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Abstract. Questions of convergence have received increasing attention in recent years, in light of the pressure for greater integration and enlargement of the European Union [EU] to countries in Central and Eastern Europe [CEE]. This paper looks at the evidence for convergence of per capita income between regions in Europe in the second half of the 1990s, when economic recovery in CEE gathered pace. The analysis is based on the simplest of the models, the unconditional *ß*-convergence model and shows that the classical test methodology is ill-designed due to two reasons. First, it cannot identify groupings of regional economies that are converging. Second, it neglects spatial effects that represent interregional interactions and spatial spillovers. The paper suggests a much richer and theoretically more satisfactory approach that is in line with both the notions of club convergence and spatial dependence, and reflects recent developments in spatial econometrics. The two-club spatial error convergence model with groupwise heteroskedasticity is found to be most appropriate for the data at hand. Two empirical key findings are worthwhile to note. The first is that the data provide much support for unconditional *ß*-convergence in Europe. The second is that the usual convergence conclusions hold. But they do so for reasons that are not revealed by the classical test equation that is typical in mainstream economics literature.

JEL Classification: C21, O52, R11, R15
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1 Introduction

At the beginning of the century, questions of convergence have become a matter of increasing concern for policy makers in Europe, not only within the EU-15, but also in the accession countries in Central and Eastern Europe. Measuring the extent to which convergence exists is far from straightforward due to several reasons. First, there are measurement problems. In particular, there is a lack of reliable GDP figures for CEE regions. This comes partly from the change in accounting conventions now used in CEE economies. More important, even if reliable estimates of the change in the volume of output produced did exist, these would be impossible to interpret meaningfully because of the fundamental change of production, from a centrally planned to a market economy system. As a consequence, figures for gross regional product [GRP] are difficult to compare between CEE and EU regions until the mid 1990s (European Commission 1999).

Second, there does not exist a consensus methodological framework to guide empirical work on testing for regional convergence. Instead, several distinct types of convergence have been suggested in the literature, each implying different test equations. Broadly considered, empirical tests fall into three categories. The first and dominating type of test studies analyses the cross-section correlation between per capita output levels and subsequent growth rates for countries or regions. A negative correlation is taken as evidence of convergence as it implies that – on average – economies with low per capita initial incomes are growing faster than those with higher initial per capita incomes. This form of convergence has been termed *ß-convergence*.

The second type of test studies investigates whether the cross-section variance of per capita output levels tends to decrease over time. This form of convergence has been called *σ-convergence*. It is important to recognise that the existence of *ß*-convergence is a necessary, but not sufficient condition for *σ*-convergence (see Bernard and Durlauf 1996, Quah 1996). The third type of tests focuses attention on the long-run behaviour of differences in per capita output across economies. These tests interpret convergence to mean that these differences are transitory in the sense that long-run forecasts of the difference between any pair of economies converge to zero as the forecast horizon grows. Convergence in this sense is called *time series forecast convergence* (Bernard and Durlauf 1996).

Contemporary expectations of catch-up in Europe largely rest on the implicit acceptance of models of *ß*-convergence. This motivates to analyse whether regional economies exhibit *ß*-convergence and if so to estimate the time needed to attain equilibrium. The study considers the behaviour of output differences across 256 regions embracing all the EU-15 countries and the CEE accession countries[1]. The study refers to the time interval

[1] Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia and Slovenia.

1995-2000 and equates convergence with the tendency to narrow. Output is measured in terms of per capita GRP. While the study shares ideas with much convergence analysis in mainstream economics[2], it differs from most studies in two major aspects. *First*, it adopts a spatial econometric perspective to allow for spatial interactions and spillovers between regions and, thus, goes beyond the neoclassical diminishing returns to capital convergence mechanism. *Second*, it relaxes the implicit assumption of a single steady-state growth path which seems out of tune with the reality of empirical dynamics (see Quah 1993). Instead the study allows groupings of regional economies [so-called convergence clubs in the sense of Baumol 1986] to form so that regional economies within a group interact more with each other than with those outside.

The rest of the paper is structured as follows. It is natural to start in Section 2 with a definition of the notion of convergence and a brief outline of the test methodology for classical cross-section β-convergence analysis. We call the methodology classical because it was the first in the literature, uses conventional techniques of classical econometrics only and is widely spread in mainstream economics. Regions are considered as isolated entities, as if their geographical location and potential in the regional linkages would not matter. Section 3 extends the classical test methodology to escape the criticism of assuming independently distributed observational units and to more fully treating spatial effects in convergence processes. Section 4 continues to describe the data and the empirical procedure suggested for identifying clubs of regional economies from a spatial econometric perspective. Section 5 presents the estimation results of the spatial econometric models in comparison to those of the classical models of unconditional β-convergence. We conclude the paper with a brief summary and some further thoughts.

2 Convergence and Cross-Section Tests

The cross-section approach to convergence analysis considers the behaviour of the output differences between regional economies over a fixed time interval and equates convergence with the tendency of the difference to narrow. Following Bernard and Durlauf (1996) we say regional economies j and j' converge over the time period $(t, t+\tau)$ if the (log) per capita output disparity at t is expected to decrease in value.

Let y_{jt} denote the log per capita gross-regional product [GRP] of region j at t and $\mathcal{F}_t$ all information available at this time then convergence between a pair of regional economies (j, j') can be defined as follows: If $y_{jt} > y_{j't}$ then

$$E\left[y_{jt+\tau} - y_{j't+\tau} \,|\, F_t \right] < y_{jt} - y_{j't} . \qquad (1)$$

[2] Recent surveys of the literature can be found in Durlauf and Quah (1999), Temple (1999) and Fingleton (2003).

This definition can easily be extended to convergence between a set of N regional economies by requiring that every pair (j, j') within the set exhibits convergence. It is worthwhile to note that in the context of the current paper the conditional expectation is taken with respect to the linear space generated by current and lagged regional income differences rather than in a general $\mathfrak{F}_t$ sense. Therefore the definition is equivalent to require that y_{jt} - $y_{j't}$ is a linearly regular process.

Classical convergence tests, used by Baumol (1986), Barro (1991), Barro and Sala-i-Martin (1991, 1992) and many others, investigate on the basis of the above definition how an economy's average income growth co-moves with initial income. Defining the average growth rate

$$g_{j\tau} = \tfrac{1}{\tau}\left(y_{jt+\tau} - y_{jt}\right) \tag{2}$$

for a set of N regional economies then the basic test used has the following form[3]

$$g_{j\tau} = \alpha + \beta y_{jt} + \varepsilon_{j\tau} \tag{3}$$

for j=1, …, N, where τ is a fixed time horizon and $E[\varepsilon_{j\tau} \mid F_t]=0$, y is the variable [log per capita GRP] being tested for convergence, ε a white noise error term, and α and β parameters to be estimated. Empirical work using Equation (3) as testing framework has equated convergence with a negative estimate of β, treating $\beta \geq 0$ as the no convergence null hypothesis.

By drawing on reasoning given by Bernard and Durlauf (1996) the requirement may be written as a constraint on the mean of output differences between two time series. Observing that

$$g_{j\tau} = \tfrac{1}{\tau}\sum_{t=1}^{\tau} \Delta y_{jt} \tag{4}$$

where $\Delta y_{jt} = y_{jt+1} - y_{jt}$ then Equation (3) implies that

[3] In some formulations of cross-section convergence tests, Equation (3) is modified to include a set variables allowing for differences in steady-states and asymmetric shocks (see, just to cite a few examples, Barro, and Sala-i-Martin 1991, 1992 and 1995, Sala-i-Martin 1996): $g_{j\tau} = \alpha + \beta y_{jt} + \prod \boldsymbol{x}_{jt} + \varepsilon_{j\tau}$, where $\boldsymbol{x}_{jt}$ is a vector of variables that holds the steady-state of regional economy j constant. A negative β means then that convergence holds conditional on a set of exogenous variables such as savings and population growth for region j (*conditional ß-convergence*). While potentially important in practice, for the discussion in this paper the differences between conditional and unconditional convergence do add neither conceptual insights nor difficulties in modelling the spatial dimension of the convergence process. Thus, we will not consider conditional convergence further in this paper.

$$\tfrac{1}{\tau}\sum_{t=1}^{\tau}\Delta y_{jt} - \tfrac{1}{\tau}\sum_{t=1}^{\tau}\Delta y_{j't} = \beta\left(y_{jt} - y_{j't}\right) + \varepsilon_{jt} - \varepsilon_{j't}. \tag{5}$$

If $y_{jt} - y_{j't}$ is positive, then the requirement that β is negative implies that the expected value of the left hand side of Equation (5) is negative. From the perspective of bivariate comparisons, the cross-section β-test, thus, analyses whether the average change in per capita GRP of an initially poorer region exceeds that of an initially richer one (Bernard and Durlauf 1996). Recall that the ordinary least squares estimator $\hat{\beta}$ can be written as

$$\hat{\beta} = \sum_{j=1}^{N} \varphi_j \theta_j \tag{6}$$

where

$$\varphi_j = \left(y_{jt} - \overline{y_{jt}}\right)^2 \Big/ \sum_{j=1}^{N}\left(y_{jt} - \overline{y_{jt}}\right)^2 \tag{7}$$

$$\theta_j = \left(g_{j\tau} - \overline{g_{j\tau}}\right) \Big/ \left(y_{jt} - \overline{y_{jt}}\right) \tag{8}$$

with

$$\overline{y_{jt}} = \tfrac{1}{N}\sum_{j=1}^{N} y_{jt} \tag{9}$$

$$\overline{g_{j\tau}} = \tfrac{1}{N}\sum_{j=1}^{N} g_{j\tau} \tag{10}$$

then it is evident that $\hat{\beta}$ equals a weighted average of the ratio of differences of growth rates from the sample means to differences of initial incomes from the sample mean. Thus, cross-section tests require that a weighted average of regional economies with above average initial incomes grow at a slower rate than the mean growth of the cross-section. In equating convergence with the neoclassical growth model, the testable restriction of the model as analysed in cross-section tests implies that the first moments of the stochastic processes governing growth rates differ for initially rich and poor economies (Bernard and Durlauf 1996).

Suppose that the estimate of β is negative. Since $\hat{\beta}$ is a weighted average of θ_j's [see Equations (6)-(10)], a negative estimate means that the output differences between some pairs of regional economies have declined over the sample. Thus, for F_t consisting exclusively of a constant, some pairs of regions are converging in the sense of the above convergence definition. But, the cross-section test defined by Equation (3) cannot identify groupings of regions that are converging.

In equating convergence with the neoclassical growth model[4] with its diminishing returns to capital convergence mechanism (see Barro and Sala-i-Martin 1992, Mankiw, Romer and Weil 1992 among others), the constant term, α, in Equation (3) can be interpreted as an equilibrium rate of income growth, and β is related to the rate of convergence (say, β^*) to a region's steady-state, a measure of how fast regions attain their long-run equilibrium path:

$$\beta = -\tfrac{1}{\tau}\left[1 - \exp(-\beta^{*}\tau)\right]. \tag{11}$$

Estimating Equation (3) jointly with Equation (11) constitutes the *canonical β-convergence analysis* in a neoclassical world[5].

The existence of the equilibrium in a neoclassical world is due to the assumption that there are diminishing returns to capital determined by the capital share coefficient in the Cobb-Douglas production function. Whether or not convergence happens is a matter of assumptions on the form of the production function and not of interactions across economies (Durlauf and Quah 1999). Canonical β-convergence analysis does not take into account other equilibrating mechanisms such as capital flows, labour migration or technological spillovers across regional economies. Regions are treated as 'isolated islands' (Quah 1993, Martin 2001, Rey 2001 among others).

3 A Spatial Econometric Approach to Convergence Analysis

A key limitation of the majority of empirical analyses of cross-sectional regional growth has been that the assumption of a single steady-state has to hold for all regional

[4] Barro and Sala-i-Martin (1992) have shown that the growth regression Equation (3) may be derived – as a log-linear approximation – from the transition path of the neoclassical growth model for closed economics. Many studies of convergence empirics share this neoclassical underpinning. The assumption of diminishing returns that drives the neoclassical convergence process is one that is particularly questionable for regional economies. But there are solid empirical reasons why it makes sense to fit growth regression models in which there is a significant convergence process even if the reasons for this convergence may be debated.

[5] Instead of estimating Equation (3) and using Equation (11) to compute the speed, β^*, one can estimate a non-linear least squares [NLS] relation directly.

economies in the sample (Durlauf 2001). If regional economies, for example, differ in their basic growth parameters (such as technological innovativeness, human capital development, etc.), or knowledge spillovers between them are weak, they may not converge to a common per capita income, but instead to different economic-specific equilibrium levels of per capita income. Different regional economies may be converging to different long-run growth rates, just because of different initial conditions. Under such circumstances there might be convergence among similar types of economies (club convergence), but little or no convergence between such clubs (Martin 2001).

This motivates to adopt a framework that enables testing for club convergence. We allow 'natural groupings' of regional economies to form, in the sense that regional economies within a group interact more with each other than with those outside. Club identification in this study is performed with the help of exploratory spatial data analysis [ESDA] focusing on the explanatory variable that defines the initial conditions of the convergence process. This technique is a convenient way of detecting spatial regimes in the data (for more details see Section 4). The virtue of the procedure lies in its ability to uncover spatial effects and spillovers among regional economies on the basis of initial incomes.

The discussion that follows will be easier to understand if one keeps in mind that the basic test equation, the *classical (unconditional) convergence model*, can be reformulated in matrix form as

$$\boldsymbol{g} = \boldsymbol{Y}\boldsymbol{\gamma} + \boldsymbol{\varepsilon} \tag{12}$$

where $\boldsymbol{g}$ is a (N, 1)-vector of observations on the dependent variable [average log of per capita GRP growth rates] for the N regions. The (2, 1)-vector $\boldsymbol{\gamma}$ consists of two components: α and β in the notation of Equation (3). The second component is the coefficient of the explanatory variable: log of initial per capita GRP. The coefficient α is a constant term and can be interpreted as the coefficient of an exogenous (explanatory) variable which takes the unit value for each of the N observations. Thus, $\boldsymbol{Y}$ is a (N, 2)-matrix of observations on the two exogenous variables. $\boldsymbol{\varepsilon}$ is a (N, 1)-vector of random disturbance terms. For the data-generating process it is assumed that the elements of the random vector $\boldsymbol{\varepsilon}$ are identically and independently distributed (i.i.d.). Thus, the error variance-covariance matrix is $E[\boldsymbol{\varepsilon}\,\boldsymbol{\varepsilon}']=\sigma^2 I_N$, where the scalar is σ^2 unknown, I_N a Nth-order identity matrix and $\boldsymbol{\varepsilon}'$ denotes the transpose of $\boldsymbol{\varepsilon}$. The parameter $\boldsymbol{\gamma}$ can be estimated by means of ordinary least squares [OLS].

It is straightforward to adopt this standard cross-section growth regression framework to account for club convergence. For matter of representation let us consider two clubs only, indicated by the indices A and B. These clubs correspond to subsets of the observations for which the regression model follows a different set of coefficients. Each club may be represented by a different cross-sectional equation. Then the *two-club growth regression model* can formally be expressed as

$$\begin{bmatrix} \boldsymbol{g}_A \\ \boldsymbol{g}_B \end{bmatrix} = \begin{bmatrix} \boldsymbol{Y}_A & 0 \\ 0 & \boldsymbol{Y}_B \end{bmatrix} \begin{bmatrix} \boldsymbol{\gamma}_A \\ \boldsymbol{\gamma}_B \end{bmatrix} + \begin{bmatrix} \boldsymbol{\varepsilon}_A \\ \boldsymbol{\varepsilon}_B \end{bmatrix} \tag{13}$$

where $\boldsymbol{g}_A$ and $\boldsymbol{g}_B$ are the dependent variables; $\boldsymbol{Y}_A$ and $\boldsymbol{Y}_B$ the explanatory variables; $\boldsymbol{\gamma}_A$ and $\boldsymbol{\gamma}_B$ the coefficients; and $\boldsymbol{\varepsilon}_A$ and $\boldsymbol{\varepsilon}_B$ the errors in the respective clubs A and B of regions. Let N_A and N_B denote the number of observations in club A and club B, respectively. Then $N=N_A+N_B$.

The simple block structure of the two-club model (13) can be expressed more succinctly in one equation

$$\boldsymbol{g}^* = \boldsymbol{Y}^* \boldsymbol{\gamma}^* + \boldsymbol{\varepsilon}^* \tag{14}$$

where the boldface variables without subscript refer to combined variable, coefficient and error matrices.

Since the full set of elements of the error variance matrix $\boldsymbol{\Psi}=E[\boldsymbol{\varepsilon}^* \ \boldsymbol{\varepsilon}^{*\prime}]$ is generally unknown and cannot be estimated from the data due to a lack of degrees of freedom, it is necessary to impose a simplifying structure. The most straightforward assumption is a model with a constant error variance over the whole set of observations:

$$\boldsymbol{\Psi} = \sigma^2 \boldsymbol{I}_N \tag{15}$$

where σ^2 is the constant error variance. This specification leads to the so-called *classical two-club convergence model* that conforms to the standard assumptions of the classical test methodology.

But this assumption may be overly restrictive. Assuming an error variance that is different in each of the clubs of regions results in a special form of heteroskedasticity

$$\boldsymbol{\Psi} = \begin{bmatrix} \sigma_A^2 \boldsymbol{I}_A & 0 \\ 0 & \sigma_B^2 \boldsymbol{I}_B \end{bmatrix} \tag{16}$$

where σ_A^2 and σ_B^2 denote the club-specific constant error variances, $\boldsymbol{I}_A$ and $\boldsymbol{I}_B$ are identity matrices of dimensions N_A and N_B. This specification results into the *two-club growth regression model with groupwise heteroskedasticity*. Estimation and testing can be carried out by means of fairly straightforward iterative techniques [so-called estimated GLS] or in a maximum likelihood framework (Anselin 1990).

In both cases, the *homoskedastic version* and the *heteroskedastic version* of the *two-club convergence model*, spatial error dependence[6] is likely to be a problem. It can arise due to several reasons. *First*, if there is a lack of independence between the observational units. *Second*, spatial error dependence may reflect important aspects of phenomena such as capital flows, labour migration or technological spillovers in the regional growth process. *Third*, spatial dependence can also arise from a variety of measurement problems, such as boundary mismatching between the administrative boundaries used to organise the data series and the actual boundaries of the economic processes believed to generate regional convergence or divergence. *Finally*, it should be noted that any parsimonious regression model, in particular the club-specific version of the canonical equation of *ß*-convergence leaves out many factors that would – from the perspective of economic theory – be likely to affect the parameter of the initial income. When there are omitted variables that are spatially autocorrelated, regression analysis will produce spatially dependent residuals, given that the omitted variables are relevant and the dependent variable is itself spatially autocorrelated.

When spatial dependence is present in the error term, the above two-club convergence models are misspecified. Spatial autocorrelation may be modelled by specifying a spatial process for the disturbance terms $\boldsymbol{\varepsilon}^*$. Different spatial processes lead to different error covariances, with varying implications about the range and extent of spatial interaction and spillovers in the model. The most common specification is a spatial autoregressive [SAR] process in the error terms $\boldsymbol{\varepsilon}^*$:

$$\boldsymbol{\varepsilon}^* = \rho \boldsymbol{W} \boldsymbol{\varepsilon}^* + \boldsymbol{\mu} \qquad (17)$$

where $\boldsymbol{W}$ is the spatial weights matrix[7] of dimension N by N, ρ is a scalar spatial autoregressive coefficient for the spatial error lag $\boldsymbol{W\varepsilon}^*$, and μ is a vector of i.i.d errors with variance σ_μ^2. The combination of Equation (14) and Equation (17) makes up the *two-club spatial error convergence model*. The resulting error covariance will be non-spherical. Thus, ordinary least squares estimation of this model would yield unbiased estimates for the convergence parameter *ß*, but a biased estimate of the parameter's variance. Therefore, inferences about the convergence process have to be based on the model estimated via maximum likelihood [ML] or general methods of moments [GMM].

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6 Spatial error dependence is the situation where the error term at each region is correlated with values for the error term at other regions. We use the terms spatial dependence and spatial autocorrelation interchangeable in this paper.

7 The spatial weights matrix consists of positive elements for pairs of locations (i, j), with $w_{ij} \neq 0$ for 'neighbours' and $w_{ij} = 0$ for others. By convention, the diagonal elements w_{ii} are set to zero. For an extensive discussion see Anselin (1988). In practice, the derivation of spatial weights from the location and spatial arrangements of observation is carried out by means of a geographic information system.

As is well-known in spatial econometrics Equation (17) can be rewritten as

$$\boldsymbol{\varepsilon}^* = \boldsymbol{A}^{-1}\,\boldsymbol{\mu} \tag{18}$$

with

$$\boldsymbol{A} = \left(\boldsymbol{I}_N - \rho\,\boldsymbol{W}\right). \tag{19}$$

Depending on the structure of the error variance in club *A* and club *B*, two model forms of two-club growth regression may be distinguished. In the first, the *homoskedastic error case*:

$$E\left[\boldsymbol{\mu}\;\boldsymbol{\mu}'\right] = \sigma_{\mu}^{2}\,\boldsymbol{I}_N \tag{20}$$

and the overall variance-covariance matrix takes the form

$$\boldsymbol{\Psi} = \sigma_{\mu}^{2}\left(\boldsymbol{A}'\boldsymbol{A}\right)^{-1}. \tag{21}$$

If the spatial structure is not constant across the geography, heteroskedasticity may result, even though the initial process (17) is *not* heteroskedastic. In this case, the heteroskedastic error case, it is reasonable to assume that the two clubs have different error variances $\left(\text{var}\left[\boldsymbol{\mu}_A\right] = \sigma_{\mu_A}^{2} \neq \sigma_{\mu_B}^{2} = \text{var}\left[\boldsymbol{\mu}_B\right]\right)$. Then the covariance matrix for the μ-terms becomes

$$E\left[\boldsymbol{\mu}\;\boldsymbol{\mu}'\right] = \boldsymbol{\Omega} = \begin{bmatrix} \sigma_{\mu_A}^{2}\,\boldsymbol{I}_A & 0 \\ 0 & \sigma_{\mu_B}^{2}\,\boldsymbol{I}_B \end{bmatrix}. \tag{22}$$

4 Data, Spatial Weights Matrix and Spatial Clubs

The data on real per capita GRP used in this study are cross-section data in logarithmic form. They are based on the European System of Accounts. The growth rate is observed as an average over 1995 to 2000 rather than at a point of time. Data availability constrains the analysis to the NUTS-2 level[8]. NUTS-2 regions are formal (that is,

[8] The European Commission uses NUTS regions as targets for the convergence process and has defined NUTS-2 as the spatial level at which to measure convergence or divergence.

administrative or political) rather than functional spatial units which represent the boundaries of economic processes believed to generate regional convergence or divergence.

Our sample includes 256 NUTS-2 regions across 25 countries in Europe:

- The member states of the European Union: Austria [9 regions], Belgium [11 regions], Denmark [1 region], Finland [6 regions], France [22 regions], Germany [40 regions], Greece [13 regions], Ireland [2 regions], Italy [20 regions], Luxembourg [1 region], The Netherlands [12 regions], Portugal [5 regions], Spain [16 regions], Sweden [8 regions], and UK [37 regions]; and

- the accession countries in CEE: Bulgaria [6 regions], The Czech Republic [8 regions], Estonia [1 region], Hungary [7 regions], Latvia [1 region], Lithuania [1 region], Poland [16 regions], Romania [8 regions], The Slovak Republic [4 regions], and Slovenia [1 region].

Spatial Weights Matrix

A spatial weights matrix is a N by N positive and symmetric matrix $\boldsymbol{W}$ which expresses for each observation (row) those regions (columns) that belong to its neighbourhood set as non-zero elements. The specification of which elements are non-zero is a matter of considerable arbitrariness. We use the traditional approach that is based on the geography of the observations, designating regions as 'neighbours' when they are within a given distance of each other, i.e. $w_{ij}=1$ for $d_{ij} \le \delta$ and $i \ne j$, where d_{ij} is the great circle distance between the capital cities of region i and j, and δ is a distance cut-off value [distance-based contiguity]. The spatial weights matrix $\boldsymbol{W}^*$ is, thus, defined by the following equation

$$w_{ij}^* = \begin{cases} 0 & \text{if } \; i = j \\ 1 & \text{if } \; d_{ij} \le \delta \text{ for } i \ne j \\ 0 & \text{if } \; d_{ij} > \delta \text{ for } i \ne j. \end{cases} \tag{23}$$

For ease of interpretation, the matrix is standardized so that the elements of a row sum to one. Therefore, the elements of the row-standardized spatial weights matrix $\boldsymbol{W}$ equal to

$$w_{ij} = \frac{w_{ij}^*}{\sum_{j=1}^{N} w_{ij}^*} \qquad i, j = 1, \ldots, N. \tag{24}$$

This ensures that all weights are zero or one. δ, the critical cut-off value[9], is chosen as 350 km on the basis of exploratory analysis and theoretical considerations.

Spatial Clubs

Economic theory does not provide guidance as to either the number of clubs or the way in which the explanatory variable defining the initial conditions determines clubs (Durlauf and Johnson 1995). Thus, it is reasonable to allow patterns of cross-section interaction – clustering together in convergence clubs – to endogenously emerge. A convergence club is a group of regional economies that interact more with each other than with those outside and that exhibit initial conditions which are near enough to converge towards the same long-run equilibrium. We use the Getis-Ord statistic G_{it}^{*}, a measure of spatial clustering, to determine clubs of regions on the basis of spatial association in per capita GRP 1995 where spatial association reflects spatial externalities among regions j within a distance δ of region i. The statistic allows to identify spatial regimes in the data by use of the concept called proximal space (Getis and Ord 1992, Ord and Getis 1995) and is formally defined as

$$G_{it}^{*}\left(\delta\right)=\frac{\sum_{j=i}^{N} w_{ij}\left(\delta\right) y_{jt}}{\sum_{j=1}^{N} y_{jt}} \tag{25}$$

where $w_{ij}\left(\delta\right)$ are the elements of a spatial weights matrix as defined in (23)-(24), with ones for all links defined as being within distance δ of a region i, all other links are zero. The numerator is the sum of all y_{jt} (t=1995) within δ of i.

A positive [significant] $G_{it}^{*}\left(\delta\right)$-value indicates a spatial cluster of high values, whereas a negative one indicates a cluster of low values. The information obtained from this statistic for all i=1, ..., N is taken to determine two spatial clubs according to the following simple rule: If $G_{it}^{*}\left(\delta\right)$ is positive, region i is allocated to spatial club A; and if $G_{it}^{*}\left(\delta\right)$ is negative, region i becomes a member of spatial club B. The result of this procedure outlined in Figure 1 seems – overall considered – quite reasonable. Richer regions tend to be clustered in club A and poorer regions in club B.

Spatial club A consists of 173 regions and includes all the EU-15 regions except those in Greece and Portugal, some Spanish regions [Galicia, Extremadura, Andalucia], some Southern Italian regions [Calabria, Apulia and Sicilia], regions located in Eastern Austria [Upper Austria, Lower Austria, Vienna, Burgenland, Styria], and Dresden and Berlin; plus two regions located in CEE [Slovenia and the most Western region in the Czech Republic].

[9] This means that above the critical value of 350 km spatial interactions are assumed to be negligible.

Spatial club B [83 regions] is made up of all NUTS-2 regions in Central and Eastern Europe, except Slovenia and the most Western Czech region [Jihozapad]; and, furthermore, all the Greek and Portuguese regions; the Italian regions Calabria, Apulia, and Sicilia; the Spanish regions Galicia, Extremadura and Andalucia; Upper Austria, Lower Austria, Vienna, Burgenland, and Styria; Dresden and Berlin.

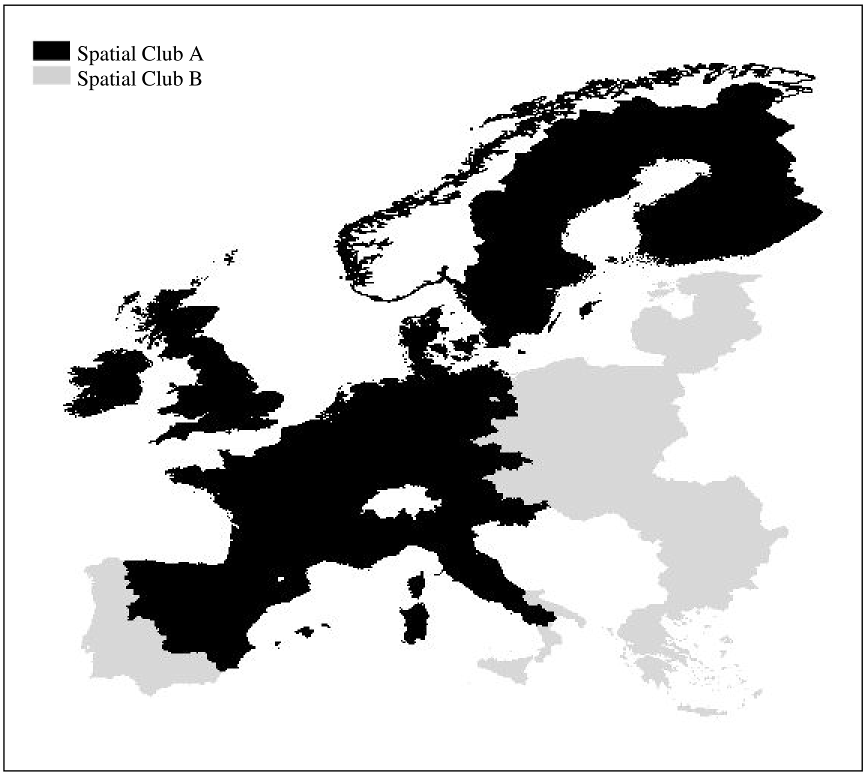

Figure 1: Two spatial regimes identified by using the Getis-Ord statistics $G_{it}^{*}\left(\delta\right)$ [GRP per capita 1995]

5 Convergence Regression Results

Table 1 present the results of the classical test methodology to convergence analysis of the 256 regional economies in Europe. The first column relates to the classical *ß*-convergence test equation [see Equation (12)] and the second to the two-club model specification [see Equations (13) and (15)]. Recall that both test equations assume *iid* zero mean error terms. All estimation and specification tests were carried out with SpaceStat Software (Anselin 1999).

The results of both models provide much support for β-convergence in Europe as the regressions yield highly significant and negative coefficients for the starting income levels. The classical convergence model estimates an annual rate of 1.9 percent of convergence. Note that this rate of convergence is slow in the sense that it would take 36.4 years (95 percent bounds: 29.9 – 46.4 years) to get half-way toward this steady-state level. This result is accordance with most studies that have yielded (un)conditional convergence rates for European regions of the order one to two percent per year (see Martin 2001 for a survey).

We should, moreover, emphasise that this result does not mean that the distribution of income is shrinking (σ-convergence). What this evidence says is that regional economies in Europe seem to approach some long-run level of income, the growth rate falls as the regional economy approaches this long-run level and on average regional economies tend to grow faster than richer ones. This result is interesting because it suggests that regional economies that are predicted to be richer in a few decades from now on are not the same regions that are wealthy today (β-convergence).

Recall, however, that the results of the classical convergence model are based on the assumption of a single steady-state for all regions which is largely at odds with reality. The second column in Table 1 reports the results obtained by the classical test methodology for the case of two clubs of regions as identified in the previous section. The regression yields highly significant and negative coefficients for the starting income levels ($\hat{\beta}_A$=–0.21 with s.d.=0.004 and $\hat{\beta}_B$=–0.0054 with s.d.=0.007) confirming the view of two-club convergence in Europe. Regions in club *B* saw faster GRP per capita growth over the period 1995-2000, as one expects from neoclassical growth theory. The estimated speed of club *B* convergence is 4.8 percent per year and suggests that it will take 14.5 years (95 percent bounds: 11.7-19.2 years) for half of the distance between the initial level of income and the club *B*-specific steady-state level to vanish. In the case of club *A* the model estimates an annual convergence rate of 2 percent. The associated half-time is 34.7 years with approximate 95 percent bounds of 25.6-54.1 years.

The bottom portion of Table 1 reports three diagnostics for the presence of spatial effects[10]: a Moran's *I* test and two Lagrange multiplier tests. Moran's *I* of 0.517 (second column) yields a standardized *z*-value of 22.517 which is very significant (p=0.000)[11]. The test indicates strong evidence of spatial dependence and, thus, misspecification of the two-club convergence model. Unfortunately, it does not allow to discriminate between spatial lag and spatial error forms of misspecification. But – as evidenced in

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[10] The Jarque-Bera (19987) test that follows a χ^2-square distribution with two degrees of freedom indicates that the non-normality requisite for the heteroskedasticity in spatial dependence test is not achieved in the current analysis.

[11] Anselin and Rey (1991) show that Moran's *I* tends to be a catchball with power against a range of alternatives including not only spatial dependence, but also non-normality and heteroskedasticity.

Anselin and Rey (1991) – the joint use of the Lagrange multiplier tests for a spatial lag and spatial error provide good guidance since the Lagrange multiplier error exceeds the Lagrange multiplier lag, the two tests point to the presence of spatial error autocorrelation rather than spatial lag. While there is very strong evidence for spatial dependence, the Koenker-Bassett (1992) test for heteroskedasticity is not significant. Thus, we consider the spatial error specification of the two-club convergence model next.

Table 1: Convergence Regression Results for the 256 European Regions, 1995-2000: The Classical Test Methodology

	The Classical Convergence Model [OLS]	**The Classical Two-Club Convergence Model [OLS]**
Parameter Estimates (*p*-values in brackets)		
Intercept	0.248 (0.000)	
Club A		0.250 (0.000)
Club B		0.580 (0.000)
Beta	-0.020 (0.000)	
Club A		-0.021 (0.000)
Club B		-0.054 (0.000)
The Time to Convergence		
Annual Convergence Rate (in percent)	1.9	
Club A		2.0
Club B		4.8
Half-Distance to the Steady-State (in years, 95% bounds in brackets)	36.4 (29.9-46.4)	
Club A		34.7 (25.6-54.1)
Club B		14.5 (11.7-19.2)
Performance Measures		
R^2	0.239	0.307
Log likelihood	513.949	
Sigma sq.	0.00106	0.00098
Diagnostics Tests (*p*-values in brackets)		
Normality		
Jarque-Bera	27.197 (0.000)	22.274 (0.000)
Heteroskedasticity		
Koenker-Bassett	1.928 (0.165)	0.717 (0.397)
Spatial Error Dependency		
Moran's *I*	26.523 (0.000)	22.517 (0.000)
Robust Lagrange Multiplier	144.911 (0.000)	45.082 (0.000)
Spatial Lag Dependency		
Robust Lagrange Multiplier	1.529 (0.216)	24.268 (0.000)

Notes: Rho [ρ] is the parameter of the autoregressive error process, Beta [β] the convergence coefficient, R^2 squared correlation [ML] or R^2 adjusted [OLS, GMM], Sigma sq. the error variance. The speed of convergence per year is computed as $\hat{\beta}^* = -\ln(1-\tau\,\hat{\beta})/\tau$ with $s.e.(\hat{\beta}^*) = s.e.(\hat{\beta})/\exp(-\hat{\beta}^*\tau)$, where τ is the length of time. The half-distance to the steady-state is computed as $\ln(2)/\hat{\beta}^*$ with the approximate confidence interval defined as $\ln(2)/(\hat{\beta}^* \pm 2\,s.e.(\hat{\beta}^*))$.

Column 1 in Table 2 reports the estimation results for the spatial error specification of the two-club convergence model as defined by Equation (14) in combination with Equation (17). Relative to the OLS regression estimates, the spatial error model achieves a better fitting as expected, given the findings of the various diagnostic tests from Table 1 and the high significance of the spatial autoregressive coefficient ($\hat{\rho}$=0.908 with p=0.000). This highlights that the classical convergence test suffers from a misspecification due to omitted spatial dependence.

The principal finding from the club convergence point of view is that modelling spatial interactions and spillovers among regional economies drastically increases the size of the β-convergence coefficient for club B ($\hat{\beta}_B$=–0.016 with s.d.=0.006), while only slightly increasing that for club A ($\hat{\beta}_A$=–0.026 with s.d.=0.004). This implies an annual convergence rate of 2.4 percent for regional economies belonging to club A and a convergence rate of only 1.5 percent per year for those in club B. Regional economies in Central and Eastern Europe seem to take 45 years (95 percent bounds: 26.8-141.4 years) for the half of the distance between the initial level of income and the club B-specific steady-state level to vanish. In the case of club A the spatial error convergence model estimates an annual convergence rate of 2.4 percent. The associated half time is 14.5 years with approximate 95 percent bounds of 11.7-19.2 years.

The Lagrange multiplier test on residual spatial lag dependence and the Likelihood ratio test on the common factor hypothesis[12] are not significant, indicating that the spatial error model specification is appropriate. But there is one further point to consider, which suggests further elaboration of the spatial error model. The Breusch-Pagan (1979) heteroskedasticity test against the regime variable indicates some heteroskedasticity of the μ-term, although no residual spatial dependence. One way to model heteroskedasticity is to assume $\sigma^2_{\mu_A} \neq \sigma^2_{\mu_B}$ (see Equation (22)). The second column in Table 2 gives the GMM estimates and summarizes the results of fitting the two-club spatial error convergence model with club-wise (group-wise) heteroskedasticity, indicating no improvement in fit as a result of modelling heteroskedasticity. The estimates of β_A and β_B are identical to those obtained by the spatial error model with homoskedastic error.

The extent to which the differences between the β-coefficients in the two clubs are statistically significant is indicated by the asymptotic Wald statistic constructed out of the spatial version of the Chow (1960) test (Anselin 1990). Table 2 shows that the null hypothesis on the joint equality of coefficients (α_A=α_B, β_A=β_B) cannot be rejected. Its value of 1.956 is not extreme for χ^2-distribution with two degrees of freedom. The same indication is provided by the tests on the individual coefficients. In other words, there is no significant difference between the convergence parameters in each of the two clubs. The convergence appears to be not so different across the clubs.

[12] See Burridge (1981) for technical details.

Table 2: Convergence Regression Results for the 256 European Regions, 1995-2000: Spatial Error Specifications of the Two-Club β-Convergence Model

	The Two-Club Spatial Error Convergence Model	
	The Homoskedastic Case [ML]	**The Heteroskedastic Case [GMM]**
Parameter Estimates (*p*-values in brackets)		
Intercept		
Club A	0.297 (0.000)	0.296 (0.000)
Club B	0.204 (0.001)	0.206 (0.000)
Beta		
Club A	-0.026 (0.000)	-0.026 (0.000)
Club B	-0.016 (0.004)	-0.016 (0.001)
Rho	0.908 (0.000)	0.905 (0.000)
The Time to Convergence		
Annual Convergence Rate (in percent)		
Club A	2.4	2.4
Club B	1.5	1.5
Half-Distance to the Steady-State (in years, 95% bounds in brackets)		
Club A	14.5 (11.7-19.2)	14.5 (11.7-19.2)
Club B	45.0 (26.8-141.4)	45.0 (26.8-141.4)
Performance Measures		
R^2	0.351	0.345
Log likelihood	633.671	
Sigma sq.	0.00037	
Diagnostics Tests (*p*-values in brackets)		
Heteroskedasticity		
Breusch-Pagan	23.635 (0.000)	
Spatial Error Dependency		
Likelihood Ratio	215.738 (0.000)	
Spatial Lag Dependency		
Lagrange Multiplier	5.881 (0.015)	
Common Factor hypothesis		
Wald	2.138 (0.343)	
Structural Instability for the Two Regimes		
Chow-Wald	1.936 (0.380)	1.956 (0.376)
Stability of Individual Coefficients		
Constant	1.764 (0.184)	1.816 (0.178)
Beta	1.900 (0.168)	1.847 (0.174)

Notes: Rho [ρ] is the parameter of the autoregressive error process, Beta [β] the convergence coefficient, R^2 squared correlation [ML] or R^2 adjusted [OLS, GMM], Sigma sq. the error variance. The speed of convergence per year is computed as $\hat{\beta}^* = -\ln(1-\tau\,\hat{\beta})/\tau$ with $s.e.(\hat{\beta}^*) = s.e.(\hat{\beta})/\exp(-\hat{\beta}^*\tau)$, where τ is the length of time. The half-distance to the steady-state is computed as $\ln(2)/\hat{\beta}^*$ with the approximate confidence interval defined as $\ln(2)/(\hat{\beta}^* \pm 2\,s.e.(\hat{\beta}^*))$.

6 Concluding Remarks

The paper has look at the evidence for regional income convergence in the New Europe along neoclassical lines. Convergence has been identified as a property of the relation between initial income and growth over the sample period 1995-2000. Admittedly, this is a short time period, while growth and convergence are long-run processes. But the unavailability of longer homogenous time series data for the set of CEE regions prevented such an analysis at the present time. Many cross-sectional analyses of regional growth variations have detected significant evidence of (un)conditional convergence of EU-regions. But the vast majority of such studies fail to consider and model spatial dependence and heterogeneity [with very few exceptions such as Fingleton (1999)], although it is evident from the current study that such an approach may be necessary.

The focus has been on the simplest of the convergence models, the unconditional *ß*-convergence model. In contrast to current practice we rejected the assumption of a single stable steady-state in favour of a multiple-regime [club] alternative in which different regional economies obey different linear convergence models when grouped according to initial conditions. The use of the Getis-Ord statistics produced a grouping that seems overall quite reasonable. We defined club convergence as the club-specific process by which each region belonging to a club moves from a disequilibrium position to its club-specific steady-state position. At the steady-state the growth rate is the same across the regional economies of a club.

There are four major lessons to be gained from the paper. *First*, there is clear evidence for unconditional *ß*-convergence in Europe for the time period of observation. The sample of regional economies belonging to club *A* converges in an unconditional sense at a speed of 2.4 percent per year and those belonging to club *B* (regional economies in CEE and Southern Europe) at a speed of 1.5 percent. It is important to emphasise that a speed of 1.5 or 2.4 percent per year is very small. It suggests that it will take, for example, 14.5 years in club *A* and 34.7 years in club *B* for half of the distance between the initial level of income and the steady-state level to vanish.

Second and closely related, this convergence process across regional economies is an interesting finding. It suggests that regional economies in a club that are predicted to be wealthier in a few decades from now on are not the same regions in the club that are wealthy today (*ß*-convergence). This result does not mean, however, that the club-specific distribution of income is shrinking (σ-convergence).

Third, the study illustrates that the classical convergence test methodology that has been the work-horse of most previous convergence studies in mainstream economics is ill-designed to analyse regional convergence due to several reasons. First, it cannot identify groupings of regional economies that are converging at different speed. Second, it neglects spatial effects that represent spatial interactions and spillovers among the regional economies. The paper suggests a much richer and theoretically more satisfactory approach that incorporates spatial effects or externalities directly into the model and reflects recent developments in spatial econometrics. The two-club spatial error convergence model with club-wise heteroskedasticity appears to be the most appropriate specification in the face of the data now available.

This leads to the *final point* to note, namely that ignoring the presence of spatial error autocorrelation in convergence analysis carried out with cross-sectional data can lead to wrong conclusions, for example, with respect to the assessment of convergence speed. Thus, testing for the presence of spatial autocorrelation (heterogeneity) by means of appropriate diagnostics and implementing alternative specifications of the convergence test equation when needed are crucial issues in income convergence analysis.

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APPENDIX: List of the NUTS-Level 2 Regions by Country

Country	Region
Austria	Burgenland
	Niederösterreich
	Wien
	Kärnten
	Steiermark
	Oberösterreich
	Salzburg
	Tirol
	Vorarlberg
Belgium	Région Bruxelles-Capitale
	Antwerpen
	Limburg (B)
	Oost-Vlaanderen
	Vlaams Brabant
	West-Vlaanderen
	Brabant Wallon
	Hainaut
	Liège
	Luxembourg (B)
	Namur
Bulgaria	Severozapadan
	Severoiztochen
	Severozapad
	Yugozapaden
	Yuzhen Tsentralen
	Yugoiztochen
Czech Republic	Praha
	Stredni Cechy
	Jihozapad
	Severozapad
	Severovychod
	Jihovychod
	Stredni Morava
	Moravskoslezsko
Denmark	Denmark
Estonia	Estonia
Finland	Itä-Suomi
	Väli-Suomi
	Pohjois-Suomi
	Uusimaa
	Etelä-Suomi
	Åland
France	Île de France
	Champagne-Ardenne
	Picardie
	Haute-Normandie
	Centre
	Basse-Normandie
	Bourgogne
	Nord-Pas-de-Calais
	Lorraine
	Alsace
	Franche-Comté
	Pays de la Loire
	Bretagne
	Poitou-Charentes
	Aquitaine
	Midi-Pyrénées
	Limousin
	Rhône-Alpes
	Auvergne
	Languedoc-Roussillon
	Provence-Alpes-Côte d'Azur
	Corse
Germany	Stuttgart
	Karlsruhe
	Freiburg
	Tübingen
	Oberbayern
	Niederbayern
	Oberpfalz
	Oberfranken
	Mittelfranken
	Unterfranken
	Schwaben
	Berlin
	Brandenburg
	Bremen
	Hamburg
	Darmstadt
	Gießen
	Kassel
	Mecklenburg-Vorpommern
	Braunschweig
	Hannover
	Lüneburg
	Weser-Ems
	Düsseldorf
	Köln
	Münster
	Detmold
	Arnsberg

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Country	Region
	Koblenz
	Trier
	Rheinhessen-Pfalz
	Saarland
	Chemnitz
	Dresden
	Leipzig
	Dessau
	Halle
	Magdeburg
	Schleswig-Holstein
	Thüringen
Greece	Anatoliki Makedonia, Thraki
	Kentriki Makedonia
	Dytiki Makedonia
	Thessalia
	Ipeiros
	Ionia Nisia
	Dytiki Ellada
	Sterea Ellada
	Peloponnisos
	Attiki
	Voreio Aigaio
	Notio Aigaio
	Kriti
Hungary	Közép-Magyarország
	Közép-Dunántúl
	Nyugat-Dunántúl
	Dél-Dunántúl
	Észak-Magyarország
	Észak-Alföld
	Dél-Alföld
Ireland	Border, Midland and Western
	Southern and Eastern
Italy	Piemonte
	Valle d'Aosta
	Liguria
	Lombardia
	Trentino-Alto Adige
	Veneto
	Friuli-Venezia Giulia
	Emilia-Romagna
	Toscana
	Umbria
	Marche
	Lazio
	Abruzzo
	Campania
	Puglia
	Basilicata
	Calabria
	Sicilia
	Sardegna
Latvia	Latvia
Lithuania	Lithuania
Luxembourg	Luxembourg
The Netherlands	Groningen
	Friesland
	Drenthe
	Overijssel
	Gelderland
	Flevoland
	Utrecht
	Noord-Holland
	Zuid-Holland
	Zeeland
	Noord-Brabant
	Limburg (NL)
Poland	Dolnoslaskie
	Kujawsko-Pomorskie
	Lubelskie
	Lubuskie
	Lódzkie
	Malopolskie
	Mazowieckie
	Opolskie
	Podkarpackie
	Podlaskie
	Pomorskie
	Slaskie
	Swietokrzyskie
	Warminsko-Mazurskie
	Wielkopolskie
	Zachodniopomorskie
Portugal	Norte
	Centro (P)
	Lisboa e Vale do Tejo
	Alentejo
	Algarve
Romania	Nord-Est
	Sud-Est
	Sud

Country	Region	Country	Region
	Molise		

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	Sud-Vest
	Vest
	Nord-Vest
	Centru
	Bucuresti
Slovenia	Slovenia
Slovak Republic	Bratislavský kraj
	Západné Slovensko
	Stredné Slovensko
	Východné Slovensko
Spain	Galicia
	Principado de Asturias
	Cantabria
	Pais Vasco
	Comunidad Foral de Navarra
	La Rioja
	Aragón
	Comunidad de Madrid
	Castilla y León
	Castilla-la Mancha
	Extremadura
	Cataluña
	Comunidad Valenciana
	Islas Baleares
	Andalucia
	Región de Murcia
Sweden	Stockholm
	Östra Mellansverige
	Sydsverige
	Norra Mellansverige
	Mellersta Norrland
	Övre Norrland
	Småland med öarna
	Västsverige
UK	Tees Valley & Durham
	Cumbria
	Cheshire
	Greater Manchester
	Lancashire
	Merseyside
	East Riding & North Lincolnshire
	North Yorkshire
	South Yorkshire
	West Yorkshire
	Derbyshire & Nottinghamshire
	Leicestershire, Rutland & Northamptonshire
	Lincolnshire
	Herefordshire, Worcestershire & Warkwick
	Shropshire & Staffordshire
	West Midlands
	East Anglia
	Bedfordshire & Hertfordshire
	Essex
	Inner London
	Outer London
	Berkshire, Buckinghamshire Oxfordshire
	Surrey, East & West Sussex
	Hampshire & Isle of Wight
	Kent
	Gloucestershire, Wiltshire & N. Somerset
	Dorset & Somerset
	Cornwall & Isles of Scilly
	Devon
	West Wales & The Valleys
	East Wales
	North Eastern Scotland
	Eastern Scotland
	South Western Scotland
	Highlands and Islands
	Northern Ireland

APPENDIX: List of the NUTS-LEVEL 2 Regions by Country and Data [1995, 2000]

Country	Region	GRP 1995	GRP 2000
Austria	Burgenland	3,970.2	4,548.0
	Niederösterreich	27,345.8	33,339.7
	Wien	50,273.3	56,410.0
	Kärnten	10,732.1	12,074.8
	Steiermark	22,498.9	25,749.3
	Oberösterreich	29,054.7	33,722.3
	Salzburg	13,142.0	15,109.4
	Tirol	14,844.9	16,878.1
	Vorarlberg	7,978.4	9,206.0
Belgium	Région Bruxelles-Capitale	40,144.5	47,030.4
	Antwerpen	39,915.6	46,211.3
	Limburg (B)	13,818.4	16,140.2
	Oost-Vlaanderen	24,503.9	28,677.4
	Vlaams Brabant	20,440.0	25,621.6
	West-Vlaanderen	21,528.2	25,031.6
	Brabant Wallon	6,273.6	7,941.4
	Hainaut	18,087.3	20,355.2
	Liège	16,689.2	18,725.3
	Luxembourg (B)	3,742.8	4,246.2
	Namur	6,407.4	7,488.5
Bulgaria	Severozapadan	622.3	915.3
	Severoiztochen	1,293.7	1,804.6
	Severozapad	1,445.4	2,024.3
	Yugozapaden	3,494.8	4,729.4
	Yuzhen Tsentralen	2,306.7	2,869.4
	Yugoiztochen	856.0	1,391.1
Czech Republic	Praha	8,574.8	13,838.7
	Stredni Cechy	3,318.1	5,049.4
	Jihozapad	4,327.6	5,958.3
	Severozapad	4,079.6	5,005.8
	Severovychod	5,007.5	6,916.6
	Jihovychod	5,714.5	7,834.3
	Stredni Morava	4,073.1	5,385.6
	Moravskoslezsko	4,709.2	5,765.9
Denmark	Denmark	137,793.4	173,889.0
Estonia	Estonia	2,728.3	5,575.4
Finland	Itä-Suomi	10,603.8	12,417.7
	Väli-Suomi	11,569.1	14,497.2
	Pohjois-Suomi	9,848.9	12,417.7
	Uusimaa	33,498.1	48,400.5
	Etelä-Suomi	32,778.6	42,538.7
	Åland	599.8	873.3
France	Île de France	335,628.3	402,824.2
	Champagne-Ardenne	24,734.8	29,366.2
	Picardie	31,215.2	35,514.7

	Haute-Normandie	33,234.5	39,407.2
	Centre	44,856.6	51,521.3
	Basse-Normandie	24,083.4	28,203.4
	Bourgogne	29,357.6	34,570.7
	Nord-Pas-de-Calais	63,338.0	74,780.4
	Lorraine	39,984.1	44,676.0
	Alsace	35,505.7	41,731.8
	Franche-Comté	19,750.5	22,722.3
	Pays de la Loire	55,459.3	67,784.8
	Bretagne	47,721.7	58,379.7
	Poitou-Charentes	26,869.2	31,656.0
	Aquitaine	50,815.9	61,283.6
	Midi-Pyrénées	44,006.5	52,754.9
	Limousin	11,599.3	13,483.8
	Rhône-Alpes	111,645.9	135,893.1
	Auvergne	21,761.2	26,217.4
	Languedoc-Roussillon	34,105.2	41,769.9
	Provence-Alpes-Côte d'Azur	81,055.0	95,584.3
	Corse	3,748.8	4,592.6
Germany	Stuttgart	107,619.2	122,236.8
	Karlsruhe	70,183.0	78,025.0
	Freiburg	46,768.3	52,021.7
	Tübingen	40,816.4	45,022.2
	Oberbayern	123,699.1	145,301.0
	Niederbayern	24,765.0	26,478.0
	Oberpfalz	23,389.1	26,933.3
	Oberfranken	25,358.9	26,769.7
	Mittelfranken	43,936.2	49,407.4
	Unterfranken	29,213.0	32,115.9
	Schwaben	40,676.1	43,662.9
	Berlin	80,783.1	75,113.2
	Brandenburg	38,238.2	41,911.5
	Bremen	20,602.9	21,935.7
	Hamburg	66,235.5	72,043.5
	Darmstadt	117,499.6	128,691.1
	Gießen	21,779.7	23,439.4
	Kassel	28,034.0	29,815.6
	Mecklenburg-Vorpommern	27,218.7	28,707.0
	Braunschweig	36,358.4	41,077.1
	Hannover	50,998.3	54,180.3
	Lüneburg	29,289.8	30,352.5
	Weser-Ems	47,936.2	50,589.7
	Düsseldorf	137,506.3	147,870.4
	Köln	108,212.0	114,431.8
	Münster	51,373.1	53,148.4
	Detmold	46,503.6	50,238.0
	Arnsberg	83,037.7	88,155.2
	Koblenz	29,772.6	31,530.6
	Trier	9,701.4	10,122.0
	Rheinhessen-Pfalz	45,072.0	48,775.9
	Saarland	23,708.4	24,040.0
	Chemnitz	23,876.3	24,949.1
	Dresden	27,090.8	28,573.1
	Leipzig	18,942.2	19,045.5

	Dessau	7,744.6	8,164.0
	Halle	13,541.7	14,135.5
	Magdeburg	17,498.0	19,483.8
	Schleswig-Holstein	59,759.8	62,103.5
	Thüringen	35,467.5	39,402.5
Greece	Anatoliki Makedonia, Thraki	4,071.5	5,306.5
	Kentriki Makedonia	14,843.7	21,168.9
	Dytiki Makedonia	2,481.4	3,514.6
	Thessalia	5,523.6	7,870.3
	Ipeiros	2,046.0	3,051.0
	Ionia Nisia	1,450.7	2,092.5
	Dytiki Ellada	5,015.9	6,521.0
	Sterea Ellada	7,046.7	8,734.1
	Peloponnisos	4,480.9	6,666.2
	Attiki	34,220.5	45,924.1
	Voreio Aigaio	1,427.4	2,070.1
	Notio Aigaio	2,559.2	3,756.0
	Kriti	4,720.8	6,446.2
Hungary	Közép-Magyarország	3,372.2	5,612.1
	Közép-Dunántúl	13,954.9	21,799.2
	Nyugat-Dunántúl	3,433.7	5,647.1
	Dél-Dunántúl	2,720.0	3,671.3
	Észak-Magyarország	3,156.8	4,125.5
	Észak-Alföld	3,673.1	4,863.4
	Dél-Alföld	3,808.0	4,852.4
Ireland	Border, Midland and Western	10,253.8	19,760.0
	Southern and Eastern	40,582.1	83,150.0
Italy	Piemonte	73,937.6	101,242.1
	Valle d'Aosta	2,346.9	2,931.1
	Liguria	25,128.7	34,576.3
	Lombardia	173,808.8	242,192.7
	Trentino-Alto Adige	17,708.0	25,372.6
	Veneto	76,416.5	106,677.0
	Friuli-Venezia Giulia	20,040.7	26,776.2
	Emilia-Romagna	73,652.2	102,166.3
	Toscana	56,215.9	79,502.2
	Umbria	11,858.7	16,687.7
	Marche	21,059.2	29,596.5
	Lazio	86,176.1	118,138.5
	Abruzzo	15,863.9	21,166.7
	Molise	3,637.5	5,088.2
	Campania	53,242.8	74,529.6
	Puglia	38,537.5	54,153.7
	Basilicata	6,084.6	8,763.7
	Calabria	18,001.1	25,067.3
	Sicilia	47,467.4	65,574.5
	Sardegna	17,857.6	24,564.0
Latvia	Latvia	3,378.2	7,775.6

Lithuania	Lithuania	4,606.8	12,218.0
Luxembourg	Luxembourg	13,827.7	20,815.0
The Netherlands	Groningen	13,606.6	15,953.2
	Friesland	10,459.5	13,046.0
	Drenthe	7,851.0	9,434.5
	Overijssel	18,552.2	23,226.4
	Gelderland	33,689.0	42,319.7
	Flevoland	4,187.4	5,869.0
	Utrecht	26,145.8	35,494.6
	Noord-Holland	58,298.9	74,789.0
	Zuid-Holland	71,229.7	89,677.5
	Zeeland	7,284.0	8,277.3
	Noord-Brabant	45,680.1	59,168.7
	Limburg (NL)	20,339.0	25,343.1
Poland	Dolnoslaskie	7,821.4	13,601.3
	Kujawsko-Pomorskie	5,243.8	8,331.0
	Lubelskie	4,356.2	6,767.5
	Lubuskie	2,508.5	4,061.5
	Lódzkie	6,181.1	10,386.4
	Malopolskie	7,095.4	12,740.0
	Mazowieckie	15,854.9	33,981.0
	Opolskie	2,719.8	4,106.2
	Podkarpackie	4,100.1	6,693.2
	Podlaskie	2,330.4	4,016.4
	Pomorskie	5,461.3	9,759.2
	Slaskie	15,229.0	23,645.0
	Swietokrzyskie	2,662.3	4,580.0
	Warminsko-Mazurskie	2,913.4	4,832.6
	Wielkopolskie	8,249.5	15,831.8
	Zachodniopomorskie	4,451.5	7,563.5
Portugal	Norte	24,850.0	33,664.8
	Centro (P)	11,613.7	15,887.5
	Lisboa e Vale do Tejo	36,097.7	51,525.9
	Alentejo	3,694.0	4,746.7
	Algarve	2,900.6	4,156.7
Romania	Nord-Est	3,618.3	4,784.0
	Sud-Est	3,475.2	4,671.9
	Sud	4,016.7	5,104.9
	Sud-Vest	2,794.2	3,631.6
	Vest	2,708.9	3,766.7
	Nord-Vest	3,236.6	4,737.1
	Centru	3,443.9	5,048.5
	Bucuresti	3,806.4	8,427.8
Slovenia	Slovenia	14,343.1	19,531.8
Slovak Republic	Bratislavský kraj	3,361.0	5,201.1

	Západné Slovensko	4,799.0	6,882.0
	Stredné Slovensko	3,173.6	4,513.6
	Východné Slovensko	3,304.9	4,735.8
Spain	Galicia	25,102.0	32,593.7
	Principado de Asturias	10,813.9	13,854.0
	Cantabria	5,584.6	7,872.7
	Pais Vasco	28,249.9	38,886.7
	Comunidad Foral de Navarra	7,617.3	10,507.3
	La Rioja	3,416.5	4,484.4
	Aragón	14,614.3	19,068.2
	Comunidad de Madrid	75,126.2	105,130.6
	Castilla y León	27,296.8	34,792.9
	Castilla-la Mancha	15,772.6	21,220.9
	Extremadura	7,695.2	10,565.5
	Cataluña	84,558.2	113,942.0
	Comunidad Valenciana	42,277.3	59,395.4
	Islas Baleares	10,281.6	14,412.3
	Andalucia	59,984.5	82,170.4
	Región de Murcia	10,248.3	14,342.5
Sweden	Stockholm	45,301.0	73,658.5
	Östra Mellansverige	29,376.6	37,497.9
	Sydsverige	24,718.7	34,631.3
	Norra Mellansverige	17,965.9	20,817.4
	Mellersta Norrland	8,667.2	10,044.4
	Övre Norrland	11,265.5	12,938.0
	Småland med öarna	16,596.6	21,275.9
	Västsverige	35,996.7	49,256.8
UK	Tees Valley & Durham	14,223.4	23,144.9
	Cumbria	17,808.6	29,131.1
	Cheshire	7,366.6	11,728.0
	Greater Manchester	16,770.2	29,377.6
	Lancashire	34,526.4	59,597.6
	Merseyside	18,304.0	30,216.0
	Cumbria	15,059.9	25,783.4
	Cheshire	12,583.4	21,833.7
	Greater Manchester	10,124.3	18,425.4
	Lancashire	14,145.1	25,442.0
	Merseyside	28,825.5	50,578.9
	East Riding & North Lincolnshire	26,235.7	47,192.8
	North Yorkshire	23,214.6	41,725.8
	South Yorkshire	7,678.4	13,928.1
	West Yorkshire	17,025.3	30,921.1
	Derbyshire & Nottinghamshire	18,396.1	33,624.3
	Leicestershire, Rutland & Northamptonshire	37,645.1	63,735.3
	Lincolnshire	33,531.6	62,672.6
	Herefordshire, Worcestershire & Warwick	23,662.9	44,871.5
	Shropshire & Staffordshire	20,860.9	39,576.2
	West Midlands	94,341.1	177,346.4
	East Anglia	54,503.7	101,994.2
	Bedfordshire & Hertfordshire	37,491.0	72,186.3
	Essex	36,231.3	71,368.1

	Inner London	25,536.2	50,904.2
	Outer London	21,806.5	38,846.9
	Berkshire, Buckinghamshire & Oxfordshire	33,661.0	59,850.2
	Surrey, East & West Sussex	14,972.8	26,953.2
	Hampshire & Isle of Wight	4,552.2	8,400.5
	Kent	12,880.2	22,276.1
	Gloucestershire, Wiltshire & Na Somerset	20,135.8	34,610.2
	Dorset & Somerset	16,098.8	27,391.6
	Cornwall & Isles of Scilly	10,154.3	16,079.8
	Devon	29,518.7	49,698.0
	West Wales & The Valleys	33,510.6	56,421.7
	East Wales	4,428.4	7,206.5
	North Eastern Scotland	19,932.9	34,351.6