THE IMPACT OF STRUCTURAL FUNDS ON EU REGIONAL GROWTH: A LOCAL ANALYSIS [*]

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ABSTRACT

This paper analyzes the impact of structural funds on the convergence process of European regions. Previous works assessing the impact of the funds have lead to mixed results. However, they are all based on global models of β-convergence or catching-up, in the sense that one coefficient pertaining to the structural funds variable is estimated for the whole sample. In this paper, we extend these works and adopt instead a local approach, where one coefficient is estimated for each region, so that the impact of structural funds can be regionally differentiated. Moreover, the presence of spatial spillover effects must be taken into account using spatial econometric techniques. For that purpose, we use a Bayesian locally linear spatial estimation method on a conditional beta-convergence model, which allows global and local beta-convergence to be viewed in a continuous fashion. Results on a set of 145 regions over the period 1980-2004 show that structural funds have a weak global impact on the convergence process between European regions but that their local impacts are very diverse, with a positive influence on the growth of British, Greek and southern Italian regions.

JEL CLASSIFICATION: C14, O52, R11, R15

KEY WORDS: European regional growth; structural funds; spatial econometrics; local models

[*] This research benefits from the financing support of ANR-CNRS 'Young researchers 2005' entitled 'Regional dynamism, urban territories and governance in Enlarged European Union'.

Introduction

The excitement of the 2007 enlargement of the European Union to include Romania and Bulgaria is associated with the traditional question on how the current members will be able to promote the economic development of these countries. While some successes have been experienced in the past (for instance, Spain, Portugal and Ireland did converge towards to the European average income after a decade of membership), the economic gap between the new member countries from Central and East Europe is tremendous. Regional development policies have often been presented as a solution to compensate regions facing any type of restructuring difficulties. They are assumed capable of decreasing inequalities of income across EU regions (including both old and new members), compensating regions experiencing high unemployment, providing a sufficient level of restructuring in old-fashioned industries, promoting social cohesion…all of this for only one-third of the EU budget. By comparison, the Common Agricultural Policy receives nearly twice as much budget and is devoted to the agricultural sector only.

With so many expectations regarding the impact of regional policies on growth, it is not surprising that it has attracted the attention of many researchers. In a recent article, Dall'erba and de Groot (2007) find that more than one hundred studies (published and unpublished) deal with European regional policies. However, only 12 articles performed a formal econometric estimation of the impact of structural funds on growth. Those articles adopt a global approach, i.e. one coefficient pertaining to the structural funds variable is estimated for the whole sample. However, as advocated by the tenants of local approaches to spatial modeling (Fotheringham *et al*., 2004), it is also important to have an idea of the geographic variations of the estimated coefficients. In our case, those "global" approaches may mask important geographic disparities in the effects of structural funds: while the global estimated coefficient pertaining to structural funds may not significant, it may be the case that it is significant and positive for some of the regions in the sample. Moreover, we follow previous work by Dall'erba and Le Gallo (2007, 2008) who adopt a spatial econometric approach, the purpose of which is to determine whether any spatial relationship among the variables is merely random or respond to a pattern of spatial dependence. Combining local approaches with a particular focus on spatial dependence patterns leads us to adopt the SALE (Spatial Autoregressive Local Estimation) model advocated by Pace and LeSage (2004) and used in a convergence context by Ertur *et al*. (2007).

Therefore, our aim in this paper is to assess the local impacts of structural funds on the convergence process between European regions. In the first section, we present a literature review on the effects of structural funds on regional growth, both from a global and a local perspective. Section 2 describes the model we use, the data and the spatial weights matrix that allows us to connect regions with each other. Section 3 presents the results of our empirical estimations based on a β-convergence model estimated by global and local heteroscedasticity robust Bayesian estimation methods, while section 4 concludes and provides policy recommendations.

Section 1 – Uncovering the ambiguity on the impact of the funds

This section shows that the impact of structural funds on the growth of recipient regions is still ambiguous. This often comes as a surprise to policy-makers as the reports of the European Commission tend to report only the impact of successful projects on the local economy of a recipient area.

In order to make our point, we show that the ambiguity on the efficiency of the funds is true from both a theoretical and an empirical view point. Indeed, whether one focuses on studies measuring the impact of the funds at the global or local level, many conclude to a positive effect, while many others do not.

1.1 From a theoretical viewpoint

Neoclassical growth theory considers structural funds, and any type of public investment, as a mean to increase the steady state income level. However, because it assumes the marginal product of capital is decreasing, the growth rate of the recipient region will increase, but only in the short-run. This is in sharp contrast with the endogenous growth theory according to which public investments, more especially in public infrastructures, increase the marginal product of private capital, fostering capital accumulation and growth.

Because one-third of structural funds are devoted to interregional transportation infrastructures (in order to fill the requirements of the Single Market) and because European regions are not isolated economies, the two theoretical approaches above are not enough to understand the impact of regional development policies on growth. One needs to rely on the economic geography literature of which recent advances indicates that new transportation infrastructures do not systematically benefit the region where they are implemented, and therefore cannot always be seen as an instrument to promote regional development (Martin and Rogers 1995; Vickerman 1996; Martin 2000). For instance, Puga and Venables (1997) show that in a transportation network based on hub-and-spoke interconnections (like the European transportation network), firms located in the hub face lower transaction costs in trading with the spokes than firms in any spoke location do when trading with firms in another spoke. Consequently, this type of network promotes gains in accessibility in the hub location first (Puga 2002; Venables and

Gasiorek 1999). This would not necessarily be a problem if the hub location were not a city that is already well developed. But hubs are often more advanced cities for the reason that demand in transportation is higher in a more populated and more dynamic location. Would new transportation infrastructures within a poor area be the solution then? By reducing local transportation costs, they may increase trade within the area, but it will not be enough to guarantee the catching-up effect that policy-makers are looking for. The idea behind regional policy is not to improve marginally the local conditions compared to previous local conditions, but to improve local conditions compared to the current conditions of the rest of the country or of the leading region (depending on how convergence is measured). As a result, only a large improvement of the poorest regions' attractiveness could induce firms to relocate there and help these regions to grow relatively faster than the rest of the country. The type of regional policies that have been implemented to support firms relocation are tax reduction, lump sum payments, subsidies on labor, as well as the identification and promotion of their competitive edge such as tourism or labor intensive activities. The paragraphs below are devoted to empirical works that have measured the impact of regional policy tools at the global and local level.

1.2 From an empirical viewpoint

(i) Studies focusing on the global impact

There are two common misconceptions about the impact of the funds on growth. The first one is the strong belief that no matter how and where public investments are implemented, they necessarily boost local growth. The paragraph above has shown that this endogenous growth theory viewpoint is not necessarily true. The second mistake is the strong belief that tons of empirical studies measuring the impact of the funds have been performed. An extensive search over the internet and in economic, geographic and political reviews[1] proves that only twelve studies have used rigorous (econometric[2]) techniques to measure the impact of the real structural funds data. Misconception on the number of empirical studies comes from the difficulties in gathering structural funds data. The European Commission does not provide any homogeneous dataset, so information on investments made with structural funds money is simply unknown to the public[3]. As a result, many studies claim they measure the impact of structural funds, whereas they only rely on proxies such as investment in public capital or the number of citizens with a certain education level to measure the impact of structural funds. Overall, the quality of

[1] See Dall'erba *et al.* (2007).
[2] We do not count the studies based on input-output models because of the sensitivity of their conclusions to the assumptions used and because they focus on the impact at the national level.
[3] This is a very important difference with the US case where every single tax payer can go online on the Federal Budget website and verify the location, amount and type of expenditure made with his tax money.

European data at the regional level is fairly poor, so further efforts should be supported soon.

Focusing on the twelve studies that have made the effort of collecting the most accurate structural funds data, the ambiguity we mentioned earlier is reflected in their results and policy recommendations. Indeed, these studies can be classified in three groups: those that conclude to a significant impact of the funds; those that do not find any significant impact; and those that conclude to a negative impact of the funds on growth.

Among the most optimistic studies, Beugelsdijk and Eijffinger (2005) are the ones who find the greatest average impact (5.18). Their results indicate that the more corrupt countries do not use the funds in a more inefficient way and therefore support the continuation of structural funds. The question as to whether their results are biased by the country-level observations they use remains open. However, Cappelen *et al*. (2003) who base their estimations on NUTS 1 and 2 regions also find a significant impact of the funds.[4] They conclude that support is most efficient when it is allocated to regions with a good economic environment (low unemployment, high R&D capabilities). According to them, support is, ironically, least efficient where it is most needed. Garcia-Solanes and María-Dolores (2001) fully support continuation of the funds. Their results, both at the regional and national level, conclude to a significant and positive impact of the funds on growth. Note, however, that the level of structural funds per inhabitant is the only explanatory variable they add to the usual initial level of per capita GDP in their model. As a result, their results may suffer from a bias of omitted variables. Bussoletti and Esposti (2004) use different specifications. Among the significant results, the impact of the funds is very small (less than 4 digits) and positive.

A couple of studies have tried to differentiate their results by type of investment or objective supported by the funds. For instance, Rodriguez-Pose and Fratesi (2004), who focus on objective 1 regions, conclude that support on infrastructure and on businesses do not have a significant impact. Only investments in education and human capital have medium-term positive effects, whilst support to agriculture has short-term positive effects on growth. Dall'erba and Le Gallo (2007) differentiate the funds by development objective and conclude that peripheral regions are significantly but to a very small extent affected by some types of structural funds (objectives 1 and 3&4 funds and Community Initiatives). The same conclusions hold for the total cost of Community projects (the sum of structural funds and additional funds provided by the national or regional government). The approach by development objective is also adopted by Fayolle and Lecuyer (2000). They conclude that within an assisted country, the wealthiest regions are the ones that

[4] NUTS stands for Nomenclature of Territorial Unit Statistics. This is the official way of dividing the European territory into regions.

benefit the most from structural funds. This is because the supply of rich regions complies with the demand derived from the European funds, or because producers in the most favored regions convey their products to new market thanks to newly built infrastructures in poor regions.

Among the studies which do not necessarily conclude to a positive impact of the funds are Puigcerver-Peñalver (2004). While she finds a positive impact of objective 1 funds on growth over 1989-93, the funds allocated during the second period (1994-1999) had a null or negative impact. This may be the reason for the weak effect of structural funds she observes over the whole period. Ederveen *et al*. (2006) find that structural funds are ineffective unless they are allocated to countries with good institutions (defined according to the country's degree of openness and an index of its institutions' quality) while Ederveen et *al*. (2002) are more careful in their conclusions. They show that the impact of structural funds varies according to the type of convergence under consideration. Their model without spatial dummy variables to account for heterogeneity in the convergence process concludes to a significantly negative effect of structural funds on growth. However, a model with regional dummies leads to an impact which is not significantly different from zero, while adding country dummies leads to a positive and significant impact. In other words, the less prescriptive one is about convergence, the less effective structural funds spending appears to be, and vice versa. Dall'erba and Le Gallo (2008) also find a non-significant impact of the funds on the recipient regions. Based on spatial econometric simulations that model the spillover effects across regions, they find that core regions diffuse growth to their neighbors, whatever the amount of structural funds they receive, while peripheral regions do not. This result suggests that the limited amount or absence of spillover effects in peripheral regions could explain their lack of development.

Finally, the study which frankly concludes to a negative impact of the funds is Fagerberg and Verspagen (1996). They focus on the 1980-1990 period and use the European Regional Development Funds over 1985-1987, the only data available at the time of their writing.

Heterogeneity among the conclusions of these studies comes from several factors such as the quality of the data they use, the sample, time period and estimation procedures they rely on. Because theoretical works and empirical studies that focus on the impact of the funds at the global level do not lead to a unanimous conclusion on the efficiency of structural funds, it is difficult to come to generally applicable conclusions on EU regional policies. In order to try to shed some light on this problem, the discussion continues with a review of papers that estimate the impact on the local economy of single projects financed by the funds.

(ii) Studies focusing on the local impact (case studies)

The majority of case studies propose an evaluation of the funds based on the addition of the kilometers of roads or number of employments directly created after the implementation of a new project (see, for instance, Huggins, 1998; Daucé, 1998). This is also true for the European Commission reports. In essence, they propose a rather poor evaluation procedure and do not really allow us to give a general conclusion on the impact of the funds. In addition, they tend to be too often positive about the impact of the funds, which can be seen as a strategy to ensure future allocations of structural funds monies.

Among the results that conclude to a positive effect of the funds, Ernst and Young (1996) rely on a review of several case studies. They conclude that regions where objective 2 funds have been implemented have experienced a 0.8 percentage point decrease in their unemployment rate. The manuscript by Bachtler and Turok (1997) is not as optimistic. It tried to summarize the impact of several projects performed throughout Europe. The authors conclude that the common point among these projects is that measuring their overall impact in the local economy is difficult but it is probably modest. Another example of a study that concludes to mitigated results is Armstrong *et al.* (2000). They focus on the Community Economic Development (CED) initiatives in Yorkshire and the Humber. They find that on the one hand new businesses have been created since the CED, but on the other hand most of them sell goods that are similar to those that could be found earlier, thus increasing local competition. The study of Dignan (1995) is partly based on case studies and frankly concludes to an ineffective impact of ERDF funds. According to him, they were not allocated to the neediest regions and the different levels of governance that manage their allocation lacked coordination.

The fact that most case studies rely on a qualitative approach to estimate the impact of the funds makes it hard to verify and replicate their results. We believe that a more appropriate approach is the one adopted by Venables and Gasiorek (1999) who use a general equilibrium model to measure the impact of six major projects in the former cohesion countries (Spain, Portugal, Greece and Ireland). For instance, in the case of Portugal they find that a project that diminishes local transportation costs, such as the Tagus bridge in Lisbon, has led to a 10% rate of return for the local economy.

Section 2 – Model, data and spatial weights matrix

With the exception of Fayolle and Lecuyer (2000) who use a catching-up model, and some estimates in Rodriguez-Pose and Fratesi (2004), all the studies above are based on the neoclassical growth model described in Barro and Sala-i-Martin (1995). This model, also called β–convergence model, has been largely documented in the literature[5]. Basically, it measures the degree to which the growth rate of GDP of a region is related to its initial level (*absolute* β–convergence) and eventually to a set of additional conditioning explanatory variables (*conditional* β–convergence). Since the primary purpose of our study is to investigate the effects of structural funds on growth, we use the following model that extends the structural equation derived by Mankiw *et al.* (1992):

$$g_T = \alpha e_N + \beta y_0 + \gamma_1 \ln(s) + \gamma_2 \ln(n + g + \delta) + X\phi + \mu SF + \varepsilon \qquad (1)$$

where g_T is the (N×1) vector of average growth rates of per capita GDP between date 0 and T; e_N is the (N×1) unit vector; y_0 is the (N×1) vector of log per capita GDP levels at date 0; s is the average gross domestic savings rate; n is the population growth rate; g is the exogenous rate of technological progress; δ is the rate of depreciation; X is a matrix of other variables, maintaining constant the steady state of each economy; SF is the (N×1) vector of structural funds; $\alpha, \beta, \phi, \gamma_1, \gamma_2$ and μ are the unknown parameters to be estimated. From the theoretical model, the following restriction should hold: $\gamma_1 = -\gamma_2$.

There is conditional β–convergence if the estimate of β is significantly negative. In addition, if the estimate of μ is significant and positive, then structural funds positively affect the regions' steady-state growth rate, hence increasing the transitional growth rate of each region towards its own steady-state.

It is important to keep in mind that β-convergence concepts have been heavily criticized on methodological grounds: these tests face several problems such as robustness with respect to choice of control variables, multicolinearity, heterogeneity, endogeneity, and measurement problems (Durlauf and Quah 1999; Temple 1999; Durlauf et al. 2005). In this paper, we pay a particular attention to the spatial dimension of the data used in the convergence studies. Indeed, regions are not isolated economies. Their spatial interactions with other regions include, among others, backward and forward linkages, technology spillovers (see, for instance, Coe and Helpman 1995; Keller 2002)

[5] See Durlauf and Quah (1999) for a review of this extensive literature.

and migration (Van Dijk et al. 1989). As a result, these spatial effects need to be formally included in our convergence model. In the context of European regions, positive spatial autocorrelation indicates that wealthier regions tend to be geographically clustered as well as poorer regions. It may come from the fact that the data are affected by processes concerning different locations. Indeed, at the regional scale, several factors such as trade between regions, labor and capital mobility, technology and knowledge diffusion, etc. may lead to spatially interdependent regions. However, spatial autocorrelation can also arise from model misspecifications (omitted variables, measurement errors) or from a variety of measurement problems, as mismatching between the administrative boundaries used to organize the data and the actual boundaries of the economic processes believed to generate regional convergence (Cheshire and Carbonaro 1995).

Spatial concentration of economic activities in European regions has already been documented in Fingleton and López-Bazo (2006), Le Gallo and Ertur (2003) and Dall'erba (2005) with the formal tools of spatial statistics. It is therefore important to explicitly incorporate spatial autocorrelation into β-convergence models for three reasons. First, from an econometric point of view, the underlying hypothesis in OLS estimations is based on the independence of the error terms. Violation of this assumption will lead to unreliable estimates and inferences. Second, it allows capturing geographic spillover effects between European regions. Third, spatial lags of the dependent variable can act as lagged dependent variables to account for omitted variables. Indeed, in the case of β–convergence models, the appropriate choice of these explanatory variables may be problematic because it is not possible to be sure that all the variables differentiating steady states are included. Furthermore, data on some of these explanatory variables may not be easily accessible and/or reliable, more especially in the case of the European regions.

Our sample is composed of 145 regions at NUTS II level over the EU12. NUTS (Nomenclature of Territorial Units for Statistics) is the spatial classification established by Eurostat on the basis of national administrative units. More specifically, the sample is composed as follows: Belgium (11 regions), Denmark (1 region), Germany (30 regions, Berlin and the nine former East German regions are excluded due to historical reasons), Greece (13 regions), Spain (16 regions, as we exclude the remote islands: Canary Islands and Ceuta y Mellila), France (22 regions), Ireland (2 regions), Italy (20 regions), Netherlands (12 regions), Portugal (5 regions, the Azores and Madeira are excluded because of their geographical distance), Luxembourg (1 region), United Kingdom (12 regions, we use regions at the NUTS I level, because NUTS II regions are not used as governmental units, they are merely statistical inventions of the EU Commission and the UK government). Note that Austria, Finland and Sweden are not included in the study, as we want to focus on the impact of structural assistance over 1989-1999. These three countries joined the EU in 1995, meaning that they did not have access to any regional fund prior to membership. In order to estimate this regression for this sample, we use data from several databases:

(i) For the dependent variable, we use the average growth rate of per capita GDP of each region over the 1989-1999 period. Concerning the explanatory variables, we measure s as the average share of real investment in GDP and we measure n as the average growth rate of population. As is usual in the literature, we assume that $g + \delta$ is 0.05. The theoretical expected sign of the former variables is positive and the one of the latter variables is negative. While Mankiw *et al.* (1992) have extended this model by introducing a human capital variable, we cannot add such a variable due to severe data limitations in Eurostat. However, in line with the regional science convergence literature, we consider a set of additional control variables to control for further differences in steady states.

First, the share of employment in agriculture in 1989 has been considered, in order to control for industrial structure and for the possibility of adverse shocks to agricultural output affecting regions differently. Such a variable has been used, inter alia, by Barro and Sala-I-Martin (1995), Cappelen *et al.* (2003) or Bussoletti and Esposti (2004). Second, the inclusion of unemployment has been motivated theoretically by Bräuninger and Pannenberg (2002). Based on an augmented Solow model, they show that unemployment reduces the long-run level of productivity and the accumulation of physical and human capital via a reduction of savings, spending on education and learning-by-doing. Long-term unemployment has been included in several empirical studies in the European regional context (Cappelen *et al.* 2003; Rodriguez-Pose and Fratesi 2004).

(ii) The period under study covers the first two programming periods and the data on structural funds, which cover the sum of the funds over the 1989-1999 period, come from the publications of the Commission: the data over 1989-1993 are from "*Community structural interventions*", *Statistical report n°3 and 4,* (European Commission, 1992a, b) and for 1994-1999, from *The 11th annual report on the structural funds* (European Commission, 1999). These data represent the total payments over each period plus the commitments taken during the second period (but that have not been paid yet). The lack of more recent data leads us to assume that structural funds commitments and expenditures are strongly correlated. All data are in 1995 euro prices. Data in euro (as opposed to data in purchasing power parity) allow us to consider differences in the capacity to produce goods. To our knowledge, only Kemmerling and Bodenstein (2006) and Becker *et al*. (2008) use more recent data. However, they do not have data for all cohesion objectives or data on additional funds.

In order to estimate the spatial version of model (1), we need to specify a spatial weights matrix. In the European context, the existence of islands does not allow the use of simple contiguity matrices; otherwise the weights matrix would include rows and columns with only zeros for the islands. We choose to base them on pure geographical distance, as exogeneity of geographical distance is unambiguous. More precisely, we use *k*-nearest neighbor matrices, defined as:

$$\begin{cases} w_{ij}^{*}(k)=0 \text{ if } i=j,\forall k \\ w_{ij}^{*}(k)=1 \text{ if } d_{ij}\le D_i(k) \\ w_{ij}^{*}(k)=0 \text{ if } d_{ij}>D_i(k) \end{cases} \quad \text{and} \quad w_{ij}=w_{ij}^{*}/\sum_j w_{ij}^{*} \tag{2}$$

where w_{ij}^{*} is an element of the unstandardized weights matrix; w_{ij} is an element of the standardized weights matrix W; d_{ij} is the great circle distance between centroids of region *i* and *j*; $D_i(k)$ is the k^{th} order distance for region *i* such that each region *i* has exactly *k* neighbors. In the paper, we use *k* = 10. This choice guarantees that Uniked Kingdom and Greece are connected to continental Europe. Each matrix is row standardized so that it is relative and not absolute distance which matters.

Section 3 – Estimation results

We first present the results obtained with a global model of β-convergence and second, we present the results obtained with a local SALE model.

3.1 Global results

We include spatial autocorrelation in the form of a spatial lag in our model. As stated by Fingleton and López-Bazo (2006): “externalities across regions in long-run growth is mostly a substantive phenomenon caused by technological diffusion and pecuniary externalities, while the regional transmission of random shocks only plays a minor role in the process of growth in the long run” (p. 179). Indeed, spatial correlation across residuals is often the result of an underspecified model where the true variables at the origin of spatial dependence are missing. Accordingly, we use a spatial lag model and take into account possible forms of misspecification using a robust Bayesian estimator. Formally, in the spatial lag model, an endogenous variable of the form Wg_T is included:

$$g_T = \rho W g_T + \alpha e_N + \beta y_0 + \gamma_1 \ln(s) + \gamma_2 \ln(n + g + \delta) + X\phi + \mu SF + \varepsilon \qquad (3)$$

where W is the (N×N) spatial weights matrix. Since W is row-standardized, the spatial lag variable Wg_T contains the spatially weighted average of the growth rates of the neighboring regions. The parameter ρ indicates the level of spatial interaction between regions. This specification allows measuring how the growth rate in a region may relate to the one in its surrounding regions after conditioning on the starting levels of per capita GDP and the other variables.

The estimation of this model can be done using maximum likelihood or two-stage least squares. However, we choose here to adopt a Bayesian approach. Indeed, as pointed out by Ertur *et al*. (2007), one of the main advantages of the Bayesian approach to test regional convergence concerns the solution of problems related to the presence in regional samples of heterogeneity and outliers; these outliers may have come about as a result of "enclave effects", where a particular observation exhibits divergent behaviour from nearby observations. These problems may be dealt with by estimating a Bayesian heteroscedasticity robust model. Formally, the disturbances of model (3) are modified as follows, in matrix form:

$$\varepsilon \sim N(0, \sigma^2 V) \qquad \text{where } V = diag(v_1, v_2, ..., v_n) \qquad (4)$$

An uninformative prior distribution is imposed on the v_i terms taking the form of a set of n independent, identically distributed by a $\chi^2(r)/r$ distribution, where r represents the single parameter of the χ^2 distribution. This allows estimating the additional n variance scaling parameters v_i by adding only a single parameter r to the model. As noted by LeSage (2002), the χ^2 prior assigned to the v_i terms can be motivated by considering that the prior mean equals unity and the prior variance is $2/r$. This implies that, as the prior assignment of a value for r becomes very large, the terms v_i will all approach unity, resulting in $V = I_n$, the traditional assumption of constant variance across space. On the other hand, assigning small prior values to r leads to a skewed distribution permitting large values of v_i that deviate greatly from the prior mean of unity. The role of these large v_i values is to accommodate outliers or observations containing large variances by assigning less weight to these observations. The approach to modelling disturbances is equivalent to a model that assumes a Student-*t* distribution for the errors (Geweke, 1993). To complete the model, we also assume a normal prior for the parameters α and β, a diffuse prior for the noise variance σ and a uniform prior over $[-1/\lambda_{\min}; +1]$ for ρ (model 2) or δ (model 3), where $\lambda_{\min}$ is the minimum eigenvalue of the standardized weights matrix.

This model is estimated using MCMC and Gibbs sampling, which are computationally-intensive methods. As a consequence, they take significantly more time to carry out than traditional methods as maximum likelihood or GMM (see LeSage, 1997 for further details on the estimation method in the spatial case and Geweke, 2006 for a discussion on the consequences of the analytical or coding errors in posterior simulators in general Bayesian models).

The estimation results are presented in table 1. The estimated coefficient associated with initial per capita GDP is highly significant and negative, leading to a convergence speed of 1.41% and a half-life of 55 years. All the coefficients are significant and have the expected sign, except the coefficient associated with population growth but it is not significant. The presence of spatial autocorrelation is confirmed by a highly significant and positive ρ coefficient ($\hat{\rho} = 0.675$) indicating that the growth rate of a region is significantly influenced by the growth rate of its surrounding regions. Finally, the coefficient associated to structural funds is not significant, which means that globally, the structural funds did not influence the convergence process between European regions.

[Table 1 about here]

3.2 Local results

In order to investigate whether this global result is valid for all the European regions, or whether it is geographically differentiated, we perform a local analysis using the SALE model suggested by Pace and LeSage (2004). As in GWR model, one coefficient is estimated for each region, so that the spatial distribution of each estimated coefficient can be assessed. Moreover, it incorporates a spatial lag. Indeed, as pointed out by Pace and LeSage (2004) spatial dependence may not be eliminated even at the optimal GWR bandwidth as it is often assumed in the related literature where it is considered that spatial dependence is mainly due to inadequately modeled spatial heterogeneity. The SALE model is based on a computationally competitive recursive maximum likelihood estimation method (see Pace and LeSage, 2004 or Ertur and Le Gallo, 2008 for details on the estimation method).

The geographic distribution of the estimated structural fund coefficient is displayed in figure 1. Only the coefficients significant at 5% are displayed whereas the regions associated to a coefficient that is not significant are left in blank. The regions in red correspond to regions that have benefited positively and significantly from structural funds whereas the regions in blue correspond to regions on which the structural funds had a negative effect. As shown by figure 1, it appears that the local impacts of the structural funds are very diverse. The British, Greek and southern Italian regions are the regions where the structural funds had a positive impact, and importantly so in the case of British regions. Conversely, some French, German, Belgian and Dutch regions were negatively affected. Therefore, the negative result that was found at a global level and in some other studies mask in fact important disparities in the effects of the funds, the pessimistic results and conclusions usually found in the literature must be nuanced.

[Figure 1 about here]

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Tables and Figures

Table 1. Estimation results from an heteroscedastic robust Bayesian MCMC estimation.

	Heteroscedastic Bayesian MCMC
Constant	0.127 (0.000)
Initial GDP per capita	-0.012 (0.000)
Structural funds	1.10^{-6} (0.223)
Ln of investments	0.007 (0.021)
Ln of population growth + 0.05	0.0003 (0.493)
Agriculture	-0.024 (0.003)
Unemployment	-0.0001 (0.012)
Spatial lag	0.675 (0.000)
σ_{ε}^{2}	0.0001
Convergence Speed	1.41%
Half-life	55
Sq. Corr.	0.557

Notes: There are N = 145 observations. p-values are in brackets.

Figure 1. Geographic distribution of the estimated structural fund coefficient