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The Evaluation of European Structural Funds on Economic Convergence with the Application of Spatial Filtering Technique

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Abstract

In our work we intend to verify the impact of European policies on economic growth of NUTS-2 regions in the EU-12. The Regional Policy of the European Union has the stated aim of improving the economic well-being of the economically weak regions. This is possible by removing the disparities in wealth, by restructuring declining industrial areas and by diversifying rural areas which have declining agriculture.

Our main aim is to evaluate the impact of Structural Funds in economic convergence. It is conceivable that the convergence rates of the European regions could differ because often the economies do not have homogeneous structure and that, at the same time, it would exist a mutual economic dependence among neighbor regions. Using a particular kind of spatial econometric approach, the spatial filtering technique, to estimate β-convergence we are able to manage both structural heterogeneity and spatial dependence. Our results show that without the Structural Funds the convergence rates are rather low and many regions diverge, while with the inclusion of the Structural Funds in the model, the rates of convergence increase, regardless of contribution, positive or negative, exerted by the Funds on the growth process. In model with the Funds for Objective 1 and 5b these provide a positive contribution to economic growth and make sure that all regions converge. The inclusion of Objective 2 Fund, instead, tends to have a distorting effect: its contribution to growth is negative and the average convergence rate increases but in some regions the local coefficients are negative.

1 - Introduction

The Structural Funds, subsequently SF, are the most important strategic tool used by the EU to promote regional development; the financial resources currently used by the Cohesion Policy represent about one third of the total EU budget. How much the regional development policy supported by the SF has been effective in promoting economic growth and in fostering the convergence of EU regions? The main objective of this study is to help answer this question.

When the EU cohesion policy began in 1989 there were strong doubts about its effectiveness. These low expectations were mainly related to poor performance of regional development policies carried out in individual member States and to the fear that the less developed areas would not be able to sustain the competition levels of the core areas of EU (Rumford [44]; Leonardi [31]).

The reality was different: not only the peripheral and less developed European regions had not lagged compared with that more developed, but often they exceeded the economic performance of the latter.

However it is still difficult to sustain that economic growth was induced from Cohesion Policy rather than from other factors, also considering the fact that the effects of Cohesion Policy were not uniform throughout the European Union. Ederveen, Groot & Nahuis [18], for example, sustain that, among others factors, the quality of the institutions influences the final results of this policy.

In other words, where and how the policy is applied seems to make a big difference. In general, Cohesion Policy has helped to change the nature of European integration: from an integration based mainly on the creation of the single market it has allowed to land to an integration based on mutual solidarity and on a common political future. Another important contribution of CP is linked to the rediscovery of the territorial rather than sectoral dimension in regional policy. This feature primarily distinguishes Cohesion Policy from other policies put in place (e.g. Common Agricultural Policy).

In any case, there are strong doubts about the future of this policy; in the Fourth Cohesion Report (Commission of the European Communities [11]), the Commission points out that 'In spite of this progress, absolute disparities remain large. This is partly as a result of recent enlargement and partly as growth tends to concentrate — during the initial phases of development — in the most dynamic areas within countries'. The need to make significant changes to the cohesion policy is also widely affirmed in the recent Barca report [1].

In this paper we aim at evaluating the effects of SF on the convergence of labour productivity in 182 NUTS-2 region of EU-12, between 1989 and 2006 using a methodology based on spatial filters which allow to estimate the convergence parameters differentiated by region, decomposable into a global trend effect and a local effect. This is important because it represents a decisive step forward in understanding and assessing the effects of policies across regions at different levels (regional, national, European). The empirical approach we use is that of β-convergence proposed by Barro & Sala-i-Martin [2] and by Mankiw, Romer & Weil [35].

Over the years many authors have analyzed the convergence process of European regions and in this section we recall some studies to give a better contextualization of our results. Cuadrado-Roura [12] tests the hypothesis that regions with an initial level of GDP per head below the EU average have an above-average growth rate over the period 1977 to 1994. The estimated convergence rate is less than 2%. This type of result is also obtained by other analyses like for instance López-Baso [32] over the period 1975 to 1996.

Others frameworks allow for conditional convergence; results differ from one analysis to the other. Fagerberg & Verspagen [20], Cappelen, Castellacci & Fragerberg [6] or Geppert, Happich & Stephan [25] detect a low or absence of the convergence process, while Neven & Gouyette [40] consider two different regimes for Northern and Southern European regions and find a significant convergence rate. Basile, Nardi & Giraldi [3] find evidence of a significant convergence process and Martin [36] distinguishes various groups of regions among which Objective 1 regions and different sub-periods.

More recent contributions also introduce a spatial dimension in the formulation of the problem (Baumont, Ertur & Le Gallo [4]; Dall'Erba & Le Gallo [13] or Fischer & Stirböck [22]). The inclusion of spatial effects tends to reduce the estimated speed of the global convergence process while highlighting that the speed of convergence is higher for the poorest regions of Europe.

Previous empirical analysis does not lead to a clear-cut conclusion concerning the relationship between growth and regional disparities. The results strongly depend on the specification adopted and on the observations (period and regions considered, dataset used) and it is therefore difficult to draw a single general conclusion from the studies. A common finding is that a convergence process is taking place among EU regions but that the process is rather slow.

An identical approach was used to analyze the effect of Cohesion Policy on convergence. Cappelen, Castellacci, Fragerberg & Verspagen [6] find that 1988 reform of SF has increased its effectiveness in generating growth in poorer regions and promoting smaller disparities in productivity and income in Europe. Rodriguez-Pose & Fratesi [43] examine how SF support is allocated among different development axes in Objective 1 regions for the period 1989 to 1999. They find no significant impact of the Funds devoted to infrastructure or to business support, while investment in education and human capital has medium-term positive effects and support for agriculture has short-term positive effects on growth.

Ederveen, Groot & Nahuis [18] attempt to assess the efficacy of SF, following the approach proposed by Burnside & Dollar [5]. Their findings points to the absence of a global significant impact of SF on regional growth but that support allocated to regions with high quality of institutions are effective, leading to the conclusion that EU SF are conditionally effective.

Dall'Erba & Le Gallo [14] include the spatial effects in the estimation of a conditional β-convergence model, analysing separately each of the five objectives of regional support. The results indicate either insignificant impact or very small and even negative in some cases. In particular, support under Objective 1 is found to have a positive impact in the core regions but an insignificant one in the periphery regions.

The paper is organized as follows: in paragraph 2 we describe the EU regional support, in paragraph 3 the empirical model, in paragraph 4 the spatial model. At last, in the paragraph 5 we discuss the estimation results.

2 - EU regional support

The economic and social cohesion of the Community has become even more important since the adoption of the programme to complete the internal market by 1992 and the accession of Spain and Portugal. The financial resources required to adequately respond to these needs were obtained through the reform of SF. The reform of the Funds was completed by the end of 1988, setting five precise objectives to assist the least-favoured regions to catch up and to reduce disparities in development between regions. There where:

- Objective 1: promoting the development and structural adjustment of the regions whose development is lagging behind (regions with GDP per capita lower than 75% of the Community average);
- Objective 2: converting the regions seriously affected by industrial decline (high unemployment and low employment growth);
- Objective 3: combating long-term unemployment;
- Objective 4: facilitating the occupational integration of young people;

- Objective 5a: speeding up the adjustment of agricultural structures;
- Objective 5b: promoting the development of rural areas.

Objectives 1, 2 and 5b are regionally targeted; Objective 1 and other Objectives are mutually exclusive. SF were allocated within operational periods: the first running from 1989 to 1993, the second from 1994 to 1999, the third form 2000 to 2006 and the fourth from 2007 to 2013. During the second period the Objective 6 (sparsely populated area) was added. The Agenda 2000 agreement has reduced the objective from 6 to 3. Objective 1 was unchanged, while the new Objective 2 brings together the former Objectives 2 (conversion of declining industrial regions) and 5b (development of rural areas).

In this work we consider only the Objectives that are regionally targeted: 1, 2 and 5b for the first and second period and Objectives 1 and 2 for the third period for the EU-12[1], because they can easily be attributed to each NUTS-2 regions[2]. The incidence of Structural Funds (payments on commitments) on GVA for each country is shown in table 1; the GVA is related only to the eligible regions.

Regarding Objective 1, an increasing amount of Funds was devoted to Germany, Spain and Portugal, while for other countries it tend to decrease. However the incidence on total GVA reaches more than 2.5% that is a big amount of budget comparing its with the other two Objectives considered. The share of Objective 2 on GVA in fact, in spite of the inclusion of

Table 1 - Percentage of Structural Funds on GVA*

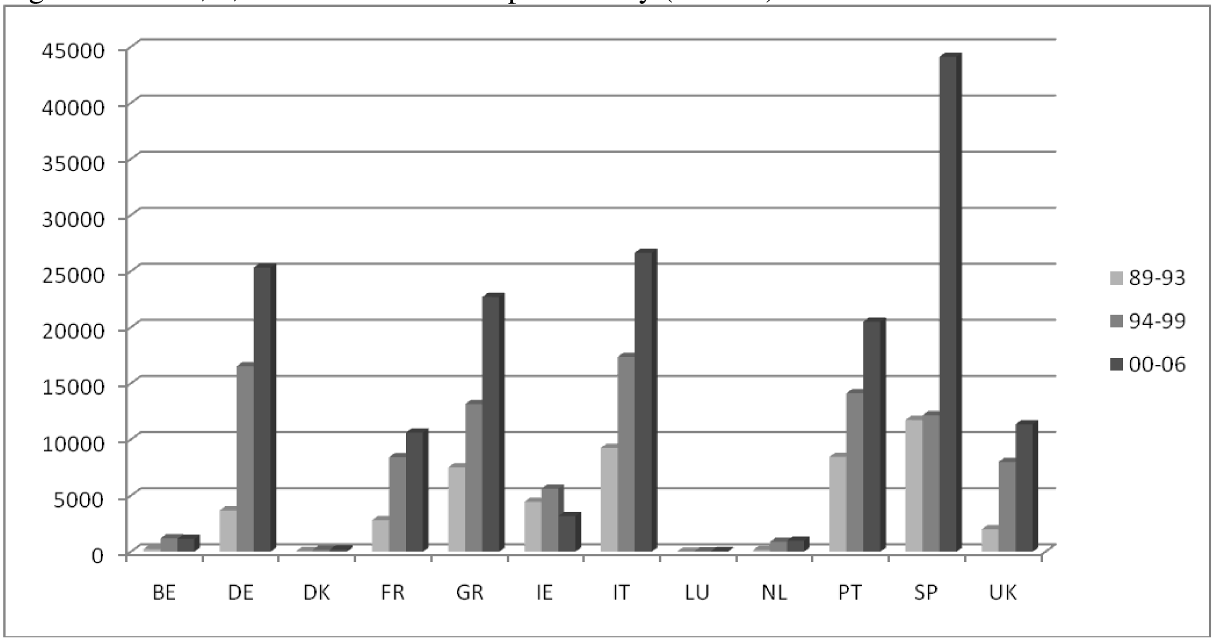
Country	Objective 1			Objective 2			Objective 5b	
	89-93	94-99	00-06	89-93	94-99	00-06	89-93	94-99
BE	-	0.0071	0.0050	0.0005	0.0009	0.0004	0.0001	0.0001
DE	0.0046	0.0086	0.0142	0.0002	0.0002	0.0003	0.0001	0.0001
DK	-	-	-	-	0.0002	0.0002	-	0.0001
FR	0.0084	0.0017	0.0012	0.0004	0.0008	0.0007	0.0003	0.0004
GR	0.0169	0.0223	0.0259	-	-	-	-	-
IE	0.0195	0.0142	0.0039	-	-	-	-	-
IT	0.0075	0.0103	0.0139	0.0001	0.0004	0.0005	0.0002	0.0002
LU	-	-	-	0.0002	0.0002	0.0003	-	0.0002
NL	-	-	0.0031	0.0007	0.0008	0.0003	-	0.0003
PT	0.0202	0.0242	0.0259	-	-	-	-	-
SP	0.0092	0.0059	0.0194	0.0012	0.0016	0.0013	0.0002	0.0003
UK	0.0000	0.0071	0.0070	0.0012	0.0010	0.0005	0.0004	0.0003
ALL	0.0106	0.0107	0.0148	0.0004	0.0006	0.0005	0.0002	0.0002

*The percentage is relative only to the eligible regions

[1] In the sample also includes regions of Germany which until 1990 were part of the former DDR.
[2] The SF for Objective 2 and 5b, when assigned at national level, were reassigned to eligible regions on the base of their population.

Objective 5b in last period, remained very low (no more than 0.016% of GVA). For Objective 5b the same happened for almost all countries, while the total share of resources for Objective 5b on GVA remains stable. Its overall incidence on GVA remained low in all periods, do not exceeding 0.02%.In figure 1 we can observe that in the three considered programming periods the regionalized Structural Funds increased significantly but, as shown in previous table, they remain a very small percentage of GVA.

Figure 1 - Ob 1, 2, 5b Structural Funds per country (MECU)



3 - The empirical model

To estimate the convergence process on labour productivity, we refer to a cross-country regression model, also defined β-convergence model. This model suggests that the regions with lower values of productivity grow faster than these with higher values (less developed regions would be catching-up with more advanced regions). It implies a negative correlation between growth rates of productivity and the initial levels of this variable. This type of approach to convergence has at least two main limitations. As shown by Mankiw [34] and Quah [42], β-convergence model considers countries and regions as "isolated islands" do not taking into account that the economies, mainly in Europe, although structurally different, are mutually interdependent. As a consequence, in order to include the influence of spatial effects on economic growth, many authors (Baumont, Ertur & Le Gallo [4]; Dall'Erba & Le Gallo [13]; Fischer & Stirböck [22], among the last), consider convergence models in presence of spatial dependence and spatial heterogeneity. A second limitation of this approach consists in its limited capacity of taking into account the structural heterogeneity of the regional economies (Durlauf, Johnson & Temple [17]) and the possible existence of heterogeneous steady states (with differences in the rates of convergence).

In our work, as shown in the following paragraph, we adopt a spatial econometric tool that is able to manage both these issues. Since it is not necessary to formulate a priori hypotheses, we can also verify the existence of convergence clubs or of conditional convergence.

The first concept refers to economies that are similar in structural characteristics and tend to converge within groups. It is based on endogenous growth models that are characterized by (possible) multiple and locally stable steady states (see Krugman [30]). The equilibrium reached by each region will depend on the range within which its initial conditions belong or other (spatial or a-spatial) attributes. Conditional convergence foresees that each region approaches its own (unique and globally stable) steady state. Nevertheless, it is not clear whether the observed differences in regional productivity levels reflect either conditional convergence or the membership of different convergence clubs due to initial condition disparities (Durlauf & Johnson [16]; Johnson & Takeyama [24]).

The linearization of the neoclassical growth model (Solow [45]) yields the following cross-sectional specification (Mankiw, Romer & Weil [35]):

$$gr_i = \frac{(\log y_{it} - \log y_{i0})}{t} = \beta_0 - \beta_1 \ln y_{i,0} + \beta_2 \left(\ln s_{k,t} - \ln\left(n_t + g_t + \delta_t\right)\right) + \varepsilon_{it} \tag{1}$$

where:

gr is the mean rate of growth of the GVA per worker y in region i over the period [0,t], $\beta_1 = -\left(1 - e^{-\theta t}\right)/t$; $\beta_0 = -\left(1 - e^{-\theta t}\right) A_0 + gt$; $\beta_2 = -\left(1 - e^{-\theta t}\right)\frac{\alpha}{(1-\alpha)}$ are the parameters to be estimated; θ is the average regional rate of convergence to the steady state s_k is the fractions of output invested in physical capital, and n, g and δ denote the growth rates of the labor force, technological progress and the depreciation rate of physical and human capital, respectively (Mankiw, Romer & Weil [35]). Unlike Mankiw, Romer & Weil [35] we prudentially assumed $g + \delta$ is equal to 0.03 (instead 0.05). The parameters α and β ($0 < \alpha < 1$, $0 < \beta < 1$) show the production elasticities of physical and human capital, and $1-\alpha-\beta > 0$ is the elasticity of ordinary labour input. The elasticities also reflect income shares because of the constant returns to scale assumption A_0 the initial index of (unobservable) technology level.

We estimate three models where the parameters can vary locally. They are specified as follows:

1 - Base model:

$$(GVA\_EMP06_i - GVA\_EMP89_i)/18 = \beta_0 + \beta_1 GVA\_EMP89_i + \beta_2 DISC\_GVA_i + \beta_3 INV\_GVA_i + \varepsilon_i$$

2 - Base model + Ob1 + Ob5b:

$$(GVA\_EMP06_i - GVA\_EMP89_i)/18 = \beta_0 + \beta_1 GVA\_EMP89_i + \beta_2 DISC\_GVA_i + \beta_3 INV\_GVA_i + \beta_4 OB1_i + \beta_5 OB5b_i + \varepsilon_i$$

3 – Base model + Ob1 + Ob2 + Ob5b:

$$(GVA\_EMP06_i - GVA\_EMP89_i)/18 = \beta_0 + \beta_1 GVA\_EMP89_i + \beta_2 DISC\_GVA_i + \beta_3 INV\_GVA_i + \beta_4 OB1_i + \beta_5 OB2_i + \beta_6 OB5b_i + \varepsilon_i$$

where:

GVA_EMP06_i = logarithm of local rate of GVA per worker in 2006;

GVA_EMP89_i = logarithm of local rate of GVA per worker in 1989;

$DISC\_GVA_i$ = logarithm of local rate of mean employment growth (between 1989 and 2006) + 0.03;

INV_GVA_i = logarithm of local rate of investment on GVA (mean between 1989 and 2006) as proxy of saving rate;

$OB1_i$ = logarithm of yearly average local level of Objective 1 Fund for the whole period divided by the level of GVA at the beginning of the period;

$OB2_i$ = logarithm of yearly average local level of Objective 2 Fund for the whole period divided by the level of GVA at the beginning of the period;

$OB5b_i$ = logarithm of yearly average local level of Objective 5b Fund for the whole period divided by the level of GVA at the beginning of the period.

The data about GVA, employment and investment are taken from Cambridge Econometrics' database, while data about Funds allocation for Objectives are taken from the Commission of European Communities [7; 8; 9].

4 – The spatial model

The externalities related to physical and human capital play an important role in the economic development of surrounding regions. In general, the influences that a region can exert on their surroundings is inversely proportional to the distance that they have from the i-th region (Tobler [49]). Among the others, an empirical confirmation of the influence of the spatial spillovers comes from Paci & Pigliaru [41] that note that the propensity to innovate in each region is related to that of the surrounding regions.

Institutional and/or socio-economic relations among regions can be caught through a spatial weights matrix, through which the region i is put in relation with all surrounding regions with a lower or equal distance than a taken threshold.

Since there is no a priori information about the exact nature of spatial dependence, the choice of spatial weights matrix is often arbitrary (Ertur & Le Gallo [19]).

In a preliminary step we had to choose an appropriate connectivity matrix and its better standardization. As a consequence, the three models described in the previous section were estimated using different connectivity matrices and standardizations. Table 2 shows the best results we obtained in term of R^2, β-convergence rates, significance and sign of the coefficients for every model using the spatial filtering technique specified below. Our choice was between a globally standardized (C) or row-standardized (W) Delaunay triangulation matrix and a C-coding Gabriel Graph matrix. In choosing the standardization we took into account that Tiefelsdorf, Griffith & Boots [48] show that in C-coding scheme spatial objects with a large local linkage degree have a strong impact on the global Moran's I while in W-coding scheme, spatial objects with a low linkage degree have a strong impact on the global Moran's I. In a first approximation we can say that Structural Funds have a more local nature because their amount and their destination are connected with the specific socio-economic characteristics of every single region.

First of all you can see that, independently from the spatial weights matrix used, the coefficients of Objectives 1 and 5b are always positive and significant, while the coefficient of Objective 2 has a negative value in the estimated models with the Delaunay triangulation spatial weights matrix and a positive value when we use Gabriel Graph spatial weights matrix.

Table 2– Estimation results with different spatial weights matrices

Model	Coding scheme	GVA_EMP89	R sqr.	Ob.1	Ob.2	Ob.5b
Delaunay triangulation						
1 - Base model	W	-0.0073 **	0.938			
2 - Base model + Ob1 + Ob5b	W	-0.0182 ***	0.943	+ ***		+ **
3 - Base model + Ob1 + Ob2 + Ob5b	W	-0.0143 ***	0.941	+ ***	- **	+ .
Delaunay triangulation						
1 - Base model	C	-0.0130 ***	0.913			
2 - Base model + Ob1 + Ob5b	C	-0.0100 ***	0.961	+ *		+ ***
3 - Base model + Ob1 + Ob2 + Ob5b	C	-0.0172 ***	0.927	+ **	-	+ ***
Gabriel Graph						
1 - Base model	C	-0.0124 ***	0.925			
2 - Base model + Ob1 + Ob5b	C	-0.0169 ***	0.950	+ *		+ .
3 - Base model + Ob1 + Ob2 + Ob5b	C	-0.0136 ***	0.937	+ ***	+ **	+ ***

Signficance: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' '

Our models show a certain degree of robustness about the relationship between Objective 1 and 5b and the convergence process, while the effects of Objective 2 are less consistent. In view of the comparison of these results and of the above considerations we preferred the Delaunay triangulation matrix with a W-coding scheme.

The spatial filter model is based on the Moran Coefficient (MC) or Moran's I; the MC of a spatial weights matrix W of n-by-n size is:

$$MC = \frac{n}{\sum_{i=1}^{n}\sum_{j=1}^{n} w_{i,j}} \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} w_{i,j}(y_i - \bar{y}_i)(y_j - \bar{y}_j)}{\sum_{i=1}^{n}(y_i - \bar{y})^2} = \frac{n}{1^t W 1} \frac{Y^t MWMY}{Y^t MY} \quad (2)$$

where i and j refer to different spatial units (i.e., cell centroids) of which there are n, and y is the data value in each and where the matrix $M = \left(I - \frac{11^t}{n} \right)$ in which I is the identity matrix of size n-by-n, 1 is a vector of one dimension n-by-1 and t is the transposed matrix. The peculiarity of the M matrix is that it centers the vector of data value Y.

In table 3 we can see that all variables have an high and significant spatial autocorrelation. We also verify their normality because the MC is very sensible to this issue.

Table 3 - Moran Coefficients of the variables

Variable	*Moran's I*	p-value	P(S-W) of the variable
(GVA_EMP06-GVA_EMP89)/18	0.6102	< 0.001	< 0.001
GVA_EMP89	0.6619	< 0.001	< 0.001
DISC_GVA	0.5309	< 0.001	< 0.001
INV_GVA	0.5141	< 0.001	< 0.001
OB1	0.5180	< 0.001	< 0.001
OB2	0.6719	< 0.001	< 0.001
OB5b	0.4988	< 0.001	< 0.001

P(S-W) of the variable: probability of the Shapiro-Wilk test.

This result implies that the spatial dependence influences the distribution of the variables. The presence of a spatial structure leads to an exclusion of the classical assumption of independence of observations for each variable (Tiefelsdorf & Griffith [47]), justifying the choice of using spatial filtering technique, proposed by Griffith [28], through which you can restore the assumption of independence of observations for each variable.

Tiefelsdorf & Boots [46] demonstrate that each of the n eigenvalues of expression

$$MWM \quad (3)$$

is a MC value, once it is multiplied by the left-hand term of expression (2), namely $\frac{n}{1^t W1}$.

This allows the extraction from the n-by-n matrix of uncorrelated numerical orthogonal components (Tiefelsdorf & Boots [46]). This nonparametric approach has the aim of managing the presence of spatial autocorrelation by introducing a set of variables, the eigenvectors, able to catch the latent spatial association of georeferenced variables (Getis & Griffith [26]). A set of candidate eigenvectors, that can be selected from the n eigenvectors on the basis of their MC values exceeding a prespecified threshold value (0.25 in our case), can be used as predictors instead of not explicitly considered variables (Fischer & Griffith [21]). Since the eigenvectors are both orthogonal and uncorrelated, a stepwise linear regression can be used to achieve this end.

The spatial model used in our work is a transformation of the GWR model (Fotheringham, Brunsdon & Charlton [23]) proposed by Griffith [29]. The model exploits the spatial filters through the construction of new variables created by the product between the spatial filter and the spatial variables.

In a regression model where Y is a n-by-1 vector that represents the dependent variable, β_j is the i_th regression coefficient and ε is an n-by-1 vector containing the random error terms, the linear model with spatial filters incorporates a set P of regressors, $X_p = (k = 1,2, ..., P)$, with a k set of selected eigenvectors, $E_k = (k = 1,2, ..., K)$, which represent different spatial models, in order to consider the residual spatial autocorrelation in the dependent variable and has the following form:

$$Y = \beta_0 1 + \sum_{p=1}^{P} X_p \bullet 1\beta_p + \sum_{k=1}^{K} E_k \beta_{E_k} + \sum_{p=1}^{P} \sum_{k=1}^{K} X_p \bullet E_k \beta_{pE_k} + \varepsilon \qquad (4)$$

where • denotes element-wise matrix multiplication (i.e., Hadamard matrix multiplication), and k_p identifies the eigenvector numbers that describe attribute variable p, with k_p being the total number of these vectors. The regression coefficients represent global values, and the eigenvectors represent local modifications of these global values; the sum of the first and third terms represents the GWR intercept while the sum of the second and of the fourth ones the local parameters of the variables. The first two terms (i.e., the global attribute variable coefficients) are multiplied by the vector I, which also is a spatial filter eigenvector. More precisely, the global values are the coefficients needed to construct linear combinations of the eigenvectors, in order to obtain GWR-type coefficients. Estimation of equation (4) needs to be followed by collecting all terms containing a common attribute variable and then factoring it out in order to determine its GWR coefficient. The GWR coefficients are linear combinations of a subset of the K eigenvectors, with those not in the subset having a regression coefficient value of 0; the GWR coefficients are n-by-1 vectors.

5 - Estimation results

In the following tables we can observe the results of the models. In table 4 we reported the global (or mean) results for every model. The model 1 shows a very low convergence rate while in the other models, the adding of Structural Funds had a positive impact on global economic convergence. A negative and significant coefficient is associated to the variable DISC_GVA while the investments are not significant. This means that the economies are negatively influenced by capital depreciation and that investments do not play a role of compensation. The introduction of Structural Funds in the analysis has an ambiguous effect. Whereas, as already said, their impact on convergence is highly positive, their coefficients show that, while the Funds for Objectives 1 and 5b are positive and significant, the introduction of Objective 2 gives a negative contribution to economic growth.

Table 4 - Global parameters of spatial filtering models

Variable	Model 1	Model 2	Model 3
Intercept	0.0226 *	0.0716 ***	0.0328 **
	(0.0098)	(0.0108)	(0.0101)
GVA_EMP89	-0.0073 **	-0.0182 ***	-0.0143 ***
	(0.0022)	(0.0019)	(0.0020)
INV_GVA	0.0002	-0.0007	0.0004
	(0.0023)	(0.0027)	(0.0022)
DISC_GVA	-0.0045 *	-0.0022	-0.0088 ***
	(0.0017)	(0.0019)	(0.0018)
OB1_GVA		0.0012 ***	0.0005 .
		(0.0002)	(0.0002)
OB2_GVA			-0.0004 ***
			(0.0001)
OB5b_GVA		0.0002 **	0.0001 .
		(0.0001)	(0.0001)
Test against heteroskedasticity			
Studentized Breusch-Pagan test	53.5541	76.2657 *	78.3728 **
Residual normality			
Jarque Bera Test	3.0058	5.7202 .	4.5776
Spatial autocorrelation of residuals			
Moran's I	-0.1609	-0.2078	-0.2069
Fit			
R-squared	0.9379	0.9431	0.9412
Residual standard error	0.0031	0.0031	0.0030
AIC	-1544.2890	-1544.318	-1548.146

In parenthesis the Std. errors

Signficance: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’

A possible explanation of this phenomenon may be found in the aim (and in the subsequent application) of the Objective 2 Fund. In fact it tends to convert the regions seriously affected by industrial decline with high unemployment and low employment growth. As a consequence the goal is not convergence, but cohesion. Our model is designed for evaluating economic convergence and not cohesion and this can be a possible explanation of the unexpected sign of the coefficient of Objective 2.

All models show an high fit with R^2 well above 0.90 and with low AIC and RSS. This is a important improvement compared with the fit of OLS for the same models (for each model R^2 is about 0.60 and the AIC are lower). An other effect of the application of spatial filtering technique is the elimination of spatial autocorrelation in the residuals.

In table 5 we note the local values of parameters. The main interesting point consists in the convergence rates distribution. In base model their values are very low and many regions tend to diverge. In model 2, the presence of the Structural Funds for Objective 1 and 5b stabilize the convergence rates, while in model 3 the addition of Objective 2 Fund negatively biases the convergence rates that generally grow but in some cases are positive (divergence).

Table 5 - Local parameters of the explanatory variables of each model

Variable	Min.	1st Qu.	Median	Mean	3rd Qu.	Max.
1 – Base model						
Intercept	- 0.1297	- 0.0262	0.0149	0.0226	0.0788	0.1667
GVA_EMP89	- 0.0357	- 0.0165	- 0.0056	- 0.0073	0.0015	0.0294
DISC_GVA	- 0.0345	- 0.0115	- 0.0038	- 0.0045	0.0020	0.0300
INV_GVA	- 0.0399	- 0.0093	0.0001	0.0002	0.0103	0.0340
2 – Base model + Ob1 + Ob5b						
Intercept	- 0.0455	0.0358	0.0722	0.0716	0.1083	0.1669
GVA_EMP89	- 0.0364	- 0.0226	- 0.0179	- 0.0182	- 0.0137	- 0.0044
DISC_GVA	- 0.0309	- 0.0102	- 0.0004	- 0.0022	0.00632	0.0262
INV_GVA	- 0.0391	- 0.0134	0.0014	- 0.0007	0.0098	0.0349
Ob.1	- 0.0040	0.0001	0.0012	0.0012	0.0022	0.0066
Ob.5b	- 0.0016	- 0.0001	0.0002	0.0002	0.0006	0.0015
3 – Base model + Ob1 + Ob2 + Ob5b						
Intercept	- 0.1343	- 0.0218	0.0279	0.0328	0.0980	0.1766
GVA_EMP89	- 0.0440	- 0.0254	- 0.0123	- 0.0143	- 0.0048	0.0083
DISC_GVA	- 0.0441	- 0.0180	- 0.0085	- 0.0088	0.0015	0.0283
INV_GVA	- 0.0267	- 0.0080	0.0008	0.0004	0.0083	0.0257
Ob.1	- 0.0048	- 0.0006	0.0005	0.0004	0.0020	0.0052
Ob.2	- 0.0011	- 0.0006	- 0.0004	- 0.0004	- 0.0003	0.0002
Ob.5b	- 0.0010	- 0.0001	0.0001	0.0001	0.0004	0.0012

Table 6 shows the eigenvectors associated with every variable. A concentration of eigenvectors of a specific geographical scale signifies that a certain variable, in the context of the model we have under examination, has that specific geographic scale. What we can observe is that not all variables have a clear geographic scale, but among those who have, Objective 1 and 5b have a more regional and local influence, while Objective 2 has a clear regional scale.

Table 6 – Selected eigenvectors associated with the explanatory variables of each model

Variable	Eigenvectors associated to explanatory variables		
	Global scale (MC > 75)	Regional scale (75 > MC > 50)	Local scale (50 > MC > 25)
	1 – Base model		
Intercept	E1, E3, E7	-	E31, E33
GVA_EMP89	E1, E3, E14	E15, E17, E18, E20, E22, E27, E28	E31, E33
DISC_GVA	E5, E6, E7, E14	E15, E23, E26, E27	E32, E33
INV_GVA	E1, E3, E6, E7	E22, E28	-
	2 – Base model + Ob1 + Ob5b		
Intercept	E4, E7	E15, E22	E42
GVA_EMP89	E7	E22	E39, E42
DISC_GVA	E3, E4, E6, E7	E15	E35, E39, E42, E48
INV_GVA	E3, E7	E22, E26	E35
Ob.1	E7, E9, E11	E15, E22, E29	E33, E44, E46
Ob.5b	E8, E12	E15, E23, E26, E29	E39, E41, E43
	3 – Base model + Ob1 + Ob2 + Ob5b		
Intercept	E3, E4	E20	E42, E48
GVA_EMP89	E3, E6, E7	-	-
DISC_GVA	E3, E4, E6	E20	E34, E42, E48
INV_GVA	E4, E7	E15	E34, E48
Ob.1	E12, E14	E19	E34, E34, E35, E38, E42
Ob.2	-	E17, E23	-
Ob.5b	E13	E15, E23	E31, E39

In table 6 it is also possible to observe how the β-convergence rates hold different scales for model 1, 2 and 3. Regional scale prevails in model 1, the local one in model 2 and the global in model 3. This is even more evident in the maps of local values of β-convergence (Figures 2, 3 and 4). The global scale of the model 3 is highlighted by large clusters of regions with similar values of β-convergence, while in model 1 the spatial heterogeneity of the values of β-convergence increases. The heterogeneity is even higher in model 2 where the scale of β-convergence is mainly local. By limiting the comparison to models 1 and 2, if in the first it is more apparent the existence of macro-regions with similar values of β-convergence within Countries, in the second model the presence of Structural Funds makes the distribution of the β-convergence rates more heterogeneous, putting in evidence that these values are tied to the performance of each region rather than geographical localization.

Speaking about the regions included in Objective 1, we can see that Structural Funds in

Figure 2 - Spatial distribution by quintile ranges of the local β-convergence rates of GVA per worker in the Base model

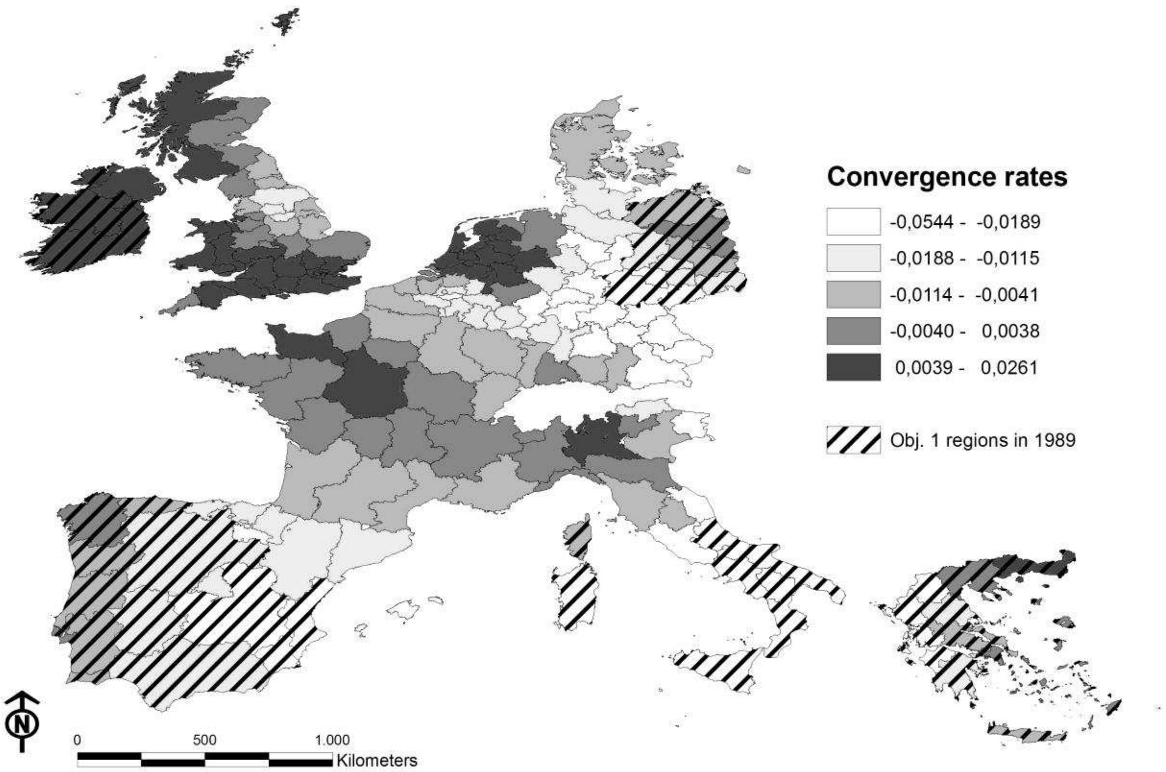


Figure 3 - Spatial distribution by quintile ranges of the local β-convergence rates of GVA per worker in the Base model + Ob1 + Ob5b

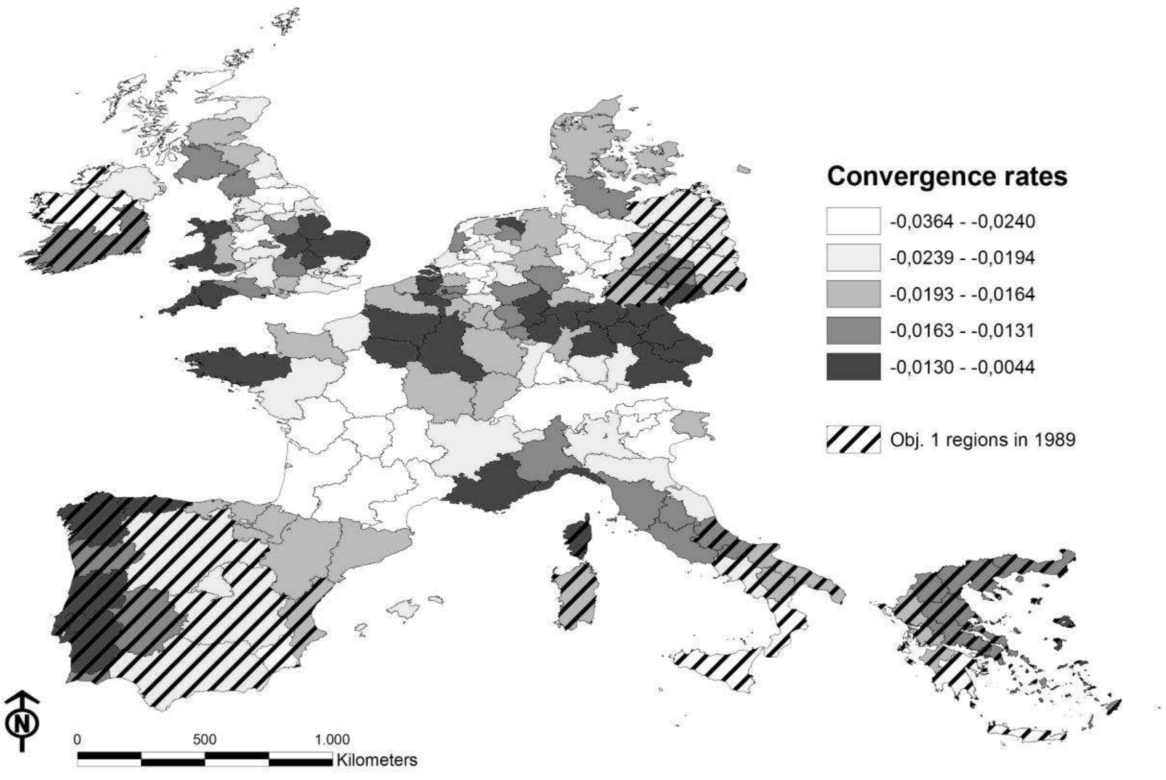
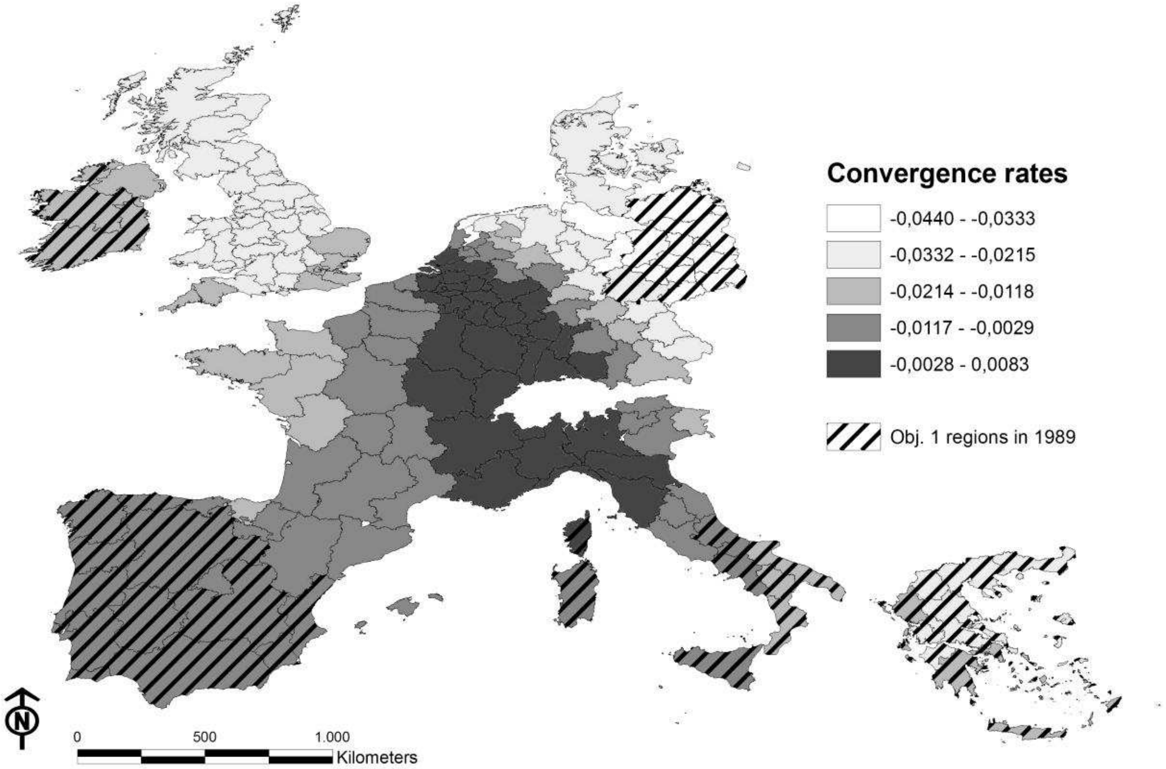


Figure 4 - Spatial distribution by quintile ranges of the local β-convergence rates of GVA per worker in the Base model + Ob1 + Ob2 + Ob5b



almost all cases accelerate the convergence process. As demonstrated by De la Fuente & Vives [15], however, the more redistributive allocation of the SF would cushion regional inequalities but could also slowdown the collective growth. This is the case of the south Italian regions. The exclusion of the Fund for Objective 2 regions leads to more stable results and avoids ambiguous effects such as divergence.

Both in model 1 and 2, in fact, many regions diverge and the variance of the β-convergence is rather high (0.0004 for the first model and 0.0002 for the latter) if it is compared with the 0.00009 of the model 3.

6 - Conclusions

The main objective of the reform of Structural Funds in 1988 was to create a tool that could help to increase economic and social cohesion among Member States. This objective has become even more strategic with EU enlargement, as 90% of the population of the New Member States live in regions with GDP per capita below 75% of the EU average and more than two-thirds live in regions in which is less than 50%. The results of our analysis show that the contribution of the SF to the process of convergence of European regions in EU-12, in relation to objectives 1 and 2 for the period 1989-2006 and to Objective 5b for the period 1989-1999, is not unique. The path to economic convergence of the European Union is still long and doubts about the ability of the Funds to ensure sustainable economic growth and to reduce the gap between center and periphery of Europe still seem to be well founded.

In the considered period there was a weak convergence in labor productivity per employee in the 182 NUTS-2 of EU-12. This process was differentiated among regions and those with lower initial values of labor productivity have not always had higher growth rates than regions with initially more advantaged conditions. Local convergence rates of Objective 1 regions are highly differentiated among themselves and they are not always higher than those of non-Objective 1 regions, even within countries.

In general, however, the inclusion of the SF in the models causes an increase in the rate of β-convergence, regardless of contribution, positive or negative, exerted by the Funds on the growth process. Objective 1 and 5b Funds provide a positive contribution to economic growth. The consideration that we can derive from this phenomenon is that the positive impact of these Funds would also be extended to regions outside Objective 1.

The contribution to economic growth of Objective 2 Fund is unclear because its inclusion tends to have a distorting effect: it has a negative impact on growth and mean convergence rate increases but in some regions it remains divergence. Objective 2, unlike the Objective 1 and 5b, although considered a "regionalized" target, has criteria for determining the eligibility of areas that differ among different areas and thus the social and economic conditions are not uniform in all eligible regions (the eligibility depends on a population ceiling, and on criteria specific to each area).

Regarding the estimation of local β-convergence rates what we can say is that it is a clear progress in the analysis of convergence processes made possible by the spatial econometric technique used in this study. This technique allows us, inter alia, to analyze the convergence process without identifying a priori the type of convergence such as conditional or convergence clubs. However, interpreting the results, we must keep in mind the existence of spatial interactions related to spatial weights matrix. In addition to the impact of the Funds, there are the effects induced in the economies of each region from the economies of surrounding regions. Therefore, the understanding of the dynamics of every region should be thorough with the analysis of individual regional economies.

Finally it also appears necessary to implement tools for evaluating the results of the Cohesion Policy and set of indicators capable of grasping the effectiveness of interventions. At the same time it is essential a counterfactual analysis to identify more precisely the effects on regional economies of the European policies (Morton [39]).

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