Space, Institutions and Growth. Empirical Tests Using Weighted Distance Matrices for the EU25 Regions

Giuseppe Arbia[♦♣], *Michele Battisti*[♣] and *Gianfranco Di Vaio*[♣]

(Very preliminary draft: Do not quote without permission)

Abstract During the last decade a great bulk of empirical works have shown that spatial effects matter for regional growth and convergence in Europe. Spatial econometric models have substantially improved the standard growth regression approach. A drawback of those models, however, is the assumption that physical distance is the only determinant of the spatial weight matrix, which incorporates the topology of the system and which is necessary to implement the spatial econometrics techniques. In the present paper we try to go beyond such limitation, by adopting a matrix that also weights for legal and institutional distance. Within this framework, the expected impact on the growth rate of a region, stemming from the neighbouring ones, is likely higher (lower) if the specific regions share similar (different) conditions. Preliminary results suggest that the variables considered have the expected signs and the inclusion of both institutional controls and heterogeneous state-weights provides a higher convergence rate than the standard Mankiw, Romer and Weil (MRW) specification.

JEL Classifications: C21, O40, R11

Keywords: Regional Convergence, Growth and Institutions, Spatial Effects

[♦] Dipartimento delle Scienze Aziendali, Statistiche, Tecnologiche ed Ambientali, *University "G. d'Annunzio" of Chieti-Pescara* (IT).

[♣] Dipartimento di Scienze Economiche e Aziendali, *LUISS "Guido Carli" University*, Rome (IT).

Corresponding author: mbattisti@luiss.it

1. Introduction

The quantitative assessment of regional growth and convergence across Europe is an important issue, in light of the recent enlargements that transformed the Union from 15 to 27 member States. Particular concerns are expressed about the economic and institutional disparities between the new entrants and the former EU-15 countries. Some questions, consequently, arise: 1) will the poor regions catch up with the rich ones? 2) what is the impact on regional growth of sharing common institutions? These two questions are strictly linked, since regional convergence requires the mobility of products and factors, in response to differentials in the revenue of factors, and the institutions may affect this process at least in two ways. Firstly, they reduce the convenience to invest in countries with "risky" environment; secondly, in presence of legal and bureaucratic heterogeneities, the entrepreneurs might prefer to invest in homogeneous countries, in order to reduce the administrative burdens due to cross-countries operations.

A lot of empirical works have shown as spatial influence is a phenomenon that matters for regional growth. Thereby, spatial econometric models have been developed improving the standard cross-sectional approach, based on ordinary least squares estimation. However, such approach considers the physical distance among geographical units as the unique determinant of the spatial weight matrix, which incorporates the topology of the system and which is necessary to implement the spatial econometrics techniques. A consolidate body of research stressed, for instance, the relevance of institutions in explaining cross–country growth differences.

The nexus between growth and space by one side, and growth and institutions by the other one, has been developed by different branches of the economic theory. So far, however, institutional and spatial topics have been analyzed separately in the empirical literature, so that the interaction among space and institutions is not explicitly treated in regional studies. In this work we try to deal with the two aspects jointly. The remainder of the paper is organized as follows: in the second section we present some remarks about the role of the institutions in the growth theory literature, in the third one we highlight the most common spatial econometric models, with special attention to the question of the distance weight matrix, in the fourth one we describe the data and we present some descriptive statistics, in the fifth one we show the results of the paper and, in the sixth one, the conclusions follow.

2. Space, institutions and regional growth: a review of the empirical literature

During the last decade a bulk of empirical literature has shown that space matters for regional growth in Europe. Quah (1996), López-Bazo *et al.* (1999), and Le Gallo and Ertur (2003), among others, assessed that the distribution of regional income across Europe tends to be influenced by their physical location, due to geographical spillovers. The channels through which space influences the economic activity are basically of two types: i) the spatial dependence, usually defined in the weaker form of spatial autocorrelation, that is the tendency of economic variable to be functionally related across space; ii) the spatial heterogeneity, in the form of spatial regimes, that is the occurrence of changing functional relationship among the variables across space (Anselin, 1988).

The two concepts have been recently discussed in terms of relative and absolute location. The former concept refers to the effect for regions of being located closer or further away from other specific regions. Actually, theoretical reasons argue that human capital spillovers and technology diffusion influence the geographical interaction of regional economic structures. The latter one, instead, relates to the impact for regions of being located in a particular point in space, i.e. in a particular country, independently from their relative neighbouring regions. Institutions, policies and culture, for instance, may be varying across countries and impacting, at the same time, on regional growth (see Abreu *et al.*, 2005a).

Omitting those two relevant questions from empirical models of regional convergence, that employ spatially organized observations, produces several misspecification problems, as we will see in the next section. In the field of spatial econometrics, researchers have usually dealt with the spatial dependence imposing to the model a spatial weight matrix, that incorporates the topology of the economic system. The criterion on which this matrix is constructed is based on geographical measures, since geography is unambiguously considered exogenous to the model. The most common matrices adopted in empirical works on European regional convergence rely on physical distance functions (Badinger et al. 2004), or on a choice of *k*-neighbouring regions (Ertur and Koch, 2006). Both of those kind of matrices assume a distance threshold over which the spatial effects are considered negligible[1].

The problem of spatial heterogeneity, on the contrary, has been treated either in the spatial or the non-spatial literature. In the spatial literature, spatial regimes has been detected by means of exploratory spatial data analysis (ESDA), based on measures of spatial association indicators as the Moran's *I* statistic, and then the spatial instability of the parameters has been tested with specific econometric specification (Ertur *et al.*, 2006, Le Gallo and Dall'erba, 2006). In the non-spatial literature, the spatial heterogeneity has been usually controlled for inserting dummy variables in the model, in order to catch up the spatial heterogeneity due to country specific effects (Armstrong, 1995, Neven and Gouyette, 1995).

A consolidate body of research stressed, for instance, the relevance of institutions, in the form of protection of property rights or market regulation, to explain cross–country growth differences (Knack and Keefer, 1995, 1997). Recently, similar conclusions has been reached

[1] Contiguity matrices are not employed, since they would leave the islands unconnected from the continental regions.

by a work on the European regions (Tabellini, 2006). Institutional differences among countries or regions could influence the decisions of the firms, since operating in two different legislative environments does not lead to scale economies (Kox *et al*, 2005). In the empirical literature the nexus between space and growth has been usually analyzed in a separate manner, even if the two elements are found to be relevant in the explanation of regional growth. We propose here an approach that seeks to treat jointly the two aspects.

3. The econometric specification

The econometric specification is very simple and tries to catch the effects of either absolute or relative location. The former effect is modelled allowing for cross-countries heterogeneities, since national institutions affect the growth of regions belonging to different States. The latter, instead, is captured by a spatial term, that account for the impact on a specific region of the geographical spillovers stemming from the neighbouring ones. Furthermore, the two effects are treated jointly, since institutional and physical distances are weighted together in the same matrix.

We start with the standard growth regression, in the form of conditional β-convergence defined by Mankiw *et al*. (1992, henceforth MRW). Then we augment the specification with a spatial error model (henceforth SEM, see Arbia, 2006), that captures the relative location impact, and we insert State specific institutional variables in order to measure the absolute location effect. The equation this way defined, in cross-sectional notation, is given by

$$g_i = \alpha + \beta x_i + \gamma H_i + \tau I_i + \theta Z_i + \xi_i (\mathbf{I} - \lambda \mathbf{W})^{-1} \qquad (1)$$

where g_i is the annual growth rate of per capita GDP of region i, α is a constant, β is a convergence coefficient[2], x_i is the log of the starting level of per capita income, H_i is a measure of human capital investment, I_i is the investment rate, Z_i is a variable that measure the institutional quality, γ, τ and θ are slope parameters, ζ is an error term, **I** is the identity matrix, **W** is the spatial weight matrix, and λ is a spatial parameter.

We adopt here a row-standardized, distance-based, matrix, whose elements are

$$\begin{cases} w_{ij}(d) = 0 \text{ if } i = j \\ w_{ij}(d) = 1/d_{\mathrm{ij}}^2 \text{ if } d_{\mathrm{ij}} \le \overline{d} \\ w_{ij}(d) = 0 \text{ if } d_{\mathrm{ij}} > \overline{d} \end{cases}$$

where d_{ij} is the Euclidean distance between the centroids of regions i and j, and $\overline{d}$ is a critical distance cut-off, given by the threshold distance corresponding to the first quartile of the distances distribution[3].

To catch the space-heterogeneous effect we assume common State institutions so that, in equation (1), for each State k $Z_i = Z_j$ if i and $j \in k$, and $Z_i \neq Z_j$ otherwise. In addition to this, we combine geographical and institutional "distances" in the weight matrix $\mathbf{W}^S$, in order to detect the interplay of the two effects. Equation (1) then becomes

$$g_i = \alpha + \beta x_i + \gamma H_i + \tau I_i + \theta Z_i + \xi_i (\mathbf{I} - \lambda \mathbf{W}^s)^{-1} \tag{2}$$

---

[2] It measure the rate at which the regions are supposed to approach their steady-state value and it is expected to be negative.

[3] We obtain very close results with other specifications such as the first quintile, the mean dinstance and so on. A higher convergence rate is obtained with matrices containing less connectivities, i.e. minimum threshold.

where the non-zero elements of $\mathbf{W}^S$ are obtained squaring and inverting, for each couple of regions, the product of the physical distance by an index of institutional heterogeneity, p_{ij} , that supplies us a scale factor,

$$w_{ij}^{s}(d,p)=\frac{1}{(p_{ij}\cdot d_{ij})^{2}} \quad \text{if} \quad d_{ij}\prec \bar{d}$$

So w_{ij}^s can be thought as generated by an "institutionally weighted" gravity function. If regions i and j belong to the same country of a region m, the index takes on a same value, i.e. $p_{ij} = p_{im} = p_{jm}$, otherwise $p_{ij} \neq p_{im} = p_{jm}$. Basically, holding the distance fixed, greater the institutional heterogeneity is, lower the impact on regional growth becomes, and vice versa. Since the matrix is row-standardized, the impact on a specific region, propagating from the neighbouring ones, is globally the same, but this time that homogeneous regions generate a greater impact, with respect to the original distance-based specification.

When we choose $\mathbf{W}^S$, we adopt an intermediate solution between a "pure" distance based matrices, as **W** in equation (1), and "social or economic" distance matrices or block structure matrices, that considers neighbours the regions sharing a common institution, i.e. the same State (Anselin, 2002b).

4. Data presentation and descriptive statistics

Our set of institutional variables is given by

- ✓ PMR, Product Market Regulation differences (Kox *et al.*, 2005, from original OECD data, 2005);

- ✓ Linguistic distances[4] (Disdier and Mayer, 2006);
- ✓ CGI, World Bank Corporate Governance Indicator;
- ✓ ICGR, International Country Grade Risk (IRIS3 dataset).

The PMR variable consists of differences in product market regulation. The basic data are indices of regulation obtained through a principal components analysis of product market answers to questionnaires. It is composed by three sub–indices, that are State controls, barriers to entrepreneurship, and barriers to trade and investment (see, for details, Nicoletti *et al*, 2000 and Conway *et al*., 2005). The second variable is a measure of linguistic diversity and it is obtained by ethnological differences by families of languages. Synthetically, greater linguistic distances are thought to be an higher obstacle to trade among countries.

CGI data are quality institution indexes that account for the percentage of firms operating in a country that furnishes satisfactory ratings to questions regarding protection of minority shareholders, quality of training, willingness to delegate authority, nepotism and corporate governance (Kaufman *et al*, 2006). ICGR is an index[5] about the soundness of institutions and it is constructed with factors related to the environment for investors in a given country. Following Knack and Keefer (1995) we use a simple sum of five indicators out of six: quality of bureaucracy, corruption in government, rule of law, expropriation risk, and repudiation of contracts by government.

The first two variables are often utilized in empirical models that explain bilateral trade, so we use them as proxies for heterogeneity in the weighting structure of the spatial matrix. More specifically, product market regulation is built as an heterogeneity index, while the linguistic index is built on proximity, so we rescale the former as one minus the PMR index, for each country, so to have both measures comprised among 0 and 1. Then we use the

[4] We wish to thank Anne-Célia Disdier and Thierry Mayer that kindly supply the data.

[5] Ranging from 1982 to 1997.

inverse of these measures, that multiplied by the inverse of the geographical distance, makes the elements in question greater or equal to that of the spatial weight matrix.

CGI and ICGR, that in several works have been proved to be highly significant in cross-country growth regression, are employed as institutional variables in the right-hand side of the growth equation. The rationale is given by the fact that the first two variables represent "differences" between institutional environments, while the second ones account for "quality" of institutions, since they are scaled as institutional rankings.

We estimate several specifications equations (1) and (2) over the period 1991–2002. Among the institutional variables we utilize, only ICGR has data at the beginning of the sample, then we use an average index between 1991 and 1997. The first observation for CGI is in 1996, so we use an average 1996–2002[6], while for PMR there are two surveys, 1998 and 2003, and we adopt the first of them. Finally, linguistic distances by construction does not have a temporal dimension. As we told before, we employ national data, in order to capture an absolute location effect, given by the spatial cross-country heterogeneity. However, if we would consider a regional aggregation, we encountered serious difficulties in finding data.

The other variables used to estimate the growth regression are the average growth rate of per capita GDP 1991-2002, the level of per capita income in 1991, both of them at constant 1995 prices, and the investment rate, taken from the Cambridge Econometrics dataset. The proxy for human capital is the tertiary school enrolment in 1998, whose data source is ISCED/Eurostat. The observations in the sample are 232 NUTS-2 regions from the EU25[7] (see the Appendix 1 for the list of regions).

[6] We assume that institutions do not change frequently. For example, the mean percentage change in the ICGR sum of indicators, between 1984 and 1990, is less than 10% and the correlation is 94%, so that the ranking seems to be stable. If we would use institutions at the end of the period, we run into the classical problem of reverse causation between growth and institution (the so–called *Lipset* hypothesis).

[7] Some regions from the New Member States are missing due to lack of data.

Before to proceed with the econometric estimation, we describe some features of the variables used. Figures from 1 to 3 show the distribution by countries of CGI, ICGR at the beginning and at the end of the period, and the ranking of PMR, while linguistic distances do not exist in absolute values but are differences by construction. We want to remark that while CGI and ICGR are institutional quality indexes, the PMR describes only a different role of the State in the economy, this way being arbitrary to judge less intervention as synonymous of more quality.

The ranking of countries based upon the corporate governance index, CGI (Kaufmann *et al*, 2006), is shown in Figure 1, while a time perspective is given by the Figure 2[8]. The latter graph highlights the changes in institutional quality, given by the sum of 5 out of 6 indicators in the ICGR database, excluding the ethnic tension. The countries in the right part of the axis have the better institutions and the countries under the tendency line experienced positive changes during the period 1984–1997. The general trend has been positive: the right upper corner is occupied by Nordic and Central European States, and New Members States and Southern countries had a strong improvement.

Figure 3 tells a similar story. The more regulated countries are in the East and in the South of Europe, but the ranking is not completely the same of the preceding two, because some Central countries, like Germany and France, are close to the others. It is worth to note that in the period 1998–2003 there is a general reduction of the State control in all the national economies. Globally, the data depict a map of European countries as a set of at least three groups, Southern (or Latin), Eastern, and Northern (with these latter divided into Central and Nordic), pointing out a high degree of heterogeneity across States.

5. Estimation results

[8] These indicators rank the countries in a similar way. Simple correlations for 1996 are ranging from 0.8 to 0.9.

As first step we try to assess the relevance of the institutions and the spatial dependence starting with the standard growth regression of β-convergence, estimated by OLS (Table 1). We test the usual *absolute* β-convergence regression without control variables (first column), afterwards we insert the human capital proxy and the investment rate, extending the specification to the MRW framework, in order to estimate the *conditional* β-convergence (second column), and then we add the institutional controls (columns three and four) and check the spatial dependence of the regression residuals (bottom part of the table).

Basically, we observe that: 1) the insertion of the CGI or ICGR index explains more variance in the data (the adjusted R^2 is 0.27 in the CGI specification) and both of the variables are positive and statistically significant; 2) the Moran's I of the residual is always significant, except for the first column, meaning that the observations are spatially autocorrelated. Looking at the Lagrange multipliers tests (LM-err and LM-lag), the SEM specification is preferred to improve the reliability of the estimates (for a review of the tests see Anselin, 2005). In addition to this, we note that the convergence coefficient is negative and equal to about 1% in CGI the specification (with an half life of 65 years) and that it grows substantially inserting the governance indicators. The other variables are all positive and significant, with the human capital being significant after controlling for CGI or ICRG.

The second step is to estimate the SEM expressed in equations (1) and (2), extending the same weighting structure also to a spatial autoregressive model (SAR), defined as

$$g_i = \alpha + \beta x_i + \gamma H_i + \tau I_i + \theta Z_i + \rho W g_i + \xi_i \quad (3)$$

where ρ is the spatial parameter. It is worth to note that in the SEM the growth process has spatial externalities (given by the multiplicative term $\lambda\mathbf{W}$) associated by random shocks either of the specific region or of the neighbouring ones. The structure of equation (4), on the contrary, allows the process for having externalities (given by the multiplicative term $\rho\mathbf{W}$) associated to the variables explaining the process, on one side, and to random shocks deriving from either the specific region or the neighbouring ones, on the other[9].

Table 2 shows the results of the estimation of SEM and SAR expressed in equations (1) and (3). The spatial weight matrix **W** is based on a threshold distance, as we specified in section 3[10]. We consider both the models but, as we have already told, the SAR is not preferred looking at the spatial tests of Table 1 and by the Akaike Information Criterion. The first three columns give the results of the SAR, estimated by Maximum-likelihood. Once again, the inclusion of human capital and investment rates lower the rate of convergence, while the inclusion of the institutional controls increase it to around 0.7%. The SEM results are very close, except that the coefficients of human capital and investment are much more higher and the convergence coefficient is not statistically significant. The spatial term is in general higher significant and the R^2 of the MRW and the full specification (the last two columns) is 0.40.

So far, we have seen that considering space and institutions in the econometric specification furnish a better explanation of the process of regional growth and convergence in Europe. Now we implement the interaction between the two dimension, inserting in equation (1) and (3) the institutionally weighted spatial matrix $\mathbf{W}^s$, as shown in equation (2). As we saw before, the institutional weights are given by the product market regulation (PMR) index and the linguistic distances. Since these are completely different measures, using both of them may give some additional insights, even if the interpretation might be different.

9 For the interpretation of the spatial effects in the convergence process see Abreu *et al* (2005b) and Fingleton and Lòpez Bazo (2007).

10 We chose such specification to avoid unconnected islands.

Further, due to potential endogenous role of the product market regulation, we need to resort to a benchmark given by the linguistic distances, that are surely exogenous by construction[11].

Tables 3 and 4 contain the results for the spatial models using the institutionally weighted matrices as previously defined. Looking at the SAR we note that the convergence rate is lower while the coefficients of all the specification rest, more or less, on similar values. The spatial terms, on the contrary, are higher either in magnitude or significance. The global fit of the regression is not satisfactory, since the R^2 is slower. Finally, the SEM results depict a bit diversified situation. The convergence rate does not change so much, but the impact of the institutions is slightly higher, the coefficient on human capital decreases and investment's rates assume a higher impact. The spatial coefficients also become bigger and the R^2 sensibly improve.

6. Conclusions

In this work we tried to consider some of determinant factors in order to explain the process of growth and convergence across European regions. Two of the main features are the geographical location and institutional setting, that we analyzed moving from the standard β-convergence approach. Those variable have been inserted either separately, as control variables, or in an combined fashion, weighting through different schemes the distance matrix. This way allowed us to catch the spillovers effects on a specific region, induced by the neighbouring ones, and the State-heterogeneity impact, given by belonging to a specific

[11] For the Hungarian regions the linguistic similitude is equal to 0 for almost all the regions of the sample, due to the fact that its linguistic root is different by the Indo-European languages. Since we cannot divide the weight distance by 0, we fix the minimum similitude to 0.001, that equals one half of the lowest value of the other interaction.

country. A contagious shock in a neighbouring region of the same country, for instance, will be probably higher than that of a region of a State with different institutions.

Results indicate that in β-regressions for EU25 regions, over the period 1991-2002, the inclusion of governance indexes in a MRW specification rises the convergence rate of about one third (it ranges from around 0.7 to 1%), while spatial effects seem works in the opposite direction, lowering the rate of convergence. The use of different weight matrices to controls for relative distance due to heterogeneity in culture and regulation make higher the convergence rate and, at same time, augment the role of governance indexes. Finally, the weights that potentially could have an endogenous specification do not have an appreciable difference with respect the standard geographical distances.

References

Abreu M, De Groot HLF, Florax RJGM (2005a) Space and Growth: A survey of Empirical Evidence and Methods. *Région et Développement* 21: 13-44

Abreu M, De Groot HLF, Florax RJGM. (2005a) A Meta-Analysis of β-Convergence: the Legendary 2%. *Journal of Economic Surveys* 19: 389-420

Anselin L. (1988) *Spatial Econometrics: Methods and Models*. Kluwer: Dordrecht

Anselin L. (2002) Spatial Externalities, Spatial Multipliers and Spatial Econometrics. *International Regional Science Review* 26: 153-166

Anselin, L. (2005) *Exploring Spatial Data with GeoDa: A Workbook*. Center for Spatial Integrated Social Science, Santa Barbara, CA

Arbia G. (2006) *Spatial Econometrics. Statistical Foundations and Applications to Regional Convergence*. Springer: Berlin. Forthcoming.

Armstrong HW. (1995) Convergence among regions of the European Union, 1950-1990. *Papers in Regional Science* 74: 143-152

Badinger H, Müller WG, Tondl G. (2004) Regional Convergence in the European Union, 1985-1999: A Spatial Dynamic Panel Analysis. *Regional Studies* 38: 241-253

Conway P, Janod V, Nicoletti G. (2005) *Product Market Regulation in OECD Countries: 1998 to 2003*. OECD Economics Department Working Paper No. 419

Disdier AC, Mayer T. (2006) *Je t'aime, moi non plus: Bilateral Opinions and International Trade*. CEPII Working paper No. 01

Ertur C, Koch W. (2006) Regional Disparities in the European Union and the Enlargement Process: An Exploratory Spatial Data Analysis, 1995-2000. *Annals of Regional Science* 40, 723-765

Ertur C, Le Gallo J, Baumont C. (2006) The European Regional Convergence Process, 1980-1995: Do Spatial Regimes and Spatial Dependence Matter?. *International Regional Science Review* 29: 3-24

Fingleton B, Lòpez-Bazo E. (2007) Empirical Growth Models with Spatial Effects. *Papers in Regional Science* 85: 177-198

Knack S, Keefer P. (1995) Institutions and Economic Performance: Cross-Country Tests Using Alternative Institutional Measures. *Economics and Politics* 7: 207-227

Knack S, Keefer P. (1997) Does Social Capital Have an Economic Payoff? A Cross-Country Investigation. *Quarterly Journal of Economics* 112: 1251-1288

Kaufmann D, Kraay A. (2002) *Growth Without Governance*. World Bank Policy Research Working Paper No. 2928

Kaufmann D, Kraay A, Mastruzzi M. (2006) Governance Matters V: Governance Indicators for 1996–2005. *World Bank Economic Review*.

Kox HL, Lejour A, Montizaan R. (2004) *The free movement of services within the EU*. CPB Document No. 69, October

Le Gallo J, Dall'erba S. (2006) Evaluating the Temporal and Spatial Heterogeneity of the European Convergence Process, 1980-1999. *Journal of Regional Science* 46: 269-288

Le Gallo J, Ertur C. (2003) Exploratory Spatial Data Analysis of the Distribution of Regional Per Capita GDP in Europe, 1980-1995. *Papers in Regional Science* 82: 175-201

Le Sage J. (1999) The theory and practice of spatial econometrics, Department of Economics, University of Toledo

López-Bazo E, Vayá E, Mora AJ, Suriñach J. (1999) Regional Economic Dynamics and Convergence in the European Union. *Annals of Regional Science* 33: 343-370

Mankiw NG, Romer D, Weil DN. (1992) A contribution to the Empirics of Economic Growth. *Quarterly Journal of Economics* 107: 407-437

Neven D, Gouyette C. (1995) Regional Convergence in the European Community. *Journal of Common Market Studies* 33: 47-65

Nicoletti G, Scarpetta S, Boylaud O. (2000) *Summary indicators of product market regulation with an extension to employment protection legislation*. OECD Economic Department Working Papers No. 226

Nicoletti, G. (2001) Regulation in Services: OECD Patterns and Economic Implications. *OECD Economic Department Working Papers* no. 287

OECD (2003) *Quantifying the Benefits of Liberalising Trade in Services*

OECD. (2005) *Product Market Regulation in OECD Countries 1998 to 2003*.

Quah DT. (1996) Regional Convergence Clusters across Europe. *European Economic Review* 40: 951-958

Tabellini G. (2006) *Culture and Institutions: Economic Development in the Regions of Europe*. IGIER Working Paper. Bocconi University: Milan

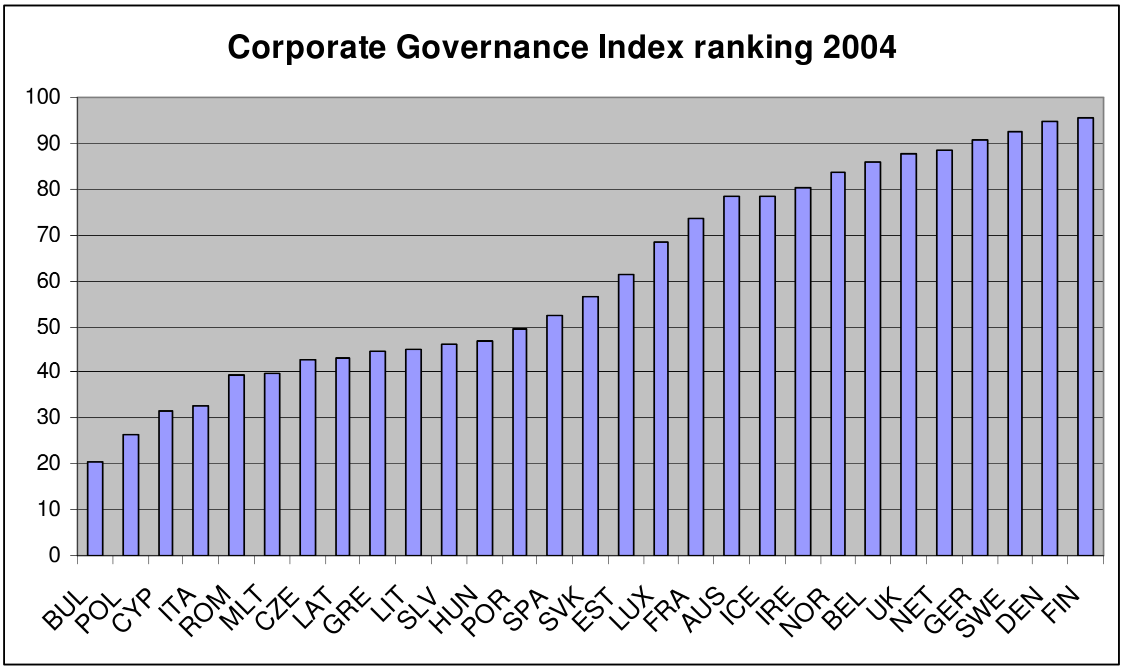
Appendix 1: List of regions

AT (9) 1. Burgenland 2. Niederösterreich 3. Wien 4. Kärnten 5. Steiermark 6. Oberösterreich 7. Salzburg 8. Tirol 9. Vorarlberg **BE (11)** 10. Région de Bruxelles-Capitale 11. Antwerpen 12. Limburg 13. Oost-Vlaanderen 14. Vlaams-Brabant 15. West-Vlaanderen 16. Brabant Wallon 17. Hainaut 18. Liège 19. Luxembourg 20. Namur **CZ (8)** 21. Praha 22. Stredni Cechy 23. Jihozapad 24. Severozapad 25. Severovychod 26. Jihovychod 27. Stredni Morava 28. Moravskoslezsko **DE (40)** 29. Stuttgart 30. Karlsruhe 31. Freiburg 32. Tübingen 33. Oberbayern 34. Niederbayern 35. Oberpfalz 36. Oberfranken 37. Mittelfranken 38. Unterfranken 39. Schwaben 40. Berlin 41. Brandenburg 42. Bremen 43. Hamburg 44. Darmstadt 45. Gießen 46. Kassel 47. Mecklenburg-Vorpommern 48. Braunschweig 49. Hannover 50. Lüneburg 51. Weser-Ems 52. Düsseldorf 53. Köln 54. Münster 55. Detmold 56. Arnsberg 57. Koblenz 58. Trier 59. Rheinhessen-Pfalz 60. Saarland 61. Chemnitz 62. Dresden 63. Leipzig 64. Dessau 65. Halle 66. Magdeburg 67. Schleswig-Holstein 68. Thüringen **DK (1)** 69. Danmark **ES (16)** 70. Galicia 71. Principado de Asturias 72. Cantabria 73. País Vasco 74. Comunidad Foral de Navarra 75. La Rioja 76. Aragón 77. Comunidad de Madrid 78. Castilla y León 79. Castilla-La Mancha 80. Extremadura 81. Cataluña 82. Comunidad Valenciana 83. Illes Balears 84. Andalucía 85. Región de Murcia **FI (4)** 86. Itä-Suomi 87. Etelä-Suomi 88. Länsi-Suomi 89. Pohjois-Suomi **FR (22)** 90. Île de France 91. Champagne-Ardenne 92. Picardie 93. Haute-Normandie 94. Centre 95. Basse-Normandie 96. Bourgogne 97. Nord - Pas-de-Calais 98. Lorraine 99. Alsace 100. Franche-Comté 101. Pays de la Loire 102. Bretagne 103. Poitou-Charentes 104. Aquitaine 105. Midi-Pyrénées 106. Limousin 107. Rhône-Alpes 108. Auvergne 109. Languedoc-Roussillon 110. Provence-Alpes-Côte d'Azur 111. Corse **GR (13)** 112. Anatoliki Makedonia, Thraki 113. Kentriki Makedonia 114. Dytiki Makedonia 115. Thessalia 116. Ipeiros 117. Ionia Nisia 1118. Dytiki Ellada 119. Sterea

Ellada 120. Peloponnisos 121. Attiki 122. Voreio Aigaio 123. Notio Aigaio 124. Kriti **HU (7)** 125. Kozep-Magyarorszag 126. Kozep-Dunantul 127. Nyugat-Dunantul 128. Del-Dunantul 129. Eszak-Magyarorszag 130. Eszak-Alfold 131. Del-Alfold **IE (2)** 132. Border, Midland and Western 133. Southern and Eastern **IT (20)** 134. Piemonte 135. Valle d'Aosta 136. Liguria 137. Lombardia 138. Trentino-Alto Adige 139. Veneto 140. Friuli-Venezia Giulia 141. Emilia-Romagna 142. Toscana 143. Umbria 144. Marche 145. Lazio 146. Abruzzo 147. Molise 148. Campania 149. Puglia 150. Basilicata 151. Calabria 152. Sicilia 153. Sardegna **LU (1)** 154. Luxembourg **NL (12)** 155. Groningen 156. Friesland 157. Drenthe 158. Overijssel 159. Gelderland 160. Flevoland 161. Utrecht 162. Noord-Holland 163. Zuid-Holland 164. Zeeland 165. Noord-Brabant 166. Limburg **PL (16)** 167. Dolnoslaskie 168. Kujawsko-Pomorskie 169. Lubelskie 170. Lubuskie 171. Lodzkie 172. Malopolskie 173. Mazowieckie 174. Opolskie 175. Podkarpackie 176. Podlaskie 177. Pomorskie 178. Slaskie 179. Swietokrzyskie 180. Warminsko-Mazurskie 181. Wielkopolskie 182. Zachodniopomorskie **PT (5)** 183. Norte 184. Algarve 185. Centro 186. Lisboa 187. Alentejo **SE (8)** 188. Stockholm 189. Östra Mellansverige 190. Sydsverige 191. Norra Mellansverige 192. Mellersta Norrland 193. Övre Norrland 194. Småland med öarna 195. Västsverige **UK (37)** 196. Tees Valley and Durham 197. Northumberland and Tyne and Wear 198. Cumbria 199. Cheshire 200. Greater Manchester 201. Lancashire 202. Merseyside 203. East Riding and North Lincolnshire 204. North Yorkshire 205. South Yorkshire 206. West Yorkshire 207. Derbyshire and Nottinghamshire 208. Leicestershire, Rutland and Northamptonshire 209. Lincolnshire 210. Herefordshire, Worcestershire and Warwickshire 211. Shropshire and Staffordshire 212. West Midlands 213. East Anglia 214. Bedfordshire and Hertfordshire 215. Essex 216. Inner London 217. Outer London 218. Berkshire, Buckinghamshire and Oxfordshire 219. Surrey, East and West Sussex 220. Hampshire and Isle of Wight 221. Kent 222. Gloucestershire, Wiltshire and North Somerset 223. Dorset and Somerset 224. Cornwall and Isles of Scilly 225. Devon 226. West Wales and The Valleys 227. East Wales 228. North Eastern Scotland 229. Eastern Scotland 230. South Western Scotland 231. Highlands and Islands 232. Northern Ireland

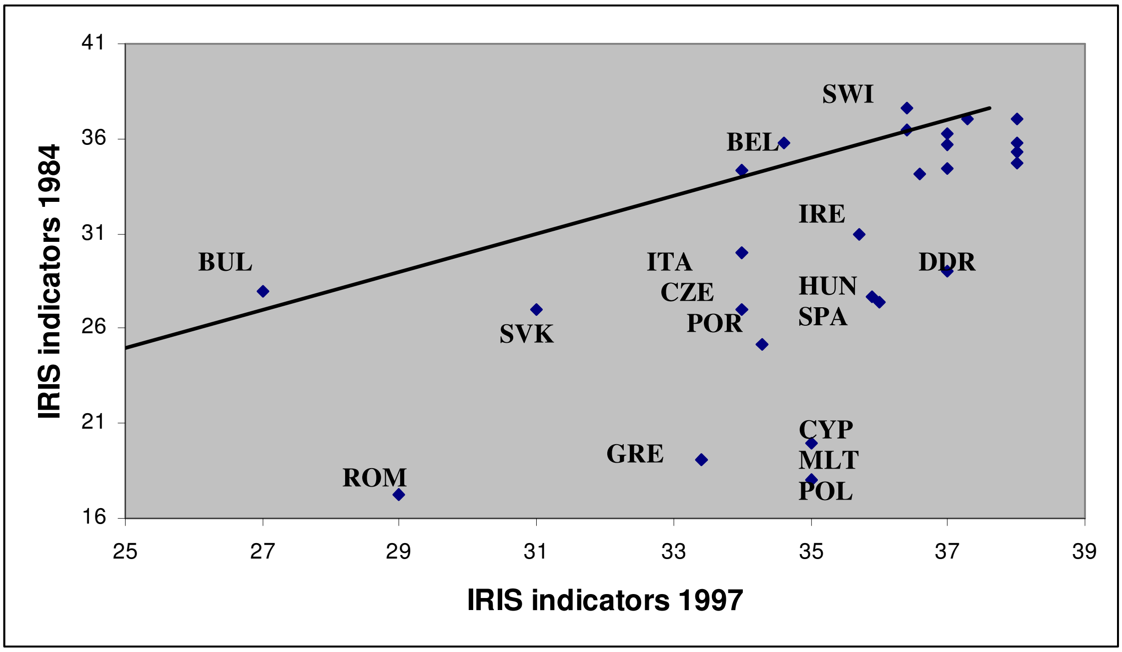
Appendix 2: Figures and Tables

Figure 1.



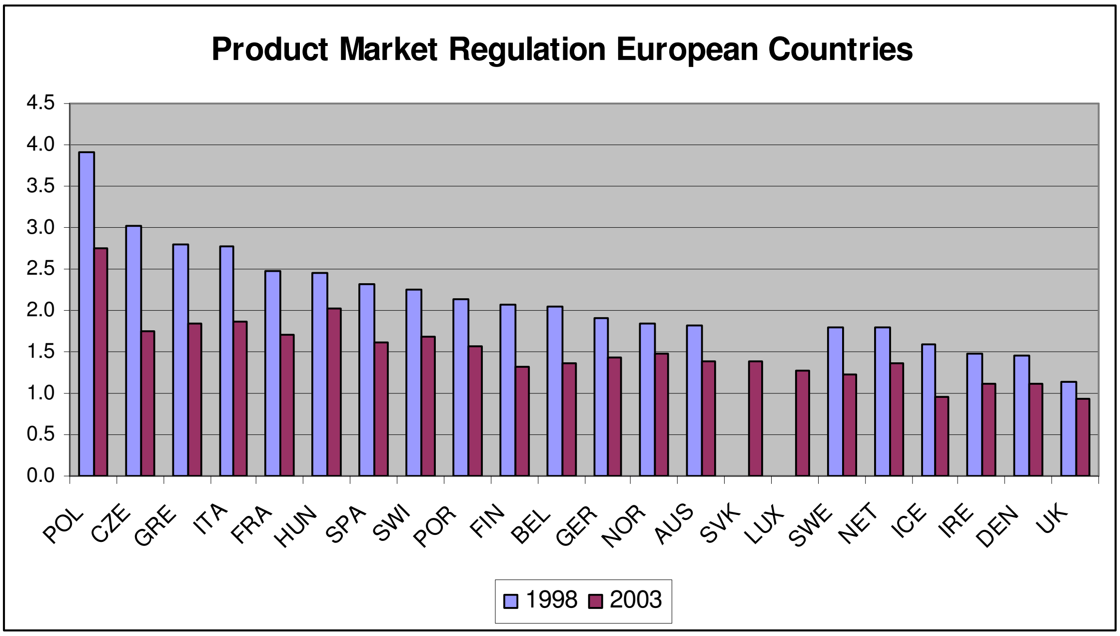
Source: see text.

Figure 2. Institutional quality changes, European countries, 1984-1997.



Source: see text.

Figure 3.



Source: see text.

Table 1 OLS results and spatial diagnostics

Dependant variable: Annual growth rate of per capita GDP, 1991-2002*					
Constant	0.089 (0.01)	0.056 (0.014)	0.018 (0.018)	0.078 (0.015)	0.094 (0.029)
GDP_91	-0.0075 (0.001)	-0.005 (0.001)	-0.008 (0.002)	-0.010 (0.002)	-0.010 (0.002)
Human capital		0.006 (0.005)	0.008 (0.005)	0.012 (0.005)	0.012 (0.005)
Investment rate		0.045 (0.012)	0.048 (0.011)	0.054 (0.011)	0.054 (0.011)
ICGR 91_97			0.178 (0.051)		-0.057 (0.09)
CGI 96_02				0.024 (0.005)	0.028 (0.009)
Half-life (years)	89	135	83	65	65
R^2 adj.	0.14	0.19	0.23	0.26	0.26
LM-lag (Prob.)	0.57 (0.45)	0.009 (0.93)	0.42 (0.52)	0.78 (0.38)	0.74 (0.39)
LM-err (Prob.)	0.0002 (0.99)	20.53 (0.000)	11.69 (0.001)	4.79 (0.03)	4.42 (0.03)
Moran's *I*-err (Prob.)	0.47 (0.64)	6.60 (0.000)	5.59 (0.000)	3.91 (0.000)	4.12 (0.000)

*Standard errors between brackets

Table 2 Spatial models results. ML estimates

Dependant variable: Annual growth rate of per capita GDP, 1991-2002*						
	SAR			**SEM**		
Constant	0.056 (4.29)	0.022 (1.60)	0.046 (3.16)	0.084 (5.45)	-0.017 (-0.87)	0.007 (0.33)
GDP_91	-0.005 (-3.81)	-0.003 (-2.08)	-0.007 (-4.34)	-0.007 (-4.30)	-0.0004 (-0.18)	-0.004 (-1.88)
Human Capital		0.008 (1.67)	0.012 (2.59)		0.033 (4.75)	0.032 (4.81)
Investment rate		0.042 (3.52)	0.050 (4.32)		0.108 (6.83)	0.099 (6.48)
CGI			0.020 (4.14)			0.019 (2.70)
ρ	0.461 (4.66)	0.449 (4.79)	0.375 (3.83)			
λ				0.456 (4.57)	0.731 (12.16)	0.666 (9.39)
Half-life (years)	135	227	95	95	1729	169
R^2 adj.**	0.13	0.09	0.20	0.22	0.40	0.40

*Asymptotic t – stats between brackets
** This statistics is a pseudo R^2 (computation done with Matlab, Econometric toolbox by James Le Sage).

Table 3 SAR results. ML estimates

Dependant variable: Annual growth rate of per capita GDP, 1991-2002*						
Weight of $\mathbf{W}^s$	**PMR**			**Linguistic differences**		
Constant	0.046 (3.78)	0.014 (1.05)	0.036 (2.53)	0.048 (3.88)	0.014 (1.03)	0.036 (2.57)
GDP_91	-0.004 (-3.28)	-0.002 (-1.52)	-0.006 (-3.74)	-0.004 (-3.32)	-0.002 (-1.49)	-0.006 (-3.74)
Human Capital		0.007 (1.61)	0.012 (2.47)		0.008 (1.69)	0.012 (2.51)
Investment rate		0.040 (3.48)	0.047 (4.21)		0.041 (3.61)	0.048 (4.34)
CGI			0.019 (3.87)			0.019 (3.89)
ρ	0.529 (6.43)	0.528 (6.76)	0.467 (5.76)	0.483 (6.11)	0.500 (6.50)	0.434 (5.64)
Half life (years)	169	343	112	169	343	112
R^2 adj.**	0.12	0.04	0.16	0.11	0.05	0.16

*Asymptotic t – stats between brackets
** This statistics is a pseudo R^2 (computation done with Matlab, Econometric toolbox by James Le Sage).

Table 4 SEM results. ML estimates

Dependant variable: Annual growth rate of per capita GDP, 1991-2002*						
Weight of $\mathbf{W}^s$	**PMR**			**Linguistic differences**		
Constant	0.086 (4.86)	-0.014 (-0.62)	0.007 (0.31)	0.093 (5.12)	-0.001 (-0.04)	0.017 (0.76)
GDP_91	-0.007 (-3.87)	-0.001 (-0.32)	-0.0043 (-1.84)	-0.008 (-4.15)	-0.002 (-0.78)	-0.0055 (-2.29)
Human capital		0.029 (3.75)	0.029 (4.00)		0.025 (3.12)	0.027 (3.61)
Investment rate		0.107 (6.70)	0.99 (6.45)		0.105 (6.63)	0.098 (6.48)
CGI			0.022 (2.70)			0.025 (2.91)
λ	0.553 (7.09)	0.720 (13.11)	0.659 (10.30)	0.523 (7.17)	0.677 (12.61)	0.601 (9.76)
Half-life (years)	95	689	157	83	343	122
R^2 adj.**	0.29	0.44	0.44	0.29	0.44	0.44

*Asymptotic t – stats between brackets
** This statistics is a pseudo R^2 (computation done with Matlab, Econometric toolbox by James Le Sage).