of investigation of the beta-convergence process in Europe, taking into account the latest research in this field (Monfort 2008; Bourdin 2013b) and data availability. One recent trend in the investigation of the economic catching-up processes is dedicated to the introduction of spatial variables in the statistical models that describe them (Bourdin 2013a; Grasland 2012) and we have made an option for the potential accessibility of the GDP, in a Gaussian functional neighborhood of 500 km. In this case, not only the starting level of the convergence process will have an explanatory role, but also the geographical and economic context of the proximity. The main part of the paper is dedicated to the implementation of the OLS models of beta convergence, together with the testing procedures (statistical and geo-statistical ones). The results of the models' implementation show that the economic accumulation is scale sensitive and that the explanatory variables behave differently, once we change the territorial reference frame of analysis. The best candidate for a better understanding of the convergence process is the NUTS2 scale, as the results at NUTS1 were biased and the results at NUTS3 scale are affected by lower values of adjusted R2. At the same time, the standardized residuals of the OLS depict the crystallization of local and regional clubs of economic over-performance, especially at NUTS3 scale. In order to implement the models and the inherent analysis, a GIS approach was needed. This GIS approach consisted in the development of a GIS tool that enabled the calculation of the potential accessibility in a Gaussian kernel with a 500 km span. Other secondary steps in the analysis were based on the development of sophisticated GIS models that allowed us to automatically access the results of the OLS beta-convergence models (Mitchell 2005). The final part presents the main scientific conclusions and some policy relevant key-findings derived from our analysis, together with the inherent limitations of our approach.

Literature Review

The research we propose in this paper can be considered an exploratory analysis of the role played by the geographical context in the manifestation of the economic convergence process, at the scale of the European Union and for a period that covers the accession to the EU of several Eastern European states, in 2004 and 2007. Some conceptual precautions are needed when one deals with the process of convergence, because the term can cover different aspects of the economic accumulation process. The first model of economic convergence has its roots in the '50s, when Solow (1956) described the role played by the technical territorial endowment at the initial time of the analysis in the process of production growth, a model that will later became the basis for the beta-convergence approach. Much later, Sala-i-Martín (1996) refined Solow's approach and applied it to the EU states. However, different criticisms, especially focusing on the statistical results of the beta-convergence models (Quah 1996), indicated that there are other possible approaches to the convergence processes, more specifically dictated by the level of internal disparities (Neven and Gouyette 1995 and Dao et al. 2003), or by different trends in the dynamics of the accumulation, trends explained by a Markov-chain approach to the accumulation process (Quah 1996). Once the EU faced the integration of new states from the East, the topic of the convergence became interesting even for policy-makers, as the studies by Monfort (2008) and Stiglitz et al. (2009) prove. From a theoretical point of view, these recent studies will bring into discussion the role played by the convergence clubs in the governance of the process, but also a new theoretical background derived from the new spatial economy. More recent studies insist to introduce in the beta and sigma-convergence models the role played by the geographical space (Bourdin 2013a; Grasland 2012), generally using the concept of functional neighborhood as a filter for economic performance. Both Grasland and Bourdin focus on the possible construction of territorial cohesion indicators based on the local or regional sigma-convergence. Our research investigates the opportunity of the introduction of specific spatial variables in the beta-convergence models (potential accessibility functions of the GDP) and how these explanatory indicators interfere with the economic accumulation at different scales (Gutiérrez 2001; Stepniak and Rosik 2013).

Data and Geometries

The dataset we use in this paper is provided by EUROSTAT in the panel of general and regional statistics datasets. The indicators we collected cover the period 2003–2014 and they are composed of two distinct sets of variables: the GDP at NUTS3 scale for the mentioned period and the population of NUTS3. The GDP indicator is expressed in millions of Euro and it is not weighted with the purchasing power index, reflecting more accurately the differences in economic performance between regions. The ratio between the GDP at NUTS3 scale and the number of inhabitants allowed us to build a new set of indicators, the GDP/inhabitant, starting from 2003 and ending in 2014. In order to have access to data describing the convergence process at NUTS2 and NUTS1 geographical scales, we have iterated the calculation of the GDP/inhabitant for these spatial frames and conserved the results in a geo-database file. The geometries needed for the mapping and spatial analysis process were extracted from the GISCO EUROSTAT internet portal and concern the NUTS3 spatial data frame for

2013. Moreover, the geocoding system of the NUTS3 in 2013 perfectly matches the geographical ID included in the economic tables extracted from the EUROSTAT (General and regional statistics, National accounts, ESA 2010 classification).The economic data previous to 2003 and the indicators related to 2015 are incomplete and not usable for large territorial scales of analysis. Specific operations of generalization were applied in ArcMap and the results of these operations were preserved as basemaps for the implementation of the beta convergence models at NUTS2 and NUTS1 scale. One major limitation related to the data and geometries consists in the exclusion of Norway, Switzerland and Iceland from our analysis. The states from the Western Balkans and Albania were also excluded, as only sparse information about the economic performance is available at intermediate geographical scales. As our intention is to focus on the trends of the economic convergence in the European Union, with a special highlight on the Eastern states, the regions composing the French DOM (Domaines d'Outre-Mer) were also eliminated. Finally, our study area is composed of 1340 NUTS3, 272 NUTS2 and 96 NUTS1 regions, from 29 countries, including the FYROM. All the spatial datasets were projected from GCS ETRS 1989 in Lambert Azimuthal Equal Area system of projection, in order to allow the processes of spatial analysis to be run.

Methodology

Our main intention is to identify and explain the trends of the economic catching-up process in Europe, using a beta-convergence model applied at different spatial scales, for the 2003–2014 period of time. Despite is simplicity, the beta-convergence model is extremely difficult to implement, if the data quality is poor (Quah 1996). The basic geo-statistical form of the model can be described as an ordinary least squares regression equation, with at least two explanatory variables:

AAGRt-tn = b*GDPt+a*SEVt +c+e, where

AAGRt-tn = the average annual growth rate of the indicator describing the economic performance for the period t-tn (starting year and ending year). In our case, the indicator retained in the model is the GDP/inhabitant and the starting year is 2003 or 2008, while the ending year is 2008 or 2014, as three different models of beta-convergence were implemented.

The equation we used for the calculation of the AAGR is:

AAGR = ((GDP/ inhabitant tn)/ (GDP/ inhabitant tn)^(1/(tn-t))-1

GDPt = the starting level of the economic process. It is basically an indicator that describes the differences in economic performance at the starting point of the analysis, 2003 or 2008, in our case. Generally, this indicator is introduced in the equation in a logarithmic form, in order to eliminate the non-linearity of the explanatory variable, but also in order to reduce its amplitude. Our option was to use the GDP/inhabitant in 2003 or 2008 as a predictor after a logarithmic transformation.

SEVt = the second explanatory variable of the convergence process. In the literature, we find a wide range of possible candidates for this indicator: stock of FDI, spatial accessibility, stock of employed personnel in branches with high added value etc. (Ben-David 1993). In the geo-statistical models we propose, we have made an option for an indicator of potential accessibility of the GDP at NUTS3 scale, using a Gaussian kernel with a span of 500 km. The t moment was set for 2003 and 2008. The values were transformed using base 10 logarithms, avoiding the massive amplitude of the data (Grasland 1990). The parameters of the model (b, a and c) reflect the role played by the candidate explanatory variables in the explanation of the economic convergence process. If the sign of b (beta-convergence) is negative and significant as a parameter, we have a statistical model that accurately describes the catching-up process of the less advanced regional economies. If the sign of b is close to 0 or negative, it indicates economic divergence or instability in the studied area.

The steps needed to perform the beta-convergence analysis and the working flows are organized as follows:

1. Data collection and preparation. This step was presented in the previous section (Data and Geometries).

2. Investigation of a possible association between the AAGR of the GDP/inhabitant and the spatial distribution of the GDP/inhabitant, at the starting year of the analysis (2003 or 2008), for different territorial configurations (NUTS0, 1, 2 and 3 levels). The method used for this investigation is the OLS regression. Three different statistical models were implemented: one for the period before the economic crisis (2003–2008), one for the period of the crisis and recovery (2008–2014) and one for 2003–2014, the latter functioning as a synthetic model. This exploratory approach was needed in order to assess the role played by the configuration of the economic performance at the starting point of the analysis. The results obtained also helped us to evaluate the link between the territorial distribution of the convergence process and the spatial scales of analysis. As the statistical models were valid, we were allowed to pass to stage 3 of our research, the implementation of the beta-convergence models.

3. Before starting to implement the beta-convergence models, a choice was made for a second explanatory variable in the OLS regression equation. The indicator we retained is the potential accessibility of the GDP at NUTS3 level, using a Gaussian kernel with a fixed span at 500 km. The indicator was calculated for all the 1340 NUTS3 units in our table, and a GIS tool was devised in order to col-

lect the results. The GIS tool is based on the Model Builder instrument in ArcGIS and it is supposed to function only with Euclidean or Manhattan distances, for the moment. In a first instance, our intention was to use road-distance between the NUTS3 centroids, but the MAUP complications due to the variable size of the NUTS3 denied the use of the Network Analyst functions. Indeed, an approach to distances using a NUTS3 origin-destination cost matrix would have been interesting, but, as the literature suggests, it is rather appropriate for analysis at LAU2 level (Spiekermann et al. 2015; Stepniak and Rosik 2013). Recently, Grasland (2012) used a time-distance matrix at NUTS3 scale in order to assess the sigma-convergence process in Eastern Europe; however, the reliability of the time-distance matrix is questionable. The mathematical model of the potential accessibility function is based on a set of starting hypotheses and the weighting of the distance matrix, according to these hypotheses. The first hypothesis deals with the role played by the distance in the evaluation of the spatial interaction between the NUTS3. Canonically, the value of this parameter (p, in our model) is sed at 2, but recent studies show that this value is overestimated in areas with a good territorial transport infrastructure and its value should be substantially lower. The second hypothesis describes the relation between the cumulated volume of spatial interactions and the distance between the NUTS3. Explicitly, we assume that 50% of the cumulated spatial interactions between regions occur at a distance band S of n km (500 km, in our case). One can empirically test and validate the two hypotheses by using a model of spatial interaction based on economic flows between regions. However, this set of indicators is not accessible at NUTS3 scale and few attempts to model the flows at NUTS2 scale are found in the literature (Rusu 2017). The formalization of the potential accessibility function in our research is: $P.A.i = e^{\alpha * Dij \wedge p}$, where $\alpha = \ln(0.5)/S^2$ and Dij represents the distance between each NUTS3 (i) and the other NUTS3 (j). The value of p was set to 2 and the value of S is 500 km. Once this function is calculated, it provides results between 0 and 1 and it can be used as a weighting function for the GDP available in the Gaussian functional neighborhood of each NUTS3 i. The weighted values of the GDP are summarized and allow us to create an indicator labelled POTGDP03, an indicator that will be used for further research on the convergence process. This indicator was devised at NUTS3 scale and aggregated by summing operations for superior geographical levels (NUTS2 and NUTS1).

4. The exploratory regressions models performed at step 2 of our methodological approach show that there is little need to observe the convergence process for the period 2008–2014, as there is evidence that it is an economically divergent period. In this case, we have focused on two distinct beta-convergence models, covering the time gap of 2003–2008 and 2003–2014. The insufficient number of spatial units available at NUTS0 scale allowed us to perform our in-

vestigation only at NUTS3, 2 and 1 scale. The 3 layers of analysis combined with the two distinct periods of time were automatically merged by using the model builder function in ArcMAP and the OLS function, available in the Spatial Statiscs Tools panel. The result is a set of six distinct OLS regression equations that describes the trends of the beta-convergence process, for different territorial scales.

5. Cartographic support and spatial analysis. The results obtained from the six beta-convergence models are also interesting from the point of view of mapping and for the inherent spatial analysis process. The validation of the six OLS regression models, from a statistical perspective, is incomplete. Much more intriguing is the fact the standardized residuals of the six models are spatially autocorrelated, as the calculated Moran's I index suggests. This aspect indicates that there are other latent variables explaining the beta-convergence process and that further research is needed (Mitchell 2005).

All these steps will be largely described in the next section of our paper, together with the technical decisions that made the beta-convergence process analysis possible.

Validation of Results

THE MAIN results of our analysis are compiled in this section. As the methodological steps were largely explained in the previous part, we considered that the results we obtained must be logically organized as a function of the deployment of our methodology. In a first instance (step 1), we have collected the needed data and the geometries to be used in the evaluation of the relation between the territorial scale and the process of economic convergence. As we mentioned, the lack of data for Norway, Switzerland and the states of the Western Balkans is a major problem for the calculation of the potential accessibility of the GDP in a Gaussian kernel of 500 km, affecting the reliability of the indicator for the countries in the vicinity of the missing data area (e.g. France, Germany, Italy, Sweden, Greece, Croatia, Bulgaria, or Hungary). The results obtained at step 3 are only partially reliable. In a second instance, we have investigated the statistical association between the AARG for each NUTS3 and the starting level of economic performance, as described by the GDP/inhabitant at time t, where t is 2003 or 2008. Three periods were covered (2003–2008, 2008–2014 and 2003–2014) by our OLS analysis, each period being declined as a function of the territorial frame of economic convergence manifestation (NUTS0, 1, 2 and 3).

Table 1. Coefficients and results of the ols Regression Models of partial beta-convergence for 2003–2008, 2008–2014 and 2003–2014, for each geographical scale of analysis

		nuts0			nuts 1			nuts 2			nuts 3		
Time	ols	R2	Slope	Inter-cept	R2	Slope	Inter-cept	R2	Slope	Inter-cept	R2	Slope	Inter-cept
2003–2008	V1	.6347	-.1047	.512	.7425	-.1336	.6232	.6993	-.1259	.587	.6687	-.1163	.54
2008–2014	V2	.0599	-.0139	.0693	.0071	-.0335	.0335	.0003	.0013	.0009	.0004	.0014	.0037
2003–2014	V3	.5885	-.0523	.2564	.6446	-.0607	.2872	.5515	-.0549	.2599	.5146	-.0501	.2386

Source: author's own calculations.

The formalization of the ols models in this part generally ignores the validation of the coefficients slope and intercept because it is supposed to provide only a superficial vision on the role played both by scale and economic cycles in the process of convergence. The y1, 2 and 3 labels in the ols column of the table represent the explained variable that is formalized as the annual average rhythm of growth of the gdp/inhabitant for 2003–2008 (y1), 2008–2014 (y2) and 2003–2014 (y3) (see the Methodology section). The explanatory variable is the gdp/inhabitant in 2003 and 2008, transformed in 10 base logarithm. Each model and its descriptors (R^2, slope and intercept) were included in the table. The ols regression model for the 2008–2014 period of time is particularly important, showing that this interval is characterized by economic divergence or instability, regardless of the scale of analysis (nuts0 to nuts3). The slope of the regression line is negative or close to 0 and it indicates that the starting level of the analysis (gdp/inhabitant in 2008) is no longer relevant to explain the rhythm of economic growth or decline for the 2008–2014 period.

According to the synthetic table, the nuts1 territorial scale is the most appropriate frame to analyze the process of economic convergence, as a function of the starting level of economic performance. At nuts2 scale, the coefficient of determination (R^2) between the aagr and the logarithmic values of the gdp/inhabitant (2003) drops to 0.69, compared to 0.74 at nuts1 level, and it will decrease even more, if the analysis is implemented at nuts3 scale (0.66). The same trend might be observed also for the coefficient of the slope. The set of the ols we calculated for step 2 indicates that the beta-convergence model is an option to be considered, when analyzing the rhythm of the economic catching-up process in Europe. Both the coefficients of determination R^2 and the slopes of the regression lines corroborate the idea that the annual average growth rhythm of the GDP per inhabitant is conditioned by the starting level of economic performance in 2003.

In this case, we have proceeded further in our research and we devised a more sophisticated model of economic beta-convergence, that will take into account not only the starting level of economic performance in 2003, but also the geographical position of the spatial units included in the analysis, more specifically the potential accessibility of the GDP, in a Gaussian kernel with a 500 km span. The implementation of step 3 of our methodology demanded a more technically-oriented approach. In a first instance, we devised a distance matrix between the centroids of the NUTS3 included in our database. The only option for the development of this matrix was the use of Euclidean distances, based on the latitude and longitude coordinates of the NUTS3 centroids. The resulting table of distances was obtained through the implementation of the Point Distance function, from the ArcMap Toolbox Proximity Tolls (Analysis Tools panel). Once the distance matrix was created, the nest steps consisted in a join and relate operation, based on a common case field (the geographical identifier of the destination NUTS3). The indicators that we joined in the distance matrix are the GDP in 2003 and 2008 (expressed in millions of euro), at NUTS3 scale. Finally, these two variables were weighted using a distance function based on a Gaussian kernel approach (explained in step 3, the Methodology section). As the distance matrix was populated with economic performance indicators, we have managed to summarize the results in the form of a new variable called potential accessibility of GDP in 2003, labelled POTGDP03. In the tables we used for the beta-convergence analysis, this indicator was transformed using base 10 logarithms. The missing data for the mentioned states (Norway, Switzerland, countries in the Western Balkans etc.) make the results questionable for all the neighboring states of the missing data area, but not only. However, taking into account the results obtained after the implementation of step 4 of our analysis, the major key findings might be independent of the quality of the statistical data.

In order to complete the methodological approach, we have developed an analytical frame that encompasses the possible trends of economic convergence at NUTS1, 2 and 3 scales. This frame is based on the results of six OLS regression models, formalized as follows:

y1 = b1*X03+a1*1POTGDP03+c1+e1

y2 = b2*X03+a2*POTGDP03+c2+e2,

where:

y1 = average annual rhythm of growth for 2003–2008, the indicator taken into account being the GDP/inhabitant (AARG_2003–2008);

y2 = average annual rhythm of growth for 2003–2014, the indicator taken into account being the GDP/inhabitant (AARG_2003–2014);

X03 = the GDP/inhabitant in 2003, expressed in logarithmic values (base10);

POTGDP03 = the potential accessibility of the GDP in 2003 (billions of Euro) and expressed in logarithmic values (base10);

c1,2 = the intercept of the Y axis for each model;

e1, e2 = standard error of the model residuals.

The two OLS regression models were iterated for all the available analysis scales in our database, meaning NUTS1, 2 and 3. Minor modifications in the ArcGIS Model builder (entry data, output results etc.) allowed us to automatically have access to the model coefficients and the main results. Two major observations might be derived from the analysis of these results. The first one suggests that approaches focused on infra-continental scales are not reliable. For example, if one follows the beta convergence process only at the scale of Eastern Europe, unstable results will be provided (a low R^2, low values of the regressions coefficients or high p-values associated with the slope coefficients (>5%). Consequently, the beta-convergence models implemented at the scale of large economic and political unions are much more reliable, from a statistical point of view. The second point of interest is a matter of the geographical scale of analysis. As the implementation of step 2 of our methodology suggests that the proper scale of investigation of the economic catching-up process is the NUTS1 frame (Y=AARG and X = GDP/ inhabitant in 2003—logarithmic values), adding a second variable in the explanatory model will bias the statistical efficiency of the model at exactly this scale. An R^2 of 0.94 (in 2003–2008) or 0.97 (2003–2014) for the beta-convergence OLS model at NUTS1 scale is high only because it is a statistical artefact. As a matter of fact, the role played by the potential accessibility of GDP in 2003 (PotGDP2003 indicator) is almost null, as the p-values of the slope coefficient suggest. With lower but significant coefficients of determination, the beta-convergence models for the NUTS2 and NUTS3 scales are more reliable. Additionally, the normal distribution of the residuals for 2003–2014, at NUTS1 scale, is violated and the histogram of the residuals is rather bi-modal. For both periods of time (2003–2008 and 2003–2014), the beta-convergence OLS equations firmly indicate that the appropriate scale of analysis of the economic catching-up process is rather appropriate for the NUTS2 frame, when using two explanatory variables: the starting level of economic performance in 2003 and the potential accessibility of the GDP in 2003.

TABLE 2. COEFFICIENTS AND RESULTS OF THE OLS REGRESSION MODELS OF BETA-CONVERGENCE FOR 2003–2008 AND 2003–2014, FOR EACH GEOGRAPHICAL SCALE OF ANALYSIS

		Coefficients (2003–2008)					
Models:		R2	b	a	c	p_b	p_a
OLS1	NUTS1	.945	-.058	-.001	-.570	.000	.475
OLS2	NUTS2	.700	-.132	.005	.593	.000	.070
OLS3	NUTS3	.681	-.131	.012	.566	.000	.000
		Coefficients (2003–2014)					
Models:		R2	b	a	c	p_b	p_a
OLS1	NUTS1	.970	-.218	.333	.352	.000	.000
OLS2	NUTS2	.587	-.064	.008	.270	.000	.000
OLS3	NUTS3	.552	-.062	.010	.261	.000	.000

SOURCE: author's own calculations.

The coefficients and the labels in the table must be read as follows:

2003–2008 = the pre-crisis period;

2003—2014 = the post-crisis and recovery period;

R^2 = adjusted coefficient of determination for the OLS models describing the beta-convergence process, both for the 2003–2008 and 2003–2014 period and for each scale (6 models).;

B = coefficient describing the role played by the economic starting level of the spatial units in 2003. The indicator used to investigate this role is the GDP/inhabitant in logarithmic values;

A = coefficient describing the role played by the potential accessibility of the GDP in a Gaussian kernel with 500 km span NUTS3 level in 2003 and logarithmic values;

C = intercept in the regression models, for each geographical scale and for each period;

p_b = probability that the coefficients attached to the explanatory variables are close to 0. Low values of this probability index mean that the coefficients are reliable and relevant;

p_a = probability that the coefficients attached to the explanatory variables are close to 0. Low values of this probability index mean that the coefficients are reliable and relevant.

The six models we implemented show that the process of economic convergence is scale dependent. With the exception of the OLS no.1 and no. 4 (NUTS1 scale), the four remaining models are acceptable, from a statistical point of view, but far from perfect. As a matter of fact, according to the adjusted coefficient of determination R^2, the best scale to capture the trends of the beta-convergence is the regional NUTS2 frame and the models work better for periods with clear spatial patterns of economic growth, like the 2003–2008 period of time. When we include the crisis years in the analysis, we observe a drop in the performance of the model, an aspect that is also corroborated by the decrease in intensity of the coefficients describing the role played by the starting level of economic performance (GDP/inhabitant in 2003, logarithmic values). The sign of these coefficients (*b* in the table) is constantly negative, indicating that beta convergence is a functional process. The second variable we took into account is the potential accessibility of the GDP in 2003. Its sign is positive and it suggests that the potential of spatial interaction had an economic impact, in terms of growth. However, the values of the *a* coefficient are larger at NUTS3 scale, meaning that the local level of geographical analysis is more sensitive to the economic context or its functional neighborhood.

Before passing to point 5 in our methodological approach, we performed a final check on the residuals of the 6 models, testing them for spatial autocorrelation. From a canonical statistical point of view, this test is not necessary, as long as the other criteria of the model's performance are respected. From a geostatistical point of view, this step is crucial in order to detect the agglomerative process of economic over-performance based on spatial proximity. Detecting the spatial autocorrelation of the residuals has two consequences:

TABLE 3. INCREMENTAL SPATIAL AUTOCORRELATION INDEX (MORAN'S I) OF THE STANDARDIZED RESIDUALS

	NUTS3			NUTS2		
Distance (km) NUTS3	Moran's I 2003–2008	Moran's I 2003–2014	Distance (km) NUTS3	Moran's I 2003–2008	Moran's I 2003–2014	p value
532	*.311*	*.131*	1.500	*.087*	*.019*	*.006*
572	*.290*	*.115*	1.605	*.076*	*.020*	*.004*
612	*.272*	*.105*	1.711	*.067*	*.017*	*.010*
652	*.255*	*.095*	1.816	*.057*	*.014*	*.021*
692	*.238*	*.090*	1.922	.046	*.008*	*.136*
732	*.223*	*.085*	2.027	.040	*.005*	*.265*
772	*.208*	*.084*	2.133	.033	*.002*	*.452*
812	*.194*	*.082*	2.238	.027	*.001*	*.542*
852	*.183*	*.079*	2.343	.023	*.000*	*.622*
892	*.173*	*.077*	2.449	0.021	*.001*	*.513*

NOTE: Italic values are significant for a p<.05.
SOURCE: author's own calculations.

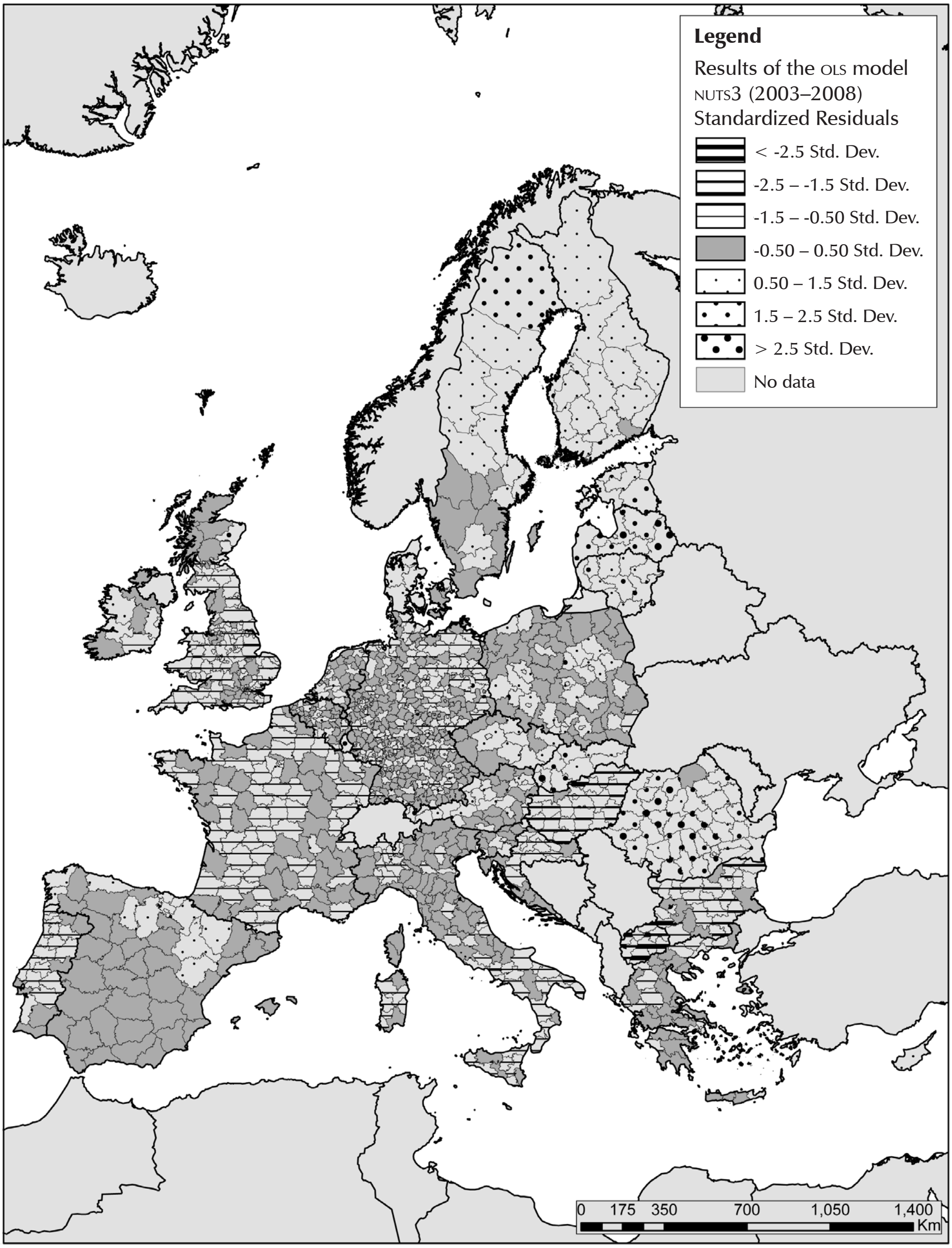
1) A lack of stationary explanatory variables. Both the GDP/inhabitant in 2003 and the potential accessibility play different roles in different parts of the continent. If one notices agglomerations of positive residuals based on proximity, she/he might suspect the apparition of regional clubs of economic performance and convergence.

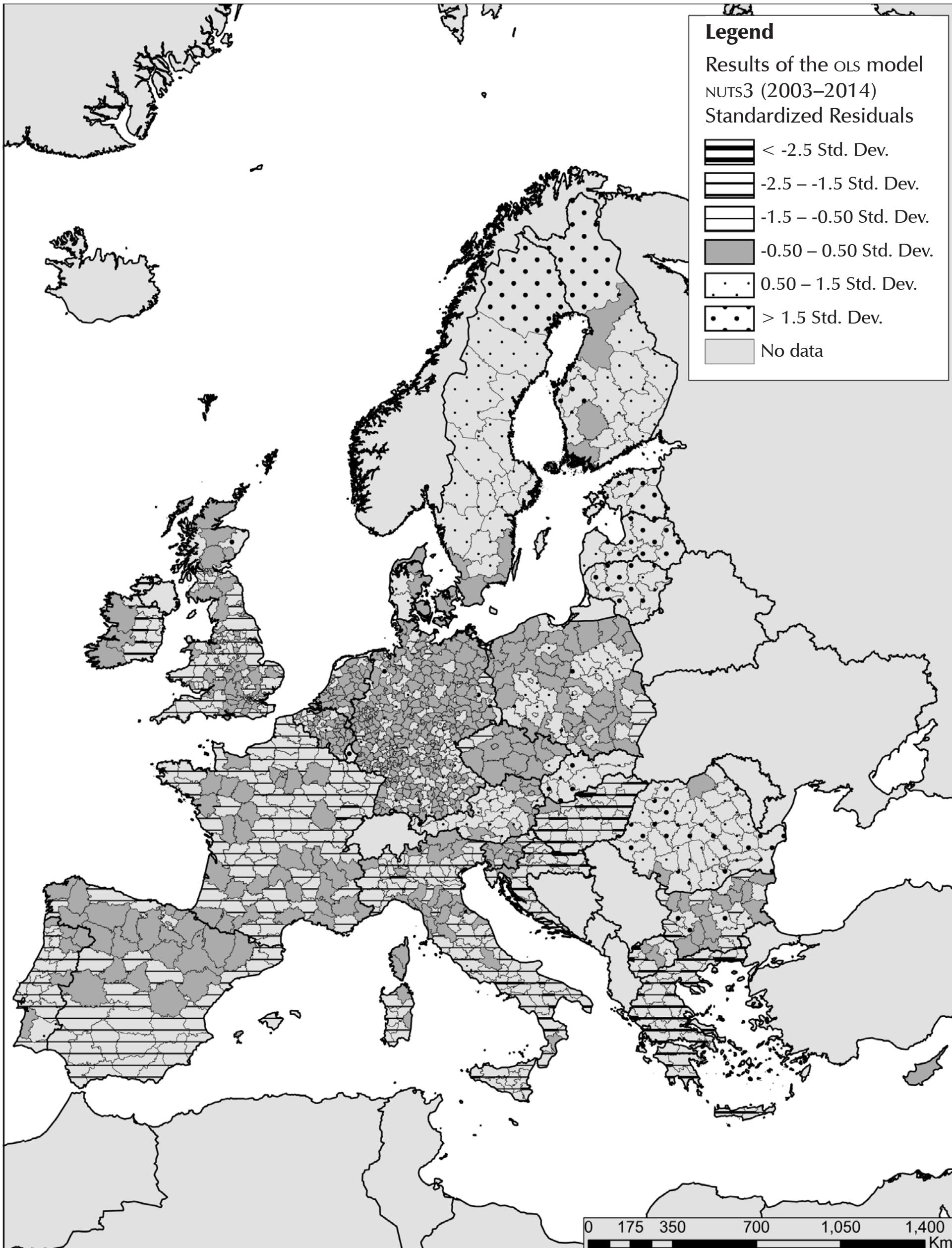
2) The models are incomplete. There are other explanatory variables at stake, both economic and spatial. However, this consequence is already suggested by the explanatory quality of the models described by R^2.

The method we used to test the residuals for spatial association is the classic Moran's I index, with incremental distance bands. As the size of NUTS3 and NUTS2 is different, the distance bands also differ. The calculated values for the 4 sets of residuals are statistically significant, except for the ones described in the NUTS2 column Moran's I 2003–2008 and explained in the table's legend. The residuals depict spatial autocorrelation, emphasizing the fact that latent variables might also be introduced in the OLS beta-convergence models. The effect of spatial association is larger at NUTS3 scale than NUTS2 scale and shows a decreasing trend for the 2003–2014 period, indicating possible readjustments of the local and regional economic performance in Europe during the crisis (Fig. 1).

The maps depicting the spatial distribution of the residuals on the short term in the convergence period (2003–2008) and on the long term (2003–2014) clearly suggest that the states of Eastern Europe are clearly included in a catching-up process of economic accumulation. This aspect is extremely visible in the 2003–2008 period of time, with three major exceptions: FYROM, Bulgaria, and Hungary. In Hungary, for example, only the NUTS3 of the Budapest metropolitan area and the Komárom region are economically over-performing, all the other spatial units being placed in situations of under-performance, according to their GDP/inhabitant in 2003 and their potential for economic and spatial interaction. The case of Bulgaria is simpler. A concentric gradient of decreasing economic performance and accumulation is centered on Sofia, only 2 NUTS3 escaping from this spatial regularity—Varna and Ruse, the first one being a confirmed metropolitan region (Groza and Rey 2008), the last one profiting from its economic extroversion near the Romanian border. The situation of the FYROM is illustrative for the destiny of countries placed in a bizarre geographical position of 'entre-deux' (Rey et al. 2004). Only the capital region of Skopje partially escapes the general under-performance rule that governs the area. At the opposite end, countries like Romania, Slovakia and the Baltic States are in a clear situation of over-performance concerning the average annual rhythm of growth of the GDP/inhabitant. However, in Romania, this over-performance is marked by the West-East opposition of the spatial units and complicated by the presence of metropolitan areas in NUTS3 like Iaşi, Dolj, Galaţi

Fig. 1. Spatial distribution of the Standardized Residuals of the ols Regression Models at nuts3 scale (2003–2008 and 2003–2014)




Legend
Results of the OLS model
NUTS3 (2003–2014)
Standardized Residuals
< -2.5 Std. Dev.
-2.5 – -1.5 Std. Dev.
-1.5 – -0.50 Std. Dev.
-0.50 – 0.50 Std. Dev.
0.50 – 1.5 Std. Dev.
> 1.5 Std. Dev.
No data
0 175 350 700 1,050 1,400
Km

or Constanţa. In Slovakia, the distribution of the positive residuals is also subject to a core-periphery logic, with Bratislava capital region in an advanced position. The Baltic States are generally included in a larger region with high rhythms of GDP/inhabitant growth and with few territorial differences, at national scale. The case of Poland is also interesting. In the 2003–2008 period, the Polish NUTS3 shows a residual distribution that is generally close to the area of confidence of the model, but with a different pattern for the metropolitan areas of Warsaw and Wrocław. The same configuration is visible in the Czech Republic, with peaks of over-performance on the Prague-Brno axis (Fig. 2).

On the long term (2003–2014), the situation seems to be stable, with the notable exception of countries that recover a positive and higher annual average rhythm of growth, after the crisis and during the recovery period. It is generally the case of some Western European states like France, Italy, or Great Britain. The situation of the Eastern European countries does not change too much, the patterns of over- or under-performance being almost identical to the pre-crisis period. However, in some of these states the dynamic territories previously described are defined by the new spatial distribution of standardized residuals.

When we change the analysis scale from NUTS3 to NUTS2, we can easily identify the shifts in the trends of economic convergence, at continental scale. In the 2003–2014 period, few NUTS2 regions remain in the cartographic classes of over-performance for their average annual rhythm of growth of the GDP/inhabitant. The NUTS2 in Eastern Europe at least stick to the beta-convergence model, but the spectacular positive residuals observed on the NUTS3 maps are now much lower. The logical conclusion is that the effects of the economic crisis and recovery period are scale-dependent. A focus on the local level of analysis (NUTS3) shows that the economic accumulation period of 2003–2008 still has an impact on the process of convergence, despite the severity of the financial crisis. The aggregation of data at NUTS2 level makes the economic effort of inter-regional catching-up extremely fragile.

Conclusions

This section is dedicated to the conclusions and it addresses the scientific key-findings observed during the research process and the policy recommendation derived from the relevant scientific observations. First, as a general conclusion, we should mention that the main goal of our investigation was fulfilled. More specifically, we have found that the beta-convergence process affecting the European spatial units is a scale-dependent process, the results of the models we implemented being affected by the geographical reference frame of the data. At the same time, we have observed that spatially aggregated indicators, such as the potential accessibility of the GDP, present a limited impact on the economic convergence process and this impact is also scale-dependent. A test concerning the aggregation of NUTS3 in pseudo-NUTS2 (Grasland 2012; Bourdin 2013a) was also implemented, but the high heterogeneity of data denied its feasibility. In this case, we considered it necessary to highlight only the most important results of our research in a paragraph dedicated to the synthetic key-findings:

a) the beta-convergence models are solid enough to describe the economic trends of the European spatial units, excepting the NUTS1 scale. The NUTS0 scale was not analyzed due to an insufficient number of spatial units;

b) if we focus our analysis on the NUTS3 scale, the period 2003–2008 might be somehow considered as the 'golden era' of regional economic convergence in Europe, even if the rhythms of participation in this process are unequally distributed, both in the Eastern and the Western states;

c) the OLS models describing the beta-convergence process are more effective at NUTS2 scale than NUTS3 or NUTS1 scale, suggesting that this level of policy and decision interventions is still reliable in the implementation of the EU territorial policies;

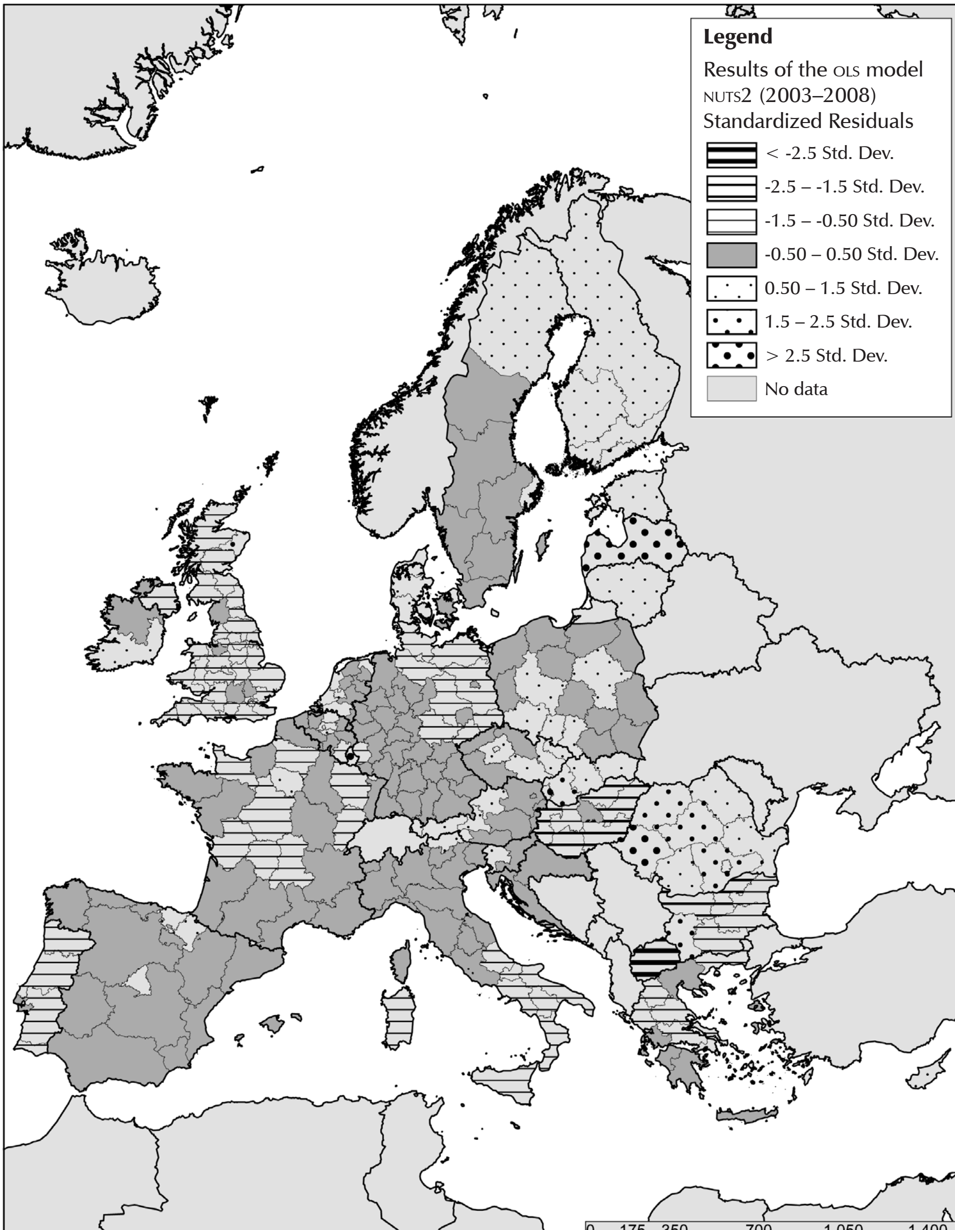
d) the starting level in the economic convergence process plays un undeniable role, the poor regions showing higher rhythms of economic growth than the rich ones. But, despite the high values of the AARG, the economic cohesion or a spectacular reduction of the disparities is not possible on the short term;

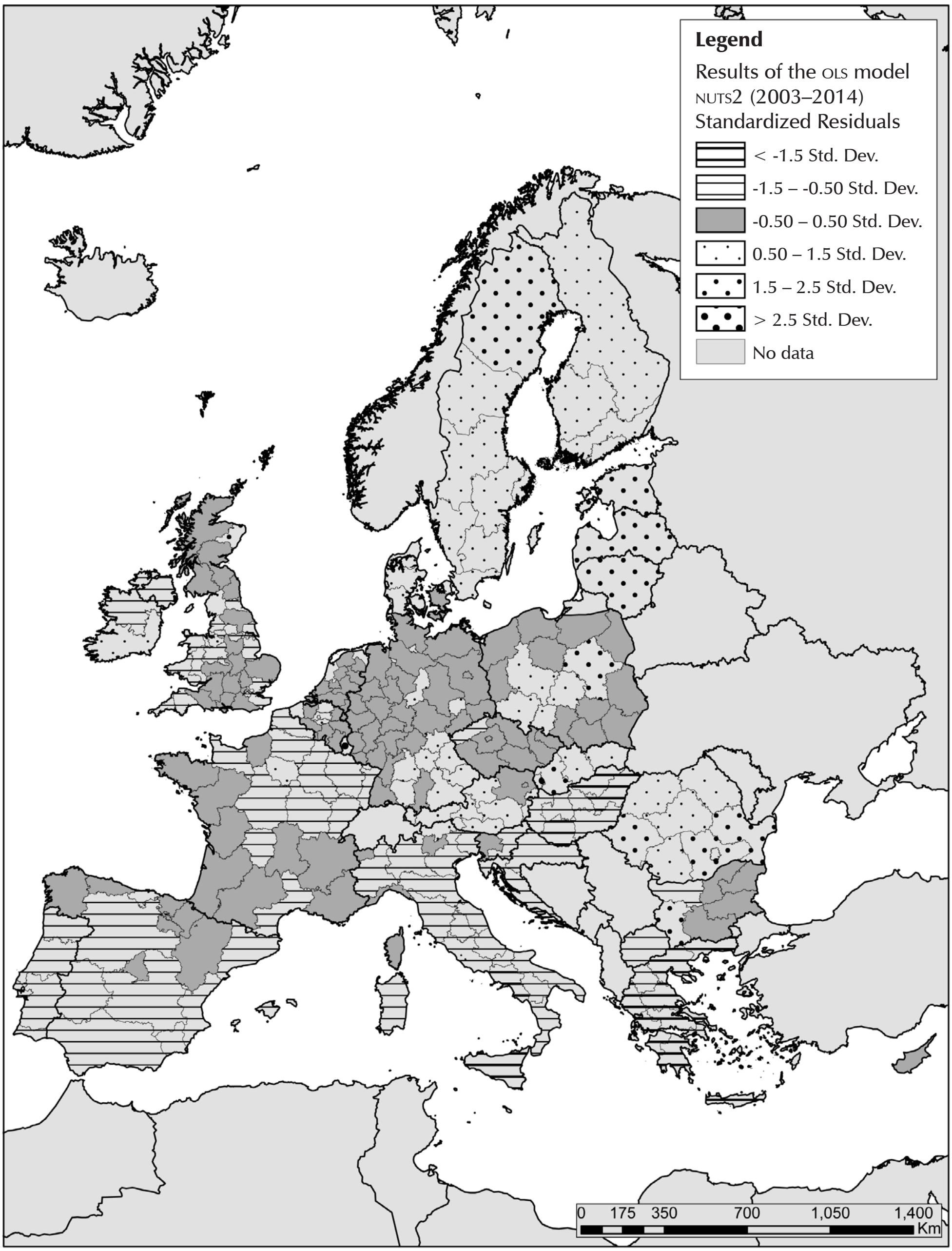
e) the potential accessibility of the GDP in a Gaussian kernel of 500 km span is a factor of convergence mostly at NUTS3 scale, losing its importance at NUTS2 and NUTS1. Despite the low values of its coefficients in the OLS models at NUTS3, its cumulative role and impact on the average annual rhythm of growth might not be an aspect to neglect on the long term;

f) the distribution of the positive residuals of the models at NUTS3 scale and the spatial autocorrelation coefficient suggest the crystallization of infra-national clubs of economic over-performance, both for the 2003–2008 and the 2003–2014 periods.

❑

FIG. 2. SPATIAL DISTRIBUTION OF THE STANDARDIZED RESIDUALS
OF THE OLS REGRESSION MODELS AT NUTS2 SCALE (2003–2008 AND 2003–2014)




Legend
Results of the OLS model
NUTS2 (2003–2014)
Standardized Residuals
< -1.5 Std. Dev.
-1.5 – -0.50 Std. Dev.
-0.50 – 0.50 Std. Dev.
0.50 – 1.5 Std. Dev.
1.5 – 2.5 Std. Dev.
> 2.5 Std. Dev.
No data
0 175 350 700 1,050 1,400
Km

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Abstract

Territorial Data Aggregation and Trends of Regional Economic Convergence in Europe: A Geo-statistical Analysis for the 2003–2014 Period

As the majority of studies and reports highlight, during the 2001–2013 period the Eastern EU states showed accelerated rhythms of economic convergence. The general conclusion stays that as the economic performance of the Eastern EU countries approaches that of the Western EU states, the level of internal disparities also increases, indicating that the trends of convergence might be affected by the territorial context of data aggregation and specific processes of economic accumulation at each NUTS scale. This paper analyzes how the territorial scale of data aggregation can explain different intensities of the economic convergence, in a flexible multi-scalar approach to the indicators. A top-down descriptive approach is employed, starting with the national level and continuing to the NUTS3 spatial frame of data modeling, estimating how the trends of the convergence process are shifting when the scale of analysis is modified.

Keywords

beta-convergence, potential accessibility, economic crisis, scale sensitivity, ESPON Space