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EMPIRICAL TEST OF SPATIAL GROWTH MODELS
FOR EUROPEAN REGIONS

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Institutions and geography: Empirical test of spatial growth models for European regions

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Abstract

This article provides an empirical assessment of the growth experiences of European regions, during the period 1991–2004, by taking into account the spatial effects due to both institutions and geography. These effects have been modelled by means of specific controls and by using a non-conventional spatial weight matrix. Results favour a model dealing with substantive spatial externalities. Within this framework, the country-specific institutions are strongly and positively related to the regional productivity's growth rate. In addition, the geo-institutional proximity increases the spatial dependence of the regional output per worker and raises the speed of convergence. By contrast, the pure geographical metrics is underperforming, while underestimating the convergence dynamics.

Keywords: Regional growth, income convergence, institutions, geography, spatial effects.

JEL classification: C21; O40; R11.

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1 Introduction

Assessing economic growth and income convergence across European regions is an important and debated issue, especially after the recent enlargements which progressively increased the EU from 15 to 27 Member States. Particular concerns are expressed about the widening of the economic and social disparities between the new Adhesion Countries and the former EU-15 States, since the bulk of the European Commission's budget is devoted to the reduction of inequalities.¹ Consequently, some important questions arise, both from a political and an economical point of view. Will the poor regions grow faster and eventually catch up with the rich ones? What are the deep determinants of the economic growth at a regional scale? Do spatial location influence the patterns of development? Could regions which share similar institutional and geographical factors converge quickly?

Starting from the pioneering work by Quah (1996), it has been largely recognized that space matters for growth in Europe. In fact, the distribution of income tends to be conditioned by its physical location, since agglomeration dynamics influence the spatial interaction of regional units by means of, for instance, human capital spillover and technology diffusion (Ciccone, 2002). The main channels through which space affects the regional economic activity can be explained in terms of 'relative' and 'absolute' location.² The first concept refers to the effects originated by the relative location of one region with respect to the others. By contrast, the second one relates to the impact on a region from the fact of being located in a particular point in space, independently from its neighboring regions.

Omitting these relevant aspects from the empirical models of regional growth and convergence is doomed to produce several misspecification problems, as we will describe in the next section. Under this respect, the growing application of spatial econometrics techniques generated a big improvement for the field of growth empirics, over the last ten years (an incomplete list of works includes Fingleton, 1999; López-Bazo et al., 1999; Arbia and Paelink, 2003; Le Gallo and Ertur, 2003; Badinger et al., 2004; Gardiner et al., 2004; Funke and Niebuhr, 2005; Ertur et al., 2006; Le Gallo and Dall'erba, 2006; Battisti and Di Vaio, 2008; Fingleton, 2008; Ramajo et al., 2008).

Such methods deal with either the absolute or the relative location effect, by imposing on the model a predefined spatial weight matrix, which incorporates the topology of the system and establishes the spatial linkages among the regions. This kind of matrix is usually based on a purely geographical metrics (like e.g. physical distance), according to criteria given by contiguity measures (rook, queen, and bishop), ' k -nearest' regions, or more complex decay functions. The main advantage of using physical distance-based weights is that they can be unambiguously considered exogenous to the model, avoiding in this way estimation problems due to identification, causal reversion and

¹Regions are the main administrative units charged with the spending of the Structural Funds.

²These concepts are commonly used in geographical analysis. Recently, they have been discussed in a regional framework by Abreu et al. (2005) and may be also related to the notions of spatial dependence and spatial heterogeneity, introduced by Anselin (1988).

non-linearity.³ However, they suffer from a major drawback, in that they fail to capture distances that are not geographically-based and yet can play an important role in shaping the economic behavior both at a micro and a macro level.

Looking at the relative location effect, the economic relationships may be affected by a multidimensional space that also includes social and institutional factors. It is widely known that social distance (e.g. heterogeneity) influences the agents' behavior by means of neighborhood effects, since social interactions provide incentives for individuals to behave similarly to others (Akerlof, 1997; Brock and Durlauf, 2006).⁴ According to this, social networks may foster the knowledge diffusion, increasing the strength of the spatial externalities. Interestingly, Bènabou (1996) highlights that heterogeneities in education and wealth lead to stratification dynamics, which in turn gives rise to persistent income inequalities. Glaeser et al. (1996) show that the variance of crime across space can be explained by social interactions, while Topa (2001) points out that local interactions in the labour market cause the unemployment rates to be spatially correlated, due to the exchange of information within the social network. In addition, considering the production structure of the economy, the multinational firms facing legal and bureaucratic costs might prefer to invest in homogeneous countries, in order to reduce the administrative burdens due to cross-border operations (Kox et al., 2004).

As for the absolute location effect, common institutional, cultural and geographical factors vary across countries while impacting on regional growth, at the same time.⁵ On one side, an important strand of research has shown the relevance of institutions, in the form of property rights' protection or market regulation, for the explanation of cross-country differences in income levels (Hall and Jones, 1999; Acemoglu et al., 2001; Rodrick et al., 2004).⁶ Efficient institutions provide the set of incentives which is conducive to economic growth, affecting the transaction costs of the economy (North, 1990). Contrary, bad institutional quality, as well as a risky environments, reduces the convenience to invest.

On the other side, geography plays a crucial role in stimulating the economic development. Physical geography, like location and climate, is highly differentiated across countries, exerting a decisive influence on the economic behavior (Olsson and Hibbs, 2005). Geographical factors indirectly condition the distribution of the level as well as the growth rate of income, impacting on transport costs, disease burdens, and agricultural productivity (Gallup et al., 1999). Furthermore, the growth rate of population in countries of lower absolute latitude is usually high, due to their tendency to pro-

³Physical distance is also a good proxy of transport costs.

⁴Akerlof (1997) defines a gravity function in which part of the distance is inherited (e.g. physical distance), and part is acquired (e.g. institutional distance).

⁵These effects have been usually controlled for by means of country-specific dummies (Armstrong, 1995; Neven and Gouyette, 1995). The shortcomings of using these variables are connected to the fact that they do not allow to identify the nature of the country-specific effect (e.g. it may be produced by institutions, geography or other characteristics). However, we inserted the country-specific dummies in the standard specification and the results obtained were very similar.

⁶In a recent work, Tabellini (2008) finds that formal institutions, as well as cultural traits, are the main determinants of the European regional economic performance.

duce large families, which depresses the rate of growth of per capita output (Strulik, 2008). Consequently, higher level of development are generally reached in the temperate regions, either between or within countries (Bloom and Sachs, 1998).

The aim of this paper is therefore to assess the European regional growth and convergence process, by taking into account both the relative and the absolute location effect due to institutions and geography. To our best knowledge, the two aspects have not been considered jointly in the previous literature. To pursue this aim, we extend the basic growth equation of Barro (1991) in order to incorporate the spatial externalities by means of a non-conventional spatial weight matrix built on geo-institutional distances. The remainder of the paper is structured as follows. Section 2 introduces the basic growth model and some alternative specifications that account for externalities and spatial effects. It also deals with the definition of the geo-institutional spatial weight matrix. Section 3 presents the data used in the empirical part of the paper together with some descriptive statistics. It particularly focuses on the non-trivial attempt to measure empirically the absolute and relative location effect on the process of European regional growth. Section 4 presents the results of the empirical analysis, their interpretation and some tentative conclusions. Finally, Section 5 summarizes the major findings and suggests possible future developments.

2 The empirical model

2.1 The growth equation

The empirical analysis that will be presented in Section 4 is based on a growth regression of Barro (1991), augmented in order to deal with the spatial effects of the absolute and the relative location due to both institutions and geography. The first of these effects is simply modelled introducing institutional and geographical country-specific controls among the regressors. The second is captured by a spatial term accounting for the region-specific effects stemming from the geo-institutional spatial externalities and it is modelled through a spatial weight matrix able to discern the causal relationships produced by those regions characterized by proximity in a multidimensional space.

Let us begin with a standard growth equation (see Durlauf et al., 2005), expressed in matrix notation as

$$\mathbf{g} = \boldsymbol{\alpha} + \beta \log \mathbf{y}_{t-T} + \mathbf{Z}\boldsymbol{\varphi} + \boldsymbol{\varepsilon}, \quad (1)$$

where $\mathbf{g} = (\log \mathbf{y}_t - \log \mathbf{y}_{t-T})/T$ is a $N \times 1$ vector of average growth rates of regional per worker output in real terms between time $t - T$ and t , t is the final year, T is a scalar denoting the time length, $\boldsymbol{\alpha}$ is a $N \times 1$ vector of constant terms, $\log \mathbf{y}_{t-T}$ is a $N \times 1$ vector of logs of regional per worker output at the beginning of the period, \mathbf{Z} is a $N \times K$ matrix of explanatory variables, β is the so-called convergence coefficient, $\boldsymbol{\varphi}$ is a $K \times 1$ vector of parameters, and $\boldsymbol{\varepsilon} \sim N(0, \sigma^2 \mathbf{I})$ is a $N \times 1$ vector of well-behaved error terms.

The parameter β is of particular interest, since it can be seen as a test of the ‘catching up’ and it is expected to be negative, meaning that poor regions grow faster than rich ones. In addition, the parameter approximates the speed of convergence towards the steady state. If the set of control variables (\mathbf{Z}) is excluded from the model, equation (1) tests the *unconditional* or *absolute* beta-convergence hypothesis, which takes place if all the regions in the sample share the same steady state determinants, converging in the long-run to the same level of per worker output (Barro and Sala-i-Martin, 2004).

However, if the steady state equilibria vary across regions, their determinants should be controlled for with a set of regressors, in order to avoid a potential bias in the convergence coefficient. In this case, equation (1) tests the *conditional* beta-convergence hypothesis, so that regions exhibit convergence towards their specific steady state. Following Mankiw et al. (1992, henceforth MRW), we hold the steady state variables fixed by the inclusion of physical (\mathbf{sk}) and human (\mathbf{sh}) capital investment rates, and a term ($\mathbf{n} + \gamma + \delta$) that accounts for population growth (\mathbf{n}), technological progress (γ), and depreciation (δ). All these variables can be considered a direct extension of the Solow growth model and some of them (e.g. human capital) are usually found to be robustly related to economic growth (Doppelhofer et al., 2004).

Furthermore, the spatial externalities are explicitly accounted for in the model. The *absolute location* effect, that is the effect of being located in a particular point in space, may be captured by country-specific institutional (\mathbf{q}) as well as geographical (\mathbf{l}) control variables, in order to test the relative importance of institutions compared to pure geography. In the full specification, the matrix of K explanatory variables is therefore given by $\mathbf{Z} = [\mathbf{sk}, \mathbf{sh}, \mathbf{n} + \gamma + \delta, \mathbf{q}, \mathbf{l}]$, where each element between parentheses is an $N \times 1$ vector.

The *relative location* effect deserves particular attention since it is related to the concept of spatial dependence, which leads the standard growth equation to be seriously misspecified (Anselin and Bera, 1998; Anselin, 2001; Arbia, 2006). In fact, the residuals from a growth regression estimated for European regions tend to be highly spatially auto-correlated (Battisti and Di Vaio, 2008). Equation (1) can thus be augmented assuming a spatial auto-regressive structure for the error term

$$\boldsymbol{\varepsilon} = \lambda \mathbf{W} \boldsymbol{\varepsilon} + \boldsymbol{\zeta}, \quad (2)$$

where \mathbf{W} is an $N \times N$ spatial weight matrix—defined below—incorporating the spatial connections of the system, λ is a spatial auto-regressive parameter, $\boldsymbol{\varepsilon}$ is an $N \times 1$ vector of spatially correlated errors, and $\boldsymbol{\zeta}$ is an $N \times 1$ vector of ‘a-spatial’ disturbance terms with regular properties.

If the inverse $(\mathbf{I} - \lambda \mathbf{W})^{-1}$ exists,⁷ combining Eqs. (2) with (1) gives rise to a reduced form

$$\mathbf{g} = \boldsymbol{\alpha} + \beta \log \mathbf{y}_{t-T} + \mathbf{Z} \boldsymbol{\varphi} + (\mathbf{I} - \lambda \mathbf{W})^{-1} \boldsymbol{\zeta}, \quad (3)$$

where \mathbf{I} is the $N \times 1$ identity matrix. Equation (3) expresses the growth process as a spatial error model (SEM), which has two main features. The first one presents spatial

⁷For a row-standardized spatial weight matrix, this condition is satisfied if $|\lambda| < 1$ (Anselin, 2003).

auto-correlation as a *global* process. This can be seen expanding the spatial ‘Leontief’ inverse $(\mathbf{I} - \lambda\mathbf{W})^{-1}$ in a sum of infinite terms $\mathbf{I} + \lambda\mathbf{W} + \lambda^2\mathbf{W}^2 + \dots$ (Waugh, 1950). The expansion implies that region-specific shocks propagate themselves to the whole set of regions, because all the locations in the system are connected to each other. The second feature can be expressed by treating the spatial externalities as unmodelled or *nuisance* factors, since they work through the error structure by means of a mix of direct (\mathbf{I}), indirect ($\lambda\mathbf{W}$) and induced ($\lambda^2\mathbf{W}^2 + \dots$) effects (see Le Gallo et al., 2005, for an application to European regions).

Recently, much emphasis has been placed to models that incorporate *substantive* spatial dependence, meaning that spatial effects propagate to neighboring regions by means of endogenous as well as exogenous variables (Fingleton and López-Bazo, 2007; LeSage and Fischer, 2008). The rationale underlying such models is twofold. First of all, they are strictly linked to theoretical growth models which consider spatial externalities in the form of technology transfer or knowledge diffusion due to the accumulation of factors in the surrounding area (López-Bazo et al., 2004; Egger and Pfaffermayr, 2006). Secondly, it has been shown that the existence of spatial dependence among the disturbances of a standard growth regression, in the presence of an omitted variable correlated with an exogenous regressor, leads to a model inclusive of substantive spatial dependence (Pace and LeSage, 2008).

After a spatial transformation, equation (3) can be written in the structural form of a Spatial Durbin Model (SDM)

$$\mathbf{g} = \boldsymbol{\xi} + \beta \log \mathbf{y}_{t-T} + \mathbf{Z}\boldsymbol{\varphi} + \lambda\mathbf{W}\mathbf{g} + \rho\mathbf{W} \log \mathbf{y}_{t-T} + \mathbf{WZ}\boldsymbol{\vartheta} + \boldsymbol{\zeta}, \quad (4)$$

where $\boldsymbol{\xi}$ is a vector of constants, $\rho = -\lambda\beta$ and $\boldsymbol{\vartheta} = -\lambda\boldsymbol{\varphi}$ can be seen as restrictions on the parameters of Eq. (3), while the other terms have the same notation as before. If the restrictions hold, the model boils down to the SEM, implying nuisance spatial dependence in the data. On the contrary, if the restrictions are not accepted, equation (4) supports substantive spatial dependence, which works by means of both endogenous and exogenous spatially-lagged variables.

The restrictions can be tested by first estimating equation (4) as the unrestricted version of equation (3), and then carrying out a likelihood ratio test of the spatial common factors (*LRCOm*) equal to

$$LRCOm = -2(L_{ur} - L_r) \sim \chi^2(k), \quad (5)$$

where L_{ur} and L_r are the values of the log-likelihood function of the unrestricted and the restricted models, respectively, and k is the number of the implied restrictions (Mur and Angulo, 2006). If the *LRCOm* is statistically significant, the null hypothesis of spatial common factors is rejected, so that the correct specification should be based upon the unrestricted version given by equation (4), where $\rho \neq -\lambda\beta$ and $\boldsymbol{\vartheta} \neq -\lambda\boldsymbol{\varphi}$. The choice between the two models, i.e. SEM and SDM, is thus operated following a ‘general to specific’ strategy (Florax et al., 2003).

A meaningful economic interpretation of the SDM can be derived from the reduced form of equation (4)

$$\mathbf{g} = (\mathbf{I} - \lambda \mathbf{W})^{-1} (\boldsymbol{\xi} + \beta \log \mathbf{y}_{t-T} + \mathbf{Z}\boldsymbol{\varphi} + \rho \mathbf{W} \log \mathbf{y}_{t-T} + \mathbf{WZ}\boldsymbol{\vartheta} + \boldsymbol{\zeta}), \quad (6)$$

which incorporates only exogenous terms among the right-hand side variables, and implies a different and more complex spatial pattern than the one derived from the SEM structure (see Anselin, 2003). It is worth noticing that in the model described through Eqs. (1) and (3) the partial derivative of per worker output's growth rate with respect to the initial level of per worker income is solely given by the convergence coefficient (i.e. β). By contrast, in the SDM such derivative is different and is expressed by

$$\partial \mathbf{g} / \partial \log \mathbf{y}_{t-T} = (\mathbf{I} - \lambda \mathbf{W})^{-1} (\beta \mathbf{I} + \rho \mathbf{W}). \quad (7)$$

In the case of a row-standardized spatial weight matrix, after the inverse expansion, and rounding to the first order spatial terms,⁸ it can be showed that the convergence speed for a generic region is given by

$$(1 + \lambda)\beta + \rho. \quad (8)$$

The catching up process is therefore influenced by the 'neighborhood', through the spatial externalities captured by the parameter ρ , and by the term $(1 + \lambda)\beta$. This second term is given by a linear combination of the spatial auto-correlation parameter multiplied by the β coefficient. Compared to the cases of either the standard growth model or the SEM (equations 1 and 3, respectively), in which the convergence speed is provided only by β , the convergence dynamics in the SDM specification also depends on the signs and magnitudes of the spatial parameters. Furthermore, the SDM can be considered a more general case with respect to the other models, in that $\partial g / \partial \log y_{t-T} \rightarrow \beta$ if $\lambda, \rho \rightarrow 0$.

2.2 The spatial weight matrix

The $N \times N$ spatial weight matrix \mathbf{W} incorporates the topology of the economic system and sets the linkages existing among the regions in the sample. It is usually specified as a row-standardized distance-based matrix which elements are defined according to a 'gravity' function that provides an exponential distance decay.⁹ The weights are given by

$$\begin{cases} w_{ij} = 0 & \text{if } i = j, \\ w_{ij} = (1/d_{ij}^{geo})^2 / \sum_j (1/d_{ij}^{geo})^2 & \text{if } d_{ij}^{geo} \leq \overline{d^{geo}}, \\ w_{ij} = 0 & \text{otherwise,} \end{cases} \quad (9)$$

⁸The effects of higher orders rapidly approach to zero.

⁹The more popular contiguity matrices are not useful in the case of European regions, since they leave the islands unconnected.

where d_{ij}^{geo} is a measure of the geographical (e.g. physical) distance between regions i and j , and $\overline{d^{geo}}$ is a critical distance cut-off after which spatial effects are considered to be negligible.¹⁰ The row-standardization helps the interpretation and the comparison of the parameters, ensuring the condition $0 < w_{ij} \leq 1$. In this way the spatially-lagged variables are equal to a weighted average of the neighboring values.

The choice of the weights constitutes a crucial issue, in that they represent the a priori knowledge of the strength of the spatial connections (Stetzer, 1982). Simple geographical metrics, as the ones defined by Eq. (9), are often used as good proxies for transport costs and technological transfers. Those metrics, however, fail to capture other kind of distances that also play a major role in shaping the economic relationships across space (Anselin, 2002).

To go beyond these limitations, socio-economic weighting structures have been proposed in the literature. For instance, Case (1991) and Case et al. (1993) combine population, income and geography to identify the influence exerted by regions that are similar in demographic or economical terms. Aten (1996) uses trade flows as a measure of relative location that accounts for differences in transport costs and hence for price differentials among geographical units. Conley and Topa (2002) employ social and economic distances reflecting the structure of agents' social networks, as disparities in ethnic and occupational distributions, to examine the spatial patterns of unemployment.

In order to assess the influence of relative location due to distance in institutions, we modify the spatial weight matrix specification, so that the non-zero elements defined by Eq. (9) become

$$w_{ij} = (1/d_{ij}^{geo} * d_{ij}^{inst})^2 / \sum_j (1/d_{ij}^{geo} * d_{ij}^{inst})^2 \text{ if } d_{ij}^{geo} * d_{ij}^{inst} \leq \overline{d^{geo} * d^{inst}}, \quad (10)$$

where $1 \leq d_{ij}^{inst} < \infty$ can be seen as an institutional heterogeneity index whose values denote increasing dissimilarity for $d_{ij}^{inst} \rightarrow \infty$, and $\overline{d^{geo} * d^{inst}}$ constitutes a minimum threshold making each region connected at least to one neighbor.¹¹

The multiplicative specification through which the institutional distance enters the weighting function, gives a leverage effect to the geographical distance so that, holding the latter fixed, the greater is the former, the lower is the neighbors impact and vice versa.¹² Since we assume that regions belonging to the same country share similar institutions, we set $d_{ij}^{inst} = 1$ if $i, j \in s, \forall i, j$, where s denotes the country. This is not

¹⁰We use the Euclidean distance between the centroids of the regions, while the cut-off is given by a minimum threshold able to guarantee that each region has at least one neighbor. The elements of the main diagonal are set equal to zero by convention, since regions cannot be neighbor to themselves.

¹¹With respect to Eq. (9), the specification of Eq. (10) may produce changes not only in the relative weights of the neighboring regions, but also in the structure of the neighborhood, so that regions which are institutionally similar become closer in space.

¹²Following Case (1991), in a previous version of the work we tested a different scheme of the weight matrix, nesting institutional and geographical distances in an additive manner. Results however are very similar.

a groundless assumption, since many social functions (like e.g. health care, education or justice) are still provided by national institutions.¹³ Finally, some empirical works support the thesis that national borders do have an impact on the regional economic dynamics, at least in an integrated regional system like the EU (Meliciani, 2006). In our model the geographical distance is therefore the only one that matters for the regions located in the same state.

3 Data and descriptive statistics

The empirical part of this paper focuses on a sample of 271 NUTS-2 European regions.¹⁴ The dependent variable consists in the average growth rate of per worker GDP from 1991 to 2004, expressed at 2000 prices. The exogenous variable employed in the absolute beta-convergence specification is given by the level of per worker GDP in 1991, at 2000 prices. Both variables are taken from Cambridge Econometrics, *European Regional Database*, Summer 2007.¹⁵ In addition, the conditional beta-convergence model includes the MRW variables, namely the average physical investment rate, the population growth, the technological progress and the depreciation rate over the period 1991-2004. These are also taken from the Cambridge Econometrics database.¹⁶ As for the human capital investment rate, we adopt a proxy consisting in the ratio of people with tertiary school attainment to the economically active population (15-over), over the period 1998-2004 which is available from Eurostat, *Regional education statistics*.¹⁷

In order to capture the absolute location effect due to country-specific institutions, we insert an institutional quality index among the set of the regressors. The index is taken from the World Bank's *Worldwide Governance Indicators* (WGI) elaborated by Kaufmann et al. (2006). The variable is made up of survey data aggregated into six indicators, averaged over the years 1996-2004.¹⁸ The indicators range from -2.5 to 2.5

¹³In the present study it is also a necessary choice, due to lack of socio-institutional data at regional level.

¹⁴The regions in the sample belong to the EU-27 countries, plus Norway and Switzerland. NUTS is the acronym for Nomenclature of Territorial Units for Statistics established by Eurostat. The list of regions is available upon request.

¹⁵For the cases of Latvia and Lithuania, we use the level of GDP in 1992 as the beginning year, since the values for 1991 seem to be highly underestimated, probably due to the conversion from the communist system to the market system.

¹⁶As it is usual in growth empirics, we assume that technological progress and depreciation rate are constant and equal to 0.02 and 0.05, respectively.

¹⁷The data are released according to the International Standard Classification of Education (ISCED) 1997. We use the ISCED level 5-6. Unfortunately, no data are available before 1998. However, the lack of data does not seem to create a severe bias in the estimates since the distribution of the attainment is substantially stable over short time periods. In fact, the Spearman's rank correlation coefficient between 1998 and 2004 is equal to 0.91. Therefore, it seems quite reasonable to assume that the distribution did not change sensibly during the period 1991-1997.

¹⁸Data before 1996 are missing. As in the case of the attainment, the distribution of the institutional variable did not vary so much over the period considered, since the simple correlation coefficient between the two years 1996 and 2004 equals 0.94. Consequently, we would not expect particular biases

and are based on voice and accountability, political stability and absence of violence, government effectiveness, regulatory quality, rule of law, and control of corruption. To check the robustness of the results we also employed the *International Country Risk Grade* (ICRG) used by Knack and Keefer (1995, 1997), which reports measures related to the soundness of institutions and to the attractiveness of the environment for investors. We used a simple sum, averaged over the years 1991-1997, of five indicators out of six: quality of bureaucracy, corruption in government, rule of law, expropriation risk, and repudiation of contracts by government.¹⁹

Figure 1 shows the WGI for the European countries. Looking at the histogram, a wide variation in the quality of institutions can be observed. In the left side of the graph, there are countries with high institutional quality. These are mainly the Northern countries (like Finland, Netherlands, Denmark, Sweden and Norway) and countries belonging to the former EU-15 (apart from Switzerland and United Kingdom). In the middle part, we find some Latin or Cohesion countries (France, Spain and Portugal) while in the right side of the graph are concentrated all the Eastern and New Adhesion countries and, in addition, Greece and Italy. These latter have a poor quality of institutions although they belong to the former EU-15. The countries with the worse institutional quality are Bulgaria and Romania, which receives a negative score.

[FIGURE 1 AROUND HERE]

Some criticism has been cast on the quality and the nature of the institutional data. For instance, corruption indicators may differ from the aspects of corruption they want to represent due to lack of clarity in the definition and of conceptual precision (Knack, 2006). Indicators of institutional quality might also be conceptually unsuitable to the assessment of the causal relationship between institutions and growth, because they depend more on the endowments of human and social capital than on variables which reflect ‘deep’ parameters affecting the development of the economy (Glaeser et al., 2004). The consensus about such kind of indicators, however, remains high (for a reply to the critics, see Kaufmann et al., 2007). In fact, WGI and ICRG have proved to be highly significant among the determinants of the income level in several cross-country studies (Hall and Jones, 1999; Acemoglu et al., 2001; Rodrik et al., 2004).

An important methodological aspects refers to the potential endogeneity of the institutional variables, because they might be influenced by the level of development. Starting from the work of Lipset (1960), several authors have argued that growth in income and human capital impacts on the institutional quality, rather than the other way around. To check if the results of our estimates would be sensitive to causal reversion (i.e. simultaneity), we used an instrumental variable (IV) estimation of the parameters in equation (1). The categorical nature of the institutional controls (i.e.

in the estimates.

¹⁹No data are available after 1997.

country-specific discrete variable), however, would lead to unreliable results of the classical IV estimator. As a further robustness check, we use data from the POLITY database (Marshall and Jaggers, 2005), which includes average scores of democracy and autocracy, and the duration of political regimes. More specifically, we utilize the POLITY2 index, measuring the difference between democracy (ranging from 0 to 10) and autocracy (ranging from 0 to 10), over the period from 1946-1980, so that a score of 10 equals a perfect democratic regime (i.e. no constraints on executives), while -10 equals perfect autocracy. The logic under this strategy relies on the assumption that past institutions might affect the current growth rate of per capita income while, on the contrary, the present growth rate cannot determine past institutions. Anyway, we wouldn't expect a large bias due to causal reversion, since institutions usually change in the long-run, while the present study covers a time span of about 15 years.²⁰

As a proxy for the absolute location effect due to geography, we use the latitude of country's centroid taken from the *Geography Datasets*, developed by J. L. Gallup, A. D. Mellinger, and J. D. Sachs, for the Center for International Development at Harvard University.²¹ This is a country-specific variable, whose impact can be directly compared to the one deriving from the institutions. Absolute latitude is commonly used in growth empirics in order to capture the role played by the geographical location. Bloom et al. (2003), for instance, find that latitude is a fundamental exogenous force that influences the economic outcome. In fact, some kinds of technologies, like those adopted in the agricultural or in the building sector, do not transfer across ecological zones. In addition, Northern hemisphere midlatitudes have, in general, larger populations and larger markets for innovation, thus attracting a higher number of firms in order to exploit lower transport costs (Bloom and Sachs, 1998).

Figure 2 reports the scatterplot of productivity in 2004 versus absolute latitude for the European countries. No clear-cut relationship can be inferred from the graph, since poorest countries fall in both high and low relative latitudes. This is mainly due to the fact that poor countries, like the Baltic states (Estonia, Latvia and Lithuania) or the North-Eastern countries (like Poland) are located in high latitudes while, at the same time, there are less developed countries falling in low latitude areas, like the South-Eastern countries (Bulgaria and Romania) or the Cohesion countries (Greece, Portugal and Spain). In some cases, however, the level of development seems to be positively related to the latitude, since the richest countries have highest values of relative latitude, like the Northern countries (Denmark, Netherlands, United Kingdom and Sweden).

[FIGURE 2 AROUND HERE]

²⁰Some doubts have been also cast on the exogeneity of the MRW variables (Bernanke and Gürkaynak, 2001), like the physical and human capital saving rates. The lack of available instruments for the European regions included in our sample prevented us from using an IV framework for those variables. As described in the next section, we conducted an IV estimation on a smaller sample where, following Barro and Lee (1994), we rely on past values of physical capital investment rates as instruments of the current ones. The differences between OLS and IV estimates are more or less negligible.

²¹Due to lack of data, we assign to Malta the same value of Italy.

Next, we describe the variables used as proxies for the relative location effect, incorporated in the spatial weight matrix. Pairwise geographical distances refer to the physical Euclidean distance between the centroids of the regions. As for the institutional distance, we considered two metrics. The first one is obtained from the OECD’s Product Market Regulation (PMR) indicators (Conway et al., 2005). More specifically, Kox et al. (2004) release the country pairwise differences from the original OECD data. For the year 1998, we calculate the inverse of similarity so as to have a more intuitive measure of the difference. The adoption of institutional distances, however, could induce endogeneity problems in the weight matrix. To avoid this effect, we also use a proxy of the institutional heterogeneity index, which is given by the linguistic distance and it is defined as ethnological differences by families of languages (Disdier and Mayer, 2007). It can be argued that languages capture specific institutional characteristics of the countries. However, since they are stable in the short-run, they can be unambiguously considered exogenous to the model. This variable is often utilized in empirical models of bilateral trade, since the greater is the linguistic distance, the higher are the obstacles to trade. Originally the pairwise linguistic indicator is built on proximity, with values ranging from 0 to 1, 1 denoting perfect similarity. In order to get a proxy of linguistic distance we then rescale such a measure by taking the inverse of the similarities.²²

On average, former EU-15 countries tend to be more similar among them, while the same is true for the New Adhesion countries. Few exceptions, however, arise in the case of Malta and Romania, which are New Adhesion countries, but are closer to the Western countries, in terms of language, and in the case of Finland, which is a former EU-15 country that shares more similarities with the former Soviet Union states, like Estonia, Latvia and Lithuania.

4 Discussion of the results

The first step of the estimation phase refers to the standard growth equation expressed by Eq. (1) in its several specifications. Subsequently we test for the potential misspecifications of the model, related to omitted variables or to the fact of neglecting the spatial effects stemming from geography and institutions.

Table 1 shows the estimation results of the absolute beta-convergence model (column 1). The estimated β is negative and highly significant, implying a convergence speed equal to about 1.2%. This value is higher than the one usually obtained from growth regression of per capita—instead of per worker—income (see Battisti and Di Vaio, 2008), but is well below the so-called ‘empirical norm’ of 2% (Barro and Sala-i-Martin, 2004). Such a result points out that the dispersion of participation rates plays a

²²For the case of Hungary the measure takes high values, because the Hungarian linguistic root is completely different from the Indo-European languages. Both the institutional and geographical distances are row-normalized by the mean, so to avoid a dominance effect due to the scale of the variables.

role in the explanation of the different patterns of regional convergence across Europe. However, the sensitivity of the coefficient to the change of the specification adopted seems to denote the existence of a potential bias. In fact, moving to the conditional beta-convergence model reported in column 2 of Table 1 produces a dramatic decrease of the convergence speed from 1.2% to 0.2%, which is not statistically different from zero. This particular result might be partly due to the fact that, in contrast with the case of cross-country growth regressions, the physical investment rates of the European regions are inversely related to the level of per worker output.²³ Therefore, the omission of this variable, which positively impacts on the regressand (see the values of φ_{sk}), causes a downward bias of the estimated convergence parameter. Once the bias is removed, the β undergoes an upward shift that reduces the convergence speed.

[TABLE 1 AROUND HERE]

The inclusion of the term given by $n + \gamma + \delta$ works in the same direction, since this variable is positively correlated with the initial level of income while affecting in a negative way the productivity growth rate (see $\varphi_{n+\gamma+\delta}$). On the contrary, an offsetting bias is caused by the human capital accumulation (sh). This latter is positively related to both the productivity growth rate and the initial level of income, creating, this way, an upward bias (see φ_{sh}). The net effect, however, consists of a decrease of the convergence speed. All the estimated parameters have the sign predicted by the MRW model, since the accumulation of physical as well as human capital increases the economic growth, at regional level, while the population growth, plus the technological progress and the depreciation, leads to a decrease.

Turning to the absolute location effect, this is captured by the inclusion among the regressors of the proxy variables for institutions, geography, or both. Adding the country-specific institutional control (column 3) produces a positive and statistically significant impact on the growth of per capita output (see φ_q), raising the convergence rate to 1%.²⁴ Therefore, regions belonging to countries endowed with a better institutional quality tend to experience higher growth rates, as well as they tend to (conditionally) converge faster among themselves. The introduction of the country-specific geographical control (column 4), represented by the absolute latitude, also has a positive and significant impact on the dependent variable (see φ_l), indicating that

²³The Pearson's correlation coefficient between initial per worker output and physical capital investment rates, human capital saving rates, and population growth rates, is equal to -0.4 , 0.4 , and 0.7 , respectively.

²⁴As a proxy for institutions we utilize the WGI. The results are largely robust to the use of the alternative measure given by the ICRG. To deal with the endogeneity issue, we conducted an IV estimation on a restricted sample of 205 regions. POLITY2 measures, and past values of fixed gross investment rates, are used as instruments of the WGI and the current investment rates, respectively. Also in this case, results do not qualitatively change. Details are available upon request.

regions located in Northern European countries grew comparatively faster than the others, over the period considered.

However, the convergence coefficient does not show a large variation, from column 2 to column 4, after controlling for the absolute location effect due to geography, indicating that latitude does not play a fundamental role as an omitted variable in European regional growth models, since it is only weakly correlated with the initial level of income. When the institutional and the geographical proxies enter the regression simultaneously (column 5), the latter becomes not significant, while the remaining parameters assume the same values as in column 3. This is an interesting aspect, with a two-fold implication. On one side, it confirms that absolute location matters. On the other side, it stresses that institutions have a dominant role, with respect to geography, as a determinant of either the growth or the convergence process of the regions of Europe. In addition, the inclusion of the institutional control helps to explain more than 50% of the variance in the data (see the R²-Adjusted, columns 3 and 5).

The following step in the empirical analysis consisted of the testing for spatial dependence among the data as the outcome of the relative location effect. The Moran's I statistics reported in the bottom part of Table 1 show the presence of a positive and highly significant spatial auto-correlation among residuals in all the regressions. In addition, the spatial correlation tends to be higher when the geo-institutional spatial weight matrix is taken into account (Moran's $I_{d^{geo*dist}}$).²⁵ In such a case, equation (1) is misspecified and OLS estimates are no longer valid. Particularly, in this case the empirical growth model should be modified to accommodate a form of spatial dependence and the parameters should be estimated by means of maximum likelihood techniques.

Consequently, estimation of the spatial growth regressions—SEM and SDM—are carried out both in the benchmark case of a pure geographical spatial weight matrix and in the case that considers geo-institutional distances. Firstly, the best weight matrix specification is chosen, within the model, according to the Akaike Information Criterion (AIC).²⁶ The values shown in Figure 3 highlight that, both for the SEM and the SDM, the model incorporating the geo-institutional spatial distance is always preferred, while the conditional beta-convergence equation (including the institutional control) fits the data better.

[FIGURE 3 AROUND HERE]

Secondly, the LRCom test is conducted in order to discriminate between the two spatial models built up with purely geographical distances and with compounded geographical and institutional distances. As it can be seen from Table 2, in both the

²⁵The result is obtained using the linguistic distance in the geo-institutional spatial weight matrix.

²⁶Within models (e.g. SEM and SDM), the preferred specification is selected according to the AIC because the two versions (with pure geographical or geo-institutional weights) have the same number of the estimated parameters.

cases of pure geographical and geo-institutional weight matrix (this latter turned out to be the preferred choice according to the AIC) the test always rejects the restrictions imposed on the parameters, implying that the SDM provides a more correct interpretation of the spatial dependence existing in the data. Therefore, the propagation of the spatial externalities across the European regions takes the form of a substantive phenomenon rather than just of a nuisance effect.

[TABLE 2 AROUND HERE]

For the sake of brevity, Tables 3 and 4 display only the estimates of the selected model (SDM) comparing the two different options given by the pure geographical and the geo-institutional spatial weight matrix. Table 3 lists the results of the benchmark case in which only the geographical distance is considered. First of all, it should be noted that the spatially-lagged parameters of the productivity's growth rate (λ) and the initial per worker income (ρ) are always positive and statistically significant. The relative location, due to proximity in the physical space, generates a spatial spillover, which can be caused by knowledge diffusion or technological transfers from the neighboring regions. This spillover works through both the growth process and the accumulation of factors. On the contrary, some parameters of the other spatially-lagged variables are not significant in all the specifications adopted (i.e. ϑ_{sk} and ϑ_q).

[TABLE 3 AROUND HERE]

From Table 3 it can be seen that the β coefficient is always negative and statistically significant in all the regressions. A correct assessment of the convergence dynamics, however, should be made by looking at the term consisting of $(1 + \lambda)\beta + \rho$. As it can be seen, the convergence speed is generally higher than the one obtained from the standard growth regression, since it ranges from 0.5 to 1.4%. Such outcome can be explained using two different arguments. On one hand, it can be seen in the logic of spatially auto-correlated omitted variables. Since per capita output is positively auto-correlated across space, and its spatial lag has a positive impact on the productivity's growth rate, the inclusion of the spatially-lagged initial level of per capita productivity tends to reduce the convergence coefficient, with respect to the standard growth model. The convergence speed turns out to be therefore increased. On the other hand, the result can be motivated by a more conceptual reason. If the regional steady-state is affected by the neighborhood's accumulation of factors, when the spatially-lagged initial level of per capita productivity is inserted in the model, we likely estimate a spatial conditional convergence, which should be generally higher since the adjustment process takes place among regions that share similar long-run determinants. Looking at the absolute effect

due to institutions, it still has a positive and significant impact (columns 3 and 5), while the one deriving from geography is negative, also when it enters the regression separately (column 4).

Table 4 reports the estimates of the SDM with the geo-institutional spatial weight matrix.²⁷ It's worth noticing that, on average, the convergence speed is about doubled with respect to the SDM with pure geographical distances, and it is about four times with respect to the standard growth regression shown in Table 1. In fact, it takes values ranging from 1.7% to 2.4%, implying that once the institutional distance (i.e. heterogeneity) is controlled for in the spatial weight matrix, the regional convergence turns out to be fostered. This basically involves that holding the physical distance fixed, regions which share similar (national) institutions tend to converge at an increased pace to each other, since the convergence rate is higher than the canonical 2%. Interestingly, the parameters of the spatially-lagged variables, given by the productivity's growth rate and the initial per worker income, generally raise their magnitude if compared to the values reported in Table 3. Relative location effects are therefore enhanced among regions which are close in terms of institutional setting, this latter playing a dominant role with respect to the geographical dimension.

[TABLE 4 AROUND HERE]

As for the absolute location effect, institutions maintain their relevance, while the impact of geography disappears in the case where it enters the model separately from the institutional control (column 4), or becomes weakly negative in the case where it enters jointly with it (column 5). To conclude, the SDM growth regression, in the form of the conditional beta-convergence specification accounting for both absolute and relative location effects due to institutions (columns 3 and 5), contributes to explain about 60% of the variance of regional growth rates across Europe.²⁸ This seems to be a remarkable result in a cross-sectional framework.

5 Conclusions

In the present paper an empirical test of growth models has been conducted in order to provide a correct assessment of the productivity's convergence dynamics across the European regions. In particular, the spatial effects of the absolute and relative location, due to either institutions or geography, have been taken into account.²⁹ Those effects have been modelled by means of specific controls and imposing a spatial weight

²⁷We utilize the linguistic distance, so to avoid the endogeneity of the weight elements. The use of the PMR indicators produces the same qualitative results, but it reduces the convergence speed. The full tables of the estimates are available upon request.

²⁸For the case of the spatial models, R^2 means a pseudo R^2 .

²⁹As far as we know, these aspects have never been treated jointly in the previous literature.

matrix, which incorporates a multidimensional concept of distance. The kind of spatial externalities have been identified following a general to specific strategy, which led to the selection of the most appropriate model, while the best weight matrix specification has been chosen according to an information criterion. In addition, the speed of convergence has been derived in the case of the chosen model.

Results show that a growth model, which deals with spatial externalities as a substantive phenomenon, seems to be the best candidate in explaining the European regional growth patterns. In fact, the spillover stemming from the neighboring regions, reasonably due to technology transfer or knowledge diffusion, mainly works through the accumulation of output.

The absolute location effect due to country-specific institutions, captured by an institutional quality index, is strongly and positively related to the growth rate of regional productivity. In fact, institutions play a dominant role with respect to geographical factors, like the country's latitude. Thus, the result seems to confirm that the 'primacy of institutions over geography', identified worldwide by Rodrik et al. (2004), applies also to the case of the European regions.

The relative location effect is accounted for, instead, by the inclusion of a spatial weight matrix, which is built on a geo-institutional distance. This effect is highly significant and increases the spatial dependence of the regional output per worker. Pure geographical metrics, like the physical distance, largely underperforms in terms of the fit of the data, and underestimates the convergence dynamics. In fact, the inclusion in the weight matrix of the institutional heterogeneity index, given by the linguistic distance, produces an increase of about four times of the speed of convergence, on average, with respect to the standard growth model. This means that holding the geographical distance fixed, the regions which share a similar institutional framework tend to converge more rapidly to each other. This findings are partly in line with the prescriptions of recent theoretical models which stress that limited forms of institutional integration may be conducive of economic growth for the merging countries (Spolaore and Wacziarg, 2005).

Finally, some policy implications can be indirectly deduced. In the last decade, some criticism has been addressed to the EU structural and cohesion policies, since they didn't exert the desired impact on the reduction of the income disparities. As it is well known, these policies have been mainly devoted to investments in infrastructures and aid to production. Looking at the results presented in this paper, a shift of such policies through the improvement of the quality of institutions, on the one side, and the reduction of the institutional heterogeneity, on the other side, might induce a stronger decrease of the inequalities across Europe. Future research should aim to use the different distance metrics in more advanced econometric settings such as, for instance, the panel-type regression. At the present stage, the work highlights the extremely different results that can be obtained by using those metrics within the most standard cross-sectional framework.

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TABLE 1: Standard growth regression

	(1)	(2)	(3)	(4)	(5)
α	0.142***	0.050***	0.113***	0.038***	0.113***
β	-0.012***	-0.002	-0.010***	-0.003**	-0.010***
φ_{sk}	-	0.138***	0.121***	0.135***	0.121***
φ_{sh}	-	0.050***	0.028**	0.037***	0.028**
$\varphi_{n+\gamma+\delta}$	-	-0.639***	-0.553***	-0.567***	-0.553***
$\varphi_q (\times 00)$	-	-	0.225***	-	0.225***
φ_l	-	-	-	0.037***	-0.000
R ² -Adjusted	0.24	0.49	0.53	0.50	0.53
Log-likelihood	737	790	801	794	801
Moran's $I_{d^{geo}}$	0.334***	0.284***	0.237***	0.258***	0.239***
Moran's $I_{d^{geo} * d^{inst}}$	0.454***	0.422***	0.413***	0.403***	0.417***

Notes: OLS estimates. Dependent variable: average growth rate of per worker GDP. Column (1): absolute beta-convergence; Column (2): MRW conditional beta-convergence; Column (3): MRW conditional beta-convergence plus institutional control; Column (4): MRW conditional beta-convergence plus geographical control; Column (5): MRW conditional beta-convergence plus both institutional and geographical controls. ***, **, and * denote statistical significance at 1%, 5%, and 10% level, respectively.

TABLE 2: Likelihood ratio test of the spatial common factors ($LRCom$)

	(1)	(2)	(3)	(4)	(5)
$LRCom (d^{geo})$	3.3*	10.5**	12.5**	21.0***	23.6***
$LRCom (d^{geo} * d^{inst})$	23.2***	46.9***	32.8***	53.2***	47.5***

Notes: d^{geo} : geographical distance weight; $d^{geo} * d^{inst}$: compounded geographical plus institutional distance weight. Column (1): absolute beta-convergence; Column (2): MRW conditional beta-convergence; Column (3): MRW conditional beta-convergence plus institutional control; Column (4): MRW conditional beta-convergence plus geographical control; Column (5): MRW conditional beta-convergence plus both institutional and geographical controls. ***, **, and * denote statistical significance at 1%, 5%, and 10% level, respectively.

TABLE 3: Spatial Durbin growth regression model (SDM) based on pure geographical distances (d^{geo})

	(1)	(2)	(3)	(4)	(5)
ξ	0.027*	-0.012	0.028	-0.023	-0.019
β	-0.016***	-0.011***	-0.015***	-0.010***	-0.017***
φ_{sk}	-	0.126***	0.119***	0.126***	0.114***
φ_{sh}	-	0.067***	0.058***	0.068***	0.060***
$\varphi_{n+\gamma+\delta}$	-	-0.535***	-0.494***	-0.542***	-0.479***
$\varphi_q(\times 00)$	-	-	0.193***	-	0.292***
φ_l	-	-	-	-0.103**	-0.172***
λ	0.715***	0.650***	0.611***	0.584***	0.579***
ρ	0.014***	0.013***	0.013***	0.009***	0.016***
ϑ_{sk}	-	-0.067**	-0.070**	-0.059*	-0.048
ϑ_{sh}	-	-0.074***	-0.083***	-0.099***	-0.096***
$\vartheta_{n+\gamma+\delta}$	-	0.315*	0.328*	0.554***	0.481**
ϑ_q	-	-	-0.001	-	-0.003**
ϑ_l	-	-	-	0.160***	0.233***
$(1 + \lambda)\beta + \rho$	-0.014	-0.005	-0.012	-0.006	-0.011
R ² -Adjusted	0.24	0.48	0.52	0.53	0.55
Log-likelihood	871	916	921	921	928
AIC	-1735	-1813	-1818	-1818	-1829

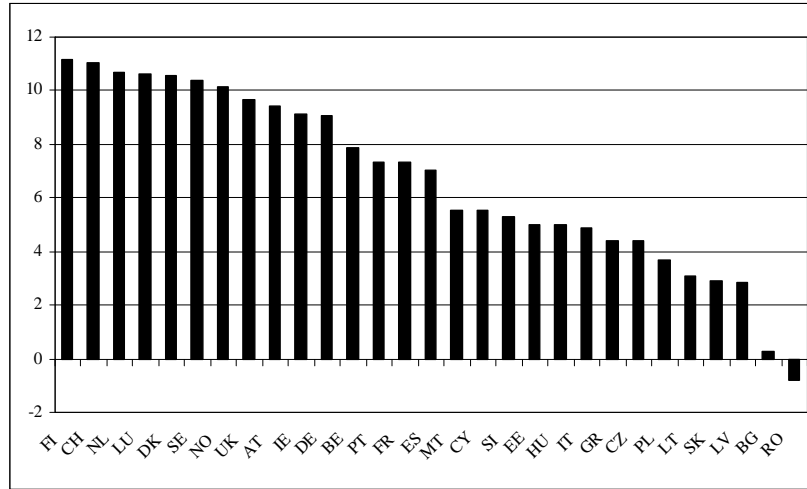
Notes: ML estimates. Dependent variable: average growth rate of per worker GDP. Column (1): absolute beta-convergence; Column (2): MRW conditional beta-convergence; Column (3): MRW conditional beta-convergence plus institutional control; Column (4): MRW conditional beta-convergence plus geographical control; Column (5): MRW conditional beta-convergence plus both institutional and geographical controls. ***, **, and * denote statistical significance at 1%, 5%, and 10% level, respectively.

TABLE 4: Spatial Durbin growth regression model (SDM) based on compounded geographical and institutional distances ($d^{geo} * d^{inst}$)

	(1)	(2)	(3)	(4)	(5)
ξ	0.009	-0.019*	0.006	-0.026**	-0.011
β	-0.030***	-0.027***	-0.030***	-0.026***	-0.030***
φ_{sk}	-	0.088***	0.084***	0.091***	0.085***
φ_{sh}	-	0.102***	0.099***	0.102***	0.101***
$\varphi_{n+\gamma+\delta}$	-	-0.251***	-0.230***	-0.269***	-0.247
λ	0.784***	0.760***	0.741***	0.744***	0.739***
ρ	0.030***	0.030***	0.031***	0.029***	0.032***
$\varphi_q(\times 00)$	-	-	0.244**	-	0.342***
φ_l	-	-	-	-0.052	-0.095*
ϑ_{sk}	-	-0.051**	-0.053***	-0.053***	-0.052***
ϑ_{sh}	-	-0.112***	-0.122***	-0.119***	-0.124***
$\vartheta_{n+\gamma+\delta}$	-	0.032	0.062	0.093	0.093
ϑ_q	-	-	-0.002	-	-0.003**
ϑ_l	-	-	-	0.075	0.116**
$(1 + \lambda)\beta + \rho$	-0.024	-0.017	-0.022	-0.017	-0.021
R ² -Adjusted	0.26	0.49	0.54	0.54	0.56
Log-likelihood	932	992	996	993	998
AIC	-1857	-1963	-1969	-1963	-1969

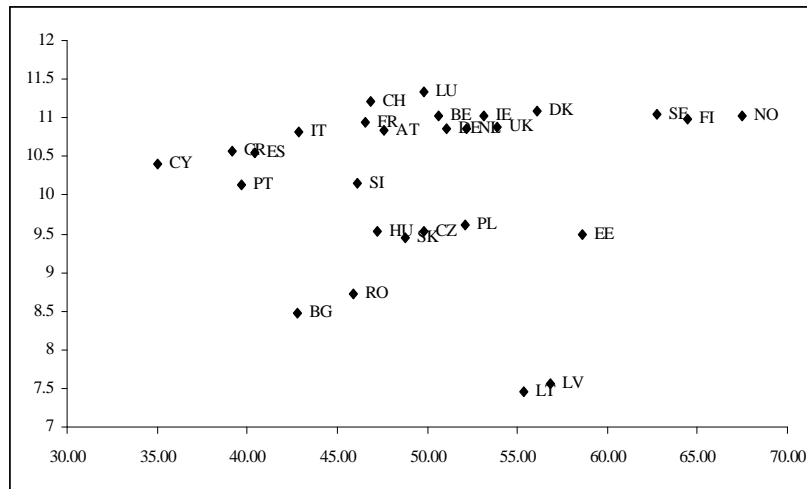
Notes: ML estimates. Dependent variable: average growth rate of per worker GDP. Column (1): absolute beta-convergence; Column (2): MRW conditional beta-convergence; Column (3): MRW conditional beta-convergence plus institutional control; Column (4): MRW conditional beta-convergence plus geographical control; Column (5): MRW conditional beta-convergence plus both institutional and geographical controls. ***, **, and * denote statistical significance at 1%, 5%, and 10% level, respectively.

FIGURE 1. Worldwide Governance Indicators, European countries



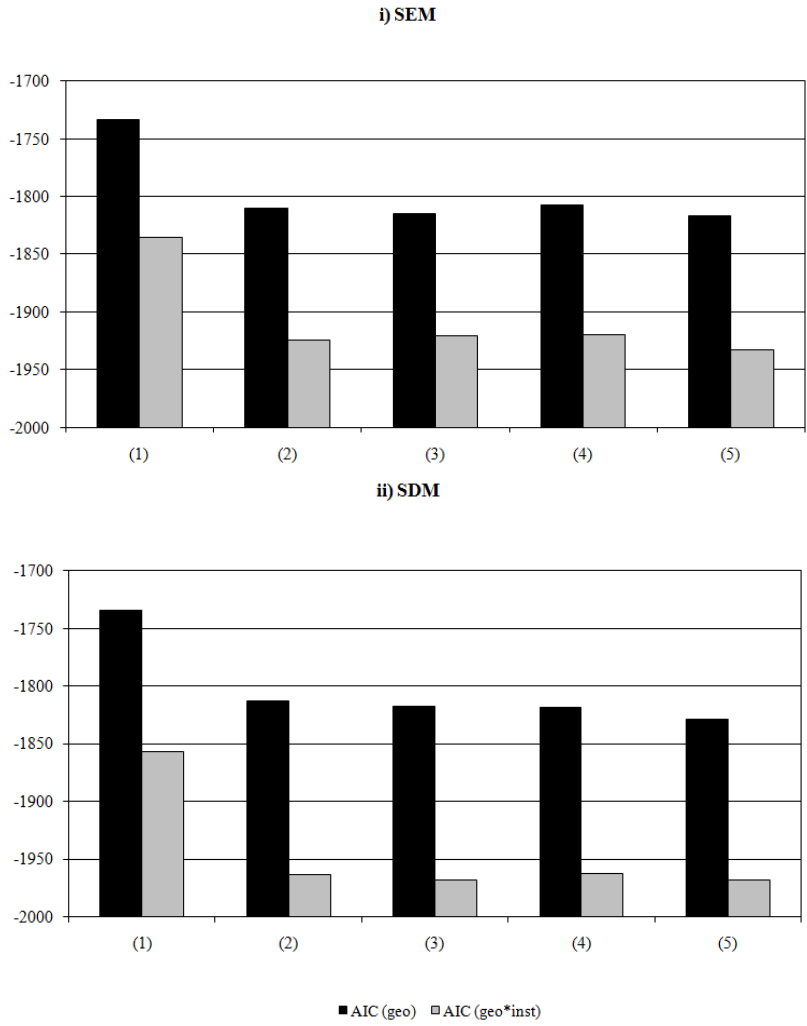
Notes: Average 1996-2004.

FIGURE 2. Geography vs productivity, European countries



Notes: X-axis, absolute latitude; Y-axis, per worker GDP in 2004.

FIGURE 3. AIC of the spatial growth regressions



Notes: Column (1): absolute beta-convergence; Column (2): MRW conditional beta-convergence; Column (3): MRW conditional beta-convergence plus institutional control; Column (4): MRW conditional beta-convergence plus geographical control; Column (5): MRW conditional beta-convergence plus both institutional and geographical controls.