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ECONOMETRIC ANALYSIS OF INCOME CONVERGENCE IN SELECTED EU COUNTRIES AND THEIR NUTS 3 LEVEL REGIONS

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Abstract

The paper estimates equations for regional income convergence in selected EU countries and their NUTS 3 level regions during the European Union pre-enlargement period (1995–2002), using both spatial and non-spatial approaches. There has been absolute income convergence between regions in both the groups of countries looked at, the countries of the EU15, or the old member states, and the new member states or NMS. When national effects are included in convergence equations using country dummies, no evidence of regional income convergence can be observed. The results of the analysis assert the importance of regional policies in inhibiting the increase of regional income disparities and improving conditions for income growth, particularly within the new member states.

1. INTRODUCTION

The eastward enlargement of the European Union (the EU) is accompanied by the challenging task of convergence, a task which emphasises the need to combine economic growth with social and institutional development at both national and regional level. Therefore income disparities and convergence in EU countries and regions remains an important area for research, as it further informs the development of EU regional policies. The essential argument for EU regional policy is that balanced regional development is a prerequisite for social cohesion and increased competitiveness in the countries and regions of the EU.

Research into regional income convergence has become particularly popular in the past 15 years, but despite the great interest in this matter, information on regional convergence in the enlarged EU is still relatively scarce. The majority of the earlier regional income convergence studies focused on traditional *beta*-convergence analysis in which the effects of spatial dependence are not considered (Barro and Sala-i-Martin, 1991; Sala-i-Martin 1996; Neven and Gouyette 1994; Tsionas 2000). However, regional data cannot be regarded as independently generated because of the presence of similarities among neighbouring regions, and so the standard estimation procedures employed in some previous empirical studies may be invalid and lead to serious bias and inefficiency in the estimation of the convergence rate (see also Arbia *et al* 2005; Abreu *et al* 2004). Because of this it is understandable that the amount of empirical literature exploring regional income disparities, convergence and growth using spatial econometric techniques and examining spatial autocorrelation has increased remarkably during the last decade.

Due to data restrictions, previous empirical research on regional convergence in Europe focused on EU-15 regions. This paper aims to provide more distinct information on regional equalisation in the enlarged EU. Special attention is paid to differences in the regional growth processes between the EU-15, or the old member states,[1] and

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[1] EU-15: Austria, Belgium, Germany, Denmark, Spain, Finland, France, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Sweden, UK.

the NMS, or the New Member States that acceded in 2004,[2] and to the role of national circumstances and the development of regional disparities within countries. Since spatial dependence was found influence regional growth in recent convergence literature, spatial econometric techniques will be applied in order to control for such effects. Based on the results of our analysis we will make some suggestions of ways for regional policy to achieve sustainable and balanced economic growth.

We have analysed regional income disparities and convergence in EU-25 countries and their NUTS 3 level regions during the years 1995–2002. These years cover the period of preparation for the fifth enlargement (known as the first eastward enlargement) of the European Union. During this period, which in the current paper is referred to as the EU pre-enlargement period, political decisions about the candidate and the acceding countries were made. The decisions about the candidate countries were made in 1997 and 1999 and about the acceding countries in 2002.

In order to analyse income convergence in EU countries and their regions we focus on empirical testing of the convergence hypothesis using GDP per capita data at current market prices at NUTS level 3 from Eurostat Regio databases. We estimate both non-spatial (simple OLS, including country dummies to capture country heterogeneity) and spatial (Spatial Lag Models (SLM) and Spatial Error Models (SEM)) models. GDP per capita in euro and purchasing power standards (PPS) of the NUTS 3 regions are used as proxies for the regional income level of the EU countries.
The paper consists of five sections. The following section gives a brief overview of the theoretical considerations and earlier empirical findings of income convergence; the third section presents an overview of the main convergence testing methodologies and an introduction to spatial econometrics tools; the fourth section presents empirical results; and the last section concludes.

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[2] NMS: Czech Republic, Cyprus, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovenia, Slovakia.

2. THE THEORETICAL CONSIDERATIONS AND SOME EMPIRICAL RESULTS OF EARLIER CONVERGENCE STUDIES

2.1. Theoretical considerations of income convergence

The concept of convergence in the most general sense is the decreasing or equalising of disparities. For economists the convergence of income levels (or total factor productivity levels) between countries or regions has been a very topical subject to investigate. Following Holocombe (2001) there are two main concepts of economic growth: a) the concept of production factors; b) the institutional economic growth theory. There are also two main competitive theories – neoclassical growth theory (Solow 1956) and endogenous growth theory (Romer 1986) – within the framework of the production factors concept. Neoclassical growth theory predicts the decrease of disparities in income levels (called convergence optimism) because of decreasing returns to reproducible capital, while endogenous growth theory predicts persistent and even increasing inequality (called convergence pessimism) because of increasing returns to scale. As a result, the two theories have different views on the necessity of government policy. Endogenous growth theory demonstrates that policy measures can have an impact on the long-term growth rate of an economy, while in the neoclassical model only a change in the savings rate could generate long-term growth.

In the traditional neoclassical growth theory regional economic growth depends on three factors: population growth, capital accumulation and technology. There is more capital in the richer regions and therefore there are also lower marginal returns to capital and slower economic growth. Additionally, international trade, migration and capital flows should create the preconditions for reducing the gap in productivity and living standards between countries and between regions. In open economies labour should move to the richer regions because of the higher wage levels, while capital on the other hand moves to the poorer regions thus increasing their economic growth (Armstrong and Taylor 1999). Furthermore, it is found that the diffusion of new technology and innovations can lead to convergence even in the case of positive returns to scale. Richer countries (or regions) are usually the innovators, poorer ones only adopt these innovations and the costs of adopting the innovations are generally significantly lower than the costs of actually creating them (Rey 2004).

In the endogenous growth theory – in contrast to the neoclassical approach – human capital is taken into account and technological progress is endogenised. When human capital is added to the model there is no longer any reason to assume decreasing returns to capital, and therefore the per capita GDP levels of different regions may not converge with one another even if the preferences, saving rates and technology are similar in these regions.

Unfortunately many convergence studies mainly focus only on the production factors concept as the theoretical framework for income convergence, meaning that the micro level of an economy is often ignored. The implications of institutional economic growth theory should be considered, because, as North (1990) pointed out, institutions are the stimulating systems of a society and can therefore both promote and hamper economic growth. Poor regions can only grow and catch up with richer ones if and when they have efficient institutions.

The integration theory, the classical trade theory and New Economic Geography (NEG) support clearly neither convergence optimism nor pessimism. However, there seems to be more support for convergence pessimism in NEG, which (Krugman 1991; Baldwin *et al.* 2003; Martin and Ottaviano 1999) aims to explain the formation of a large variety of economic agglomerations in geographical space. Using the general equilibrium framework, NEG shows that increasing returns at the level of the individual producer or plant, imperfect competition, transport costs, and the locational movement of productive factors and consumers are the prerequisites for agglomeration and the core-periphery pattern to occur. Even regions that are initially perfectly symmetrical might re-organise themselves into a core and a periphery and nothing more than a decrease in the cost of trade between them is necessary for that to happen.

NEG also claims that location plays an important role in the economic activity of a region. In addition to other factors, the economic situation of a region depends on its location and its neighbours, so poor regions have greater chances for development if they are surrounded by the rich neighbours (see also Le Gallo 2001). NEG has particularly highlighted location and agglomeration externalities, which can arise because of knowledge spillovers, various market effects, and input-output linkages between the firms operating at various spatial levels (e.g. regions, cities, districts of cities, rural areas, etc).

Overall, economic theory does not give a unique answer for the direction of the dynamics in income distribution. There are many complex relationships and factors that influence economic growth and the income convergence process, which makes it quite understandable that different theories can lead to different conclusions.

2.2. Convergence hypotheses

There are three well-known competitive convergence hypotheses:

- the absolute (unconditional) convergence hypothesis
- the conditional convergence hypothesis
- the club convergence hypothesis.

In the absolute convergence hypothesis, the per capita incomes of countries or regions converge with one another in the long-term regardless of the initial conditions. Poorer countries and regions grow faster than richer ones and there is a negative relationship between average growth rates and initial income levels even if no other variables are included in the regression model as explanatory factors. It is assumed that all economies converge to the same unique and globally stable steady state equilibrium, which is a reasonable assumption in the case of a homogeneous sample of countries or regions (such as states of the USA, OECD countries, European regions (as given by Arbia *et al* 2005)).

According to the conditional convergence hypothesis, the per capita incomes of countries or regions converge with one another in the long-term provided that their structural characteristics (eg technologies, human capital, institutions, population growth rates, preferences, infant mortality rates) are identical. The initial conditions, as in the case of absolute convergence, are irrelevant. In the case of conditional convergence, equilibrium differs by economy, and each particular economy approaches its own but unique equilibrium. In other words the evidence should suggest the existence of conditional convergence if the negative relationship between initial per capita incomes and their growth rates holds only after the possibility of the above-mentioned structural characteristics has been controlled for (see also Mankiw *et al* 1995). Thus conditional convergence can occur even if the absolute convergence hypothesis is not valid.

In the club convergence hypothesis the per capita incomes of countries or regions that are similar in both their structural characteristics and initial factors (eg GDP per capita, human capital, preferences, public infrastructure) converge with one another in the long-term. Fischer and Stirböck (2004) define 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. Cappelen (2001) notes that the possibility of club convergence is ruled out by implication in the standard neoclassical model, because agents are assumed to be homogeneous (which means there are no different initial conditions and therefore no convergence clubs), but if agents are allowed to be heterogeneous the dynamic system of the neoclassical growth model could lead to multiple steady-state equilibria in spite of diminishing returns to capital. Durlauf (2001) points out that 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 the regional economies in the sample, which is the case in the absolute and conditional convergence hypotheses. The club convergence hypothesis, on the other hand, allows multiple and only locally stable steady-state equilibriums. Martin (2001) explains that if regional economies differ in their basic growth parameters (for example technological innovativeness and human capital development under his definition), or knowledge spillovers between them are weak, they may not converge to a common per capita income, but instead to different economy-specific equilibrium levels of per capita income. Under such circumstances there might be convergence among similar types of economies (clubs, regimes), but little or no convergence between such clubs (see Martin 2001). We share the opinion that the concept of club convergence is in line with the phenomena which characterise modern economies, such as polarisation, clustering and permanent poverty. We also agree with the point (see also Islam 2003) that despite the conceptual distinction, it is not easy to distinguish 'club convergence' from 'conditional convergence' empirically. This is reflected in the problems associated with the choice of criteria to be used to group the countries when testing for club convergence.

2.3. Beta and sigma convergence

The traditional and widely used tool for testing convergence hypotheses is *beta*-convergence analysis (growth-initial level regression). The starting point for the *beta*-convergence studies was that of Baumol (1986) and the approach has become extremely popular since then (Barro 1991, Barro and Sala-i-Martin 1992, Sala-i-Martin 1996, Fischer and Stirböck 2004). *Beta*-convergence (β-convergence) is defined as a negative relationship between the initial income level and subsequent income growth rate. If poorer economies grow faster than richer ones, there should also be a negative correlation between the initial income level and the growth rate. A distinction between absolute convergence and conditional convergence is usually made when discussing *beta*-convergence processes, as the absolute β-convergence hypothesis rests on the assumption that there is a negative correlation between the initial income level and the growth rate. Therefore poorer economies grow faster than richer ones and will catch them up in the long run. The absolute β-convergence hypothesis is usually tested by the following cross-sectional equation, in matrix form (see Baumont *et al* 2002):

$$(1)\ g_T = \alpha S + \beta y_0 + \varepsilon \qquad \varepsilon \sim N(0, \sigma_\varepsilon^2 I),$$

where g_T is the (n*1) vector of *per capita* GDP average growth rate (where *n* is the number of regions) in the period (*0, T*); y_0 is the vector of *per capita* GDP (natural logarithms) initial levels (at time *0*); *S* is the unit vector and ε is the vector of error terms. The absolute convergence hypothesis can be accepted if the estimate of *beta* is statistically significant and negative.

The conditional β-convergence hypothesis assumes that the negative correlation occurs only if some structural characteristics (such as the demographic situation, government policy, human capital, employment rate etc) are identical in the economies under consideration. There exists a negative correlation between the growth rate and the distance that the income level is away from its steady state equilibrium. Therefore poorer regions do not necessarily grow faster than richer regions because the latter ones may be even further away from their steady state equilibria. The usual cross-sectional equation for testing conditional β–convergence is as follows, in matrix form (Baumont *et al* 2002):

$$(2)\ g_T = \alpha S + \beta y_0 + X\phi + \varepsilon, \ \ \varepsilon \sim N\left(0, \sigma_\varepsilon{}^2 I\right),$$

where *X* is the matrix of explanatory variables constant in the steady state equilibria and all other terms are as previously defined. There exists conditional β–convergence if the estimated value for β is significantly negative.

The *sigma*-convergence approach has become popular since the work by Daniel Quah in the beginning of the 1990s. Using the connection with Galton’s famous fallacy, Daniel Quah (1993) showed that the traditional growth-initial level relationship does not give a clear answer about convergence as the relationship tends to be negative even if the income differences have not decreased. *Sigma*-convergence (σ – convergence) pertains to the decline in the cross-sectional dispersion of per capita incomes over time. As suggested by Quah (1993) σ-convergence should be of interest since it answers directly whether or not the distribution of income across economies is becoming more equitable. On the other hand, as also pointed out by Islam (2003), methodologies associated with the investigation of β-convergence also provide information on the structural parameters of growth models, while research taking the distribution approach usually does not provide such information.

It should be noticed that *beta*-convergence is a necessary but not sufficient condition for s*igma*-convergence to occur (see also Barro and Sala-i-Martin 1991; Salai-i-Martin 1996; Bernard and Durlauf, 1996; Quah 1996a; Young *et al* (2004)). A negative β from a growth-initial level regression does not necessarily imply a reduction in variation of regional income or growth rates over time.

2.4. Some empirical results of previous income convergence studies

Although theoretical literature has suggested the importance of location and agglomeration externalities as the key determinants of the spatial concentration of economic activity and income (see also Krugman, 1991; Fujita et al., 1999), the empirical literature has still lagged behind theoretical developments in exploring regional income disparities and convergence. Until the 1990s country level (as opposed to regional level) studies clearly prevailed in the empirical literature on the issue of income convergence. The results of some earlier studies indicated that the majority of countries and regions have become much richer during the past century, but those that were already richer have gained considerably more (see also Durlauf and Quah (1999); Dowrick and DeLong (2001)). Therefore the gap between rich and poor countries has increased. Exploring income convergence and divergence in various countries of the world during the last 200 years, Dowrick and DeLong (2001) distinguished four periods where direction of the process towards income convergence or divergence varies. According to their research results, there has been no convergence of economic development in the second half of the 20th century. Overall inequality between the world's countries has increased, and convergence has occurred only in small groups (clubs) of economies, for example OECD countries after World War II (see also Dowrick and Nguyen

1989), East Asia after 1960 (see World Bank 1994), and the regions of India in the end of 20th century (see Bajpai and Sachs 1999). These examples are in line with the club convergence hypothesis[3], the idea of which, incidentally, rests on theoretical models that yield multiple regimes. According to the models each region moves towards its club-specific steady-state equilibrium, which depends on the initial position of the region. The steady-state equilibrium is the same for every region in a particular convergence club but differs between different clubs.

Studies of regional income convergence have become particularly popular in the past 15 years (Armstrong 1995; Barro and Sala-i-Martin 1991; Bernat, Andrew 2001; Carlino and Mills 1993, 1996; López-Bazo *et al* 1997; Molle and Broeckhout 1995; Neven and Gouyette 1994; Suarez-Villa and Cuadrado-Roura 1993; Rey 2001; Rey and Montouri 1999; Tsionas 2000; Vohra 1998). In one of the pioneering studies on the issue Barro and Sala-i-Martin (1991) found significant evidence of economic convergence across 48 states in the USA (since 1880) and across 73 European regions (since 1950). There appears to be a general agreement in the majority of later studies that there was regional income convergence in Europe from the 1950s to the 1970s. In the decades since then the convergence process appears to have slowed down and stagnation to have arrived (Molle and Broeckhout 1995; Armstrong 1995). However, the real picture is not so simple. Neven and Gouyette (1994) have stressed that there are strong differences in the patterns of convergence across sub-periods and across subsets of regions. According to their study, there was divergence (or stagnation) in the first half of the 1980s in Northern Europe and strong convergence afterwards. On the other hand, regions in Southern Europe converged in the beginning of the decade and at best stagnated thereafter. Similar slowdowns in the convergence process after the second half of the 1970s have also been found in other countries (see Andrés

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[3] The term “club convergence`” can be traced back to Baumol (1986) and its more rigorous formulation comes from Durlauf and Johnson (1995) and Galor (1996) (see Nazrul Islam’s overview (Islam 2003) of the convergence debate).

and Doménech (1995) for OECD countries; Sala-i-Martin (1996) for Japan, USA and five European countries).

The study of Rey and Montouri (1999) was, to the best knowledge of the authors, the first to explicitly consider the role of spatial effects in a regional income convergence study. Analysing convergence patterns across states of the USA they found strong evidence of spatial autocorrelation in both the levels and growth rates of state per capita incomes. The authors deduced that while states may be converging in relative incomes, they do not do so independently but rather tend to display movements similar to those of their regional neighbours. Givin that the high degree of spatial aggregation might mask the existence of different growth trajectories below the state level, Lim (2003) assessed regional income convergence for the period 1969–99 using data for 170 economic areas[4] in the conterminous States of the USA, as defined by the Bureau of Economic Analysis. His findings reveal strong evidence supporting the presence of spatial dependence in both per capita personal income levels and per capita personal income growth during the sample period. However, taking the spatial dimension of growth into account lowers the estimation of *beta* (as an absolute value) but does not alter the general conclusion that per capita personal income growth in the economic areas is characterised by a process of convergence.

Arbia *et al* (2005) used spatial dependence panel data models to analyse the long-term convergence of *per capita* income in 92 Italian provinces in the period 1951–2000, and considered a structural break in the growth of Italian provinces at the beginning of the seventies. The speed of the convergence process was much higher in the first subperiod (1951–1970), and furthermore, the speed of convergence estimated using the spatial lag model was much lower than that arrived at with the classical fixed-effect specification.

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[4] An Economic Area is defined as a functional area which comprises one or more economic nodes, or metropolitan areas or similar areas that serve as centres of economic activity and the surrounding counties that are economically related to the nodes (Lim 2003).

Baumont *et al* (2002) showed that spatial dependence and spatial heterogeneity matter when estimating the *beta*-convergence process among 138 European regions over the period 1980–1995. Using spatial econometrics tools, the authors detected both spatial dependence and spatial heterogeneity in the form of structural instability across spatial convergence clubs. By using a spatial error model they found that the convergence process is different across spatial regimes. Slightly fewer regions (125 from 10 countries) but the same time period were used in the study by Arbia and Piras (2005) and the findings also indicate significant spatial effects between regions.

As we noted when looking at the earlier regional convergence studies, the empirical results vary considerably depending on the methods and the samples of countries and periods. Thus neither economic theory nor earlier empirical studies can give a clear prediction of regional income convergence processes in the EU-25 countries and their regions. Therefore further empirical analysis using modern econometric tools is an important input for elaborating regional policy instruments.

3. SPATIAL ECONOMETRICS METHODOLOGY FOR EXPLORING REGIONAL INCOME CONVERGENCE

3.1. Spatial econometrics tools for exploring regional income convergence

3.1.1. Spatial autocorrelation and heterogeneity

The use of spatial econometrics tools has become particularly popular in studies in recent years (eg Le Gallo *et al.*, 2003, Arbia and Paelinck, 2003a, 2003b). The motivation for using spatial econometrics tools is obvious: taking regional units as “isolated islands” (e.g. by using non-spatial estimation techniques) may lead to the wrong results, and in the presence of spatial effects in regression analysis the OLS estimations may be biased or inaccurate. Probably the main reason for income data being correlated between regions is spillover effects. Both spillover effects and their geographical range are significant for the development of regional disparities. Poorer regions might benefit from the growth and innovation initiated in the richer regions, but they will not be able to catch up to their income level if the spillovers are only local (see Bräuninger and Niebuhr 2004). Paci and Pigliaru (2001) found that the performance of each region does depend on that of the surrounding areas, and that the intensity of such spillovers fades with distance.

The main outcomes of spatial interactions are spatial dependence (spatial autocorrelation) and spatial heterogeneity. Spatial dependence in a collection of sample data observations refers to the fact that one observation associated with a location which we might label i depends on other observations at locations $j \neq i$. Mathematically (Le Sage 1998):

$$y_i = f(y_j),\ j \neq i. \tag{3}$$

The most widely used tools for testing spatial dependence are Moran's I and Geary c. Moran's I can be found by the formula

$$(4) \qquad I = (N/S)(\mathbf{e}'\mathbf{We}/\mathbf{e}'\mathbf{e}),$$

which – if the weight matrix W is row-standardised – simplifies to

$$(5) \qquad I = \mathbf{e}'\mathbf{We}/\mathbf{e}'\mathbf{e},$$

where $\boldsymbol{e}$ is the vector of regression residuals, $S = \sum_i \sum_j w_{ij}$ (where w_{ij} is the row-standardised weight) and N is the number of observations. A positive value of *Moran's I* indicates positive spatial autocorrelation and a negative value indicates negative spatial autocorrelation.

The Geary c can be found by the following equation:

$$(6) \qquad c = \frac{(n-1)\sum_i^n \sum_j^n w_{ij}(y_i - y_j)^2}{2(\sum_i^n \sum_j^n w_{ij})\sum_i^n (y_i - \bar{y})^2}, \ E(c) = 1,$$

where w_{ij} is the element of the weight matrix W, $\bar{y}$ is the mean of the dependent variable and n is the number of observations. If the value of *Geary c* is below one, there is positive spatial autocorrelation, while if the value of *Geary c* is above one, there is negative spatial autocorrelation. In addition to Moran's I and Geary c, Getis&Ord's G has been quite widely used.

The term spatial heterogeneity reflects a general instability in a behavioural relationship across the observational units. It might be expected that a different relationship would hold for every point in space. In regression analyse it can appear that the regression coefficients are varying or the dispersions of the error terms are not constant. We should also emphasise that there are complex relations between spatial autocorrelation and spatial heterogeneity; as pointed out by Anselin (2001) they often appear together. It is usually not clear cut whether spatial effects are in form of spatial autocorrelation or spatial heterogeneity.

3.1.2. Spatial weights

The most discussable question in using spatial econometric methods is how to define a weight matrix. The simplest and most often used spatial weight matrix is called the contiguity matrix. Measures of contiguity rely on the regions' or countries' depiction on the map. The contiguity matrix is usually a binary one where the observational units that have touching borders (are neighbours) are labelled with ones and the others with zeros. There are several ways to define the neighbourhood or contiguity (for more detailed overview see LeSage 1999).

Besides the contiguity-based matrices, spatial weight matrices can also be developed by using the location in Cartesian space represented by latitude and longitude, or by the direct distances between observational units. Observations that are near each other should reflect a greater degree of spatial dependence than those further away from each other. (*Ibid.*)

In this paper the distances (travel time) are used as the base of the weight matrix. More specifically, our weight matrix is based on the travel time of freight vehicles between the centres of regions.[5] As border impediments are included, the travel time from region *i* to region *j* may not be the same as that from region *j* to region *i*. If this is the case then the average travel time is used for technical reasons. An element w_{ij} of distance matrix W is calculated as follows:

$$w_{ij} = w_{ji} = \frac{1}{1/2\,(time_{ij} + time_{ji})} \tag{7}$$

As seen from the preceding review there are many different ways to construct the weight matrices. The one chosen in the paper has

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[5] We would like to thank Carsten Schürmann for the generous provision of the travel time data.

the advantage of using all of the available information, although it loses in simplicity and does not allow cut-points in distances.

3.1.3. Spatial econometrics models

The two main spatial dependence models are the spatial error model (SEM) and the spatial lag model (SLM). The spatial error model is relevant when the spatial dependence works through the error process, when the errors from different states (countries, regions) may display spatial covariance (see Rey and Montouri 1999). In a spatial error model we cannot distinguish the possible causes of spatial dependence (common shocks, institutions, national effects) (see also Abreu, et al 2005).

The spatial error model can be expressed as follows (in matrix notation):

(8) $y = X\beta + u$, $u = \lambda Wu + \varepsilon$,

where u is the spatially correlated error term, λ the spatial autoregressive error coefficient, W the spatial weight matrix and $\varepsilon \sim N(0, \sigma^2 I)$.

In the spatial lag model the spatial dependence comes into the model through the spatially lagged dependent variable. In the model of income convergence the growth rate in one country (region) depends on growth rates in its neighbours. The spatial lag model in the matrix notation can be expressed:

(9) $y = \rho Wy + X\beta + \varepsilon$.

where ρ is the scalar spatial autoregressive parameter and other terms are as previously defined.

The OLS (Ordinary Least Squares) method assumes that observations are independent of one another, and hence in the case of spatial dependence the OLS assumptions are violated. Spatial error model betas estimated using OLS are unbiased but inefficient and standard errors are biased. In the case of spatial lag model OLS estimates are biased and inconsistent (for proof see Anselin and Bera 1998).

The most popular method for estimating spatial lag and spatial error model is the maximum likelihood (ML) framework, first used by Ord (1975). The log-likelihood function for the spatial error model is as follows (see also Bivand 1999):

(10)

$$\ln L = -\frac{N}{2}\ln(2\pi) - \frac{N}{2}\ln\sigma^2 + \ln|\mathbf{I} - \lambda\mathbf{W}| - \\ - \frac{1}{2\sigma^2}[(\mathbf{y} - \mathbf{X}\beta)'(\mathbf{I} - \lambda\mathbf{W})'(\mathbf{I} - \lambda\mathbf{W})(\mathbf{y} - \mathbf{X}\beta)]$$

The log-likelihood function for the spatial lag model is:

(11)

$$\ln L = -\frac{N}{2}\ln(2\pi) - \frac{N}{2}\ln\sigma^2 + \ln|\mathbf{I} - \rho\mathbf{W}| - \\ - \frac{1}{2\sigma^2}[(\mathbf{y} - \rho\mathbf{W}\mathbf{y} - \mathbf{X}\beta)'(\mathbf{y} - \rho\mathbf{W}\mathbf{y} - \mathbf{X}\beta)]$$

The betas (β_{SE} and β_{SL} for the spatial error model and the spatial lag model respectively) in matrix form are expressed as follows:

(12) $\beta_{SE} = (\mathbf{X}'\mathbf{X})^{-1}\mathbf{X}'(\mathbf{I} - \lambda\mathbf{W})\mathbf{y}$, where λ is ML estimate,

(13) $\beta_{SL} = (\mathbf{X}'\mathbf{X})^{-1}\mathbf{X}'(\mathbf{y} - \rho\mathbf{W}\mathbf{y})$, where ρ is ML estimate,

In formulas (12) and (13) X is the matrix of the explanatory variable (per capita GDP initial level), W the spatial weight matrix and y the matrix of the dependent variable (per capita

GDP growth rate). The ML method is also used in our empirical analysis of income convergence in EU NUTS 3 level regions.

The other quite widely used method in recent years has been the generalised moments estimator (see Kelejian, Prucha 1999), and the Bayes approach, the spatial 2SLS and the computational estimators methods have also been used.

3.2. Equations for testing beta-convergence in EU countries

In this paper the following standard equation as a starting point for testing *beta*-convergence is estimated:

$$\ln(\frac{y_{if}}{y_{ib}}) = \alpha + \beta \ln(y_{ib}) + \sum_{j=1}^{N} \gamma_j d_{ji} + \varepsilon_i \qquad (14)$$

where

y_{ib} – GDP *per capita* in EURO (or PPS) in region *i* in base year (1995)

y_{if} – GDP *per capita* in EURO (or PPS) in region *i* in final year (2002),

d_{ij} = 1 if region *i* belongs to country *j*, otherwise d_{ij} = 0,

α , β and γ_j parameters to be estimated,

ε_i – error term.

Country specific dummy variables d_{ij} are used to test the conditional convergence hypothesis, assuming that they control for country-specific factors such as government policy, institutions, etc that affect income growth in region *i*. Of course there may be other factors that influence the income growth rate which are region specific rather than country specific (for example human capital) and which should be added into the regression if and when sufficient data (at NUTS 3 level) becomes available.

We estimate the equations both with and without country specific intercepts (corresponding to the conditional and unconditional convergence hypotheses respectively) and in both PPS terms and euro terms. We estimate the equations not only for the EU-25 as a whole but also for the EU-15 and the NMS, enabling us to control for possible convergence clubs (or convergence regimes) inside the EU-25. If the speed of convergence is significantly higher for those two groups compared to the EU-25 as a whole we can conclude that different convergence clubs exist.

To take spatial effects into account we use a spatial weight matrix that consists of the inverse of the time needed for travel between the regions. Because the necessary data are unavailable for some regions we have had to restrict our sample to 824 regions. See Appendix 1 for source data and technical details.

We first estimate the equation (13) with ordinary least squares and test for the presence of spatial effects using Lagrange Multiplier tests. If the presence of spatial effects is discovered, we continue estimating spatial lag (SLM) and spatial error models (SEM) using the Maximum Likelihood method.[6]

We estimate the following spatial lag model:

(15)

$$\ln(\frac{y_{if}}{y_{ib}}) = \alpha + \rho\left[W \cdot \ln(\frac{y_f}{yb})\right]_i + \beta \ln(y_{ib}) + \sum_{j=1}^{N} \gamma_j d_{ji} + \varepsilon_i ,$$

where

ρ is the spatial autoregressive parameter,

W is the weight matrix,

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[6] All the estimation is done in Stata. We use tools for spatial data analysis in Stata (ado files *spatwmat*, *spatreg, spatdiag*, etc) written by Maurizio Pisati (University of Milano), version 1.0. Stata Technical Bulletin 60 (2001).

$\left[W \cdot \ln(\frac{y_f}{y_b})\right]_i$ is the *i*-th element of the vector of weighted growth rates of other regions.

We also estimate the following spatial error model:

(16) $\ln(\frac{y_{if}}{y_{ib}}) = \alpha + \beta \ln(y_{ib}) + \sum_{j=1}^{N} \gamma_j d_{ji} + \varsigma_i$, and

$\varsigma_i = \lambda [W \cdot \varepsilon]_i + u_i$

where

λ is spatial autocorrelation coefficient,

$[W \cdot \varepsilon]_i$ is i-th element from the vector of weighted errors of other regions,

u_i is normally independently distributed random term.

We test whether $\rho = 0$ or $\lambda = 0$ using ML-based tests.

From the estimate of β we can derive two indicators often used to characterise *beta*-convergence: the speed of convergence and the half-life.

The speed of convergence measures how fast economies converge towards the steady state and we calculate it using the following formula[7]:

(17) $s = -\ln(1+\beta)/T$

where *T* is the number of periods for which we have data for *per capita* GDP growth rates (T=7, covering the time series 1996–2002).

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[7] Note that if the dependent variable is defined as average growth (as often found in the empirical literature), the formulas are slightly different (modifying the slope coefficient). Speed of convergence: $s = -\ln(1+T\beta)/T$ ·

Half-life: $\tau = -\ln(2)/\ln(1+\beta)$ (see for example Arbia *et al* 2005).

The half-life is defined as the time necessary for the economies to cover half of the initial lag from their steady states and we calculate it as follows:

$$(18)\quad \tau = -\ln(2)/\ln(1+\beta/T)$$

Of course, we should be rather careful when drawing conclusions on speed of convergence and half-life as the data come from a relatively short time period (1995–2002).

We follow the argument by Anselin and Florax (1995) that if the Lagrange Multiplier (LM) test for spatial lag is more significant than the LM test for spatial error, and the robust LM test for spatial lag is significant but the robust LM test for spatial error is not, then the appropriate model is the spatial lag model. Conversely, if the LM test for spatial error is more significant than the LM test for spatial lag and the robust LM test for spatial error is significant but the robust LM test for spatial lag is not, then the appropriate specification is the spatial error model. Because we often encounter situations when this decision rule cannot be strictly applied, we present all results in Annex 3 and Annex 4.

4. EMPIRICAL RESULTS

4.1. Data

The analysis of regional income disparities is conducted using Eurostat income data from the EU-25 countries and their 1214 NUTS 3 level regions during the period 1995–2002. We use GDP per capita in purchasing power standard (PPS) units and in euros of the NUTS 3 regions. Eurostat publishes nominal income levels by sub-national unit for the member states. Data on the EU-25 are also available for the period before the EU's first eastward enlargement. Income levels have been converted to euros by use of PPP (purchasing power parities), but within each country the relative incomes of regions have simply been scaled to the average GDP *per capita* in euros on a PPP basis. Regional price indexes – the adjusted data which convert these regional nominal incomes into regionally comparable incomes by taking account of the differing price levels within countries – are not available yet. It should be noted that Eurostat warns against using PPP adjusted GDP values to calculate growth rates over years, but as we use the growth rates not for single countries but to compare growth rates between countries, it should be less valid for our case. On the other hand, GDP in euros includes nominal convergence, causing potential for an overestimate of the real convergence.

Table 1 presents descriptive information on the sample of regions considered for the income convergence analysis. The data given in table 2 characterise the heterogeneity of regional income levels in the EU-25 and its groups of countries, the EU-15 and the NMS.

The NUTS 3 regions in the NMS constitute only 10% of the total of EU-25 regions; the equivalent share of the NMS countries' population is 16%. The average population of the NMS regions is twice as big as in EU-15 regions but the average per capita GDP (weighed by the population of the regions) was twice as big in the old member states than in the new ones in 2002. The income level of the poorest region (Tamega in Portugal) was almost 15 times lower than the income level of the richest region (Inner London West) of the EU-15, while in the NMS the same gap

Table 1. Data characterising the groups of countries in EU-25 and NUTS 3 level regions, 2002

Group of countries	Number of regions	Population of the groups of countries (mln)	Average population of regions ('000s)	Average population density in km^2	Regions' average GDP per capita (PPS, '000s)*
EU-25	1214	453.8	374	116.6	21.2
EU-15	1091	379.5	348	120.3	23.2
NMS-10	123	74.2	604	100.5	11.0

Source: Eurostat, authors' calculations; * – weighted by population

Table 2. Regional income disparities in the EU-25 countries, 2002 (per cent of EU-25 average)

	Average	Minimum	Maximum	Variation coefficient*
EU-25	100.0	18.9 (Latgale, Latvia)	569.8 (Inner London West, UK)	0.039
EU-15	108.4	38.2 (Tamega, Portugal)	569.8 (Inner London West, UK)	0.040
NMS	51.8	18.9 (Latgale, Latvia)	152.8 (Prague, Czech Republic)	0.032

*Of ln (GDP per capita)

Source: *Eurostat*, authors' calculations.

indicator was 8: the poorest region was Latgale in Latvia and the richest one Prague in the Czech Republic in 2002. The income level of the EU-15's poorest region is about double that of the NMS's, while in the richest region it is quadruple the level of the NMS's richest. It is true, however, that high-income regions usually have higher prices, but in the calculations of GDP in PPS the average of the country is used. Thus, the real income disparities are likely to be a bit less dramatic.

4.2. Beta-convergence analysis

The estimation results are summarised in Table 3 (see Annex 2 and Annex 3 for details). Results for the EU-15 and the NMS are presented both with and without country dummies, and using GDP per capita in both in euros and in PPS.

Two main preliminary conclusions can be drawn from the models. First, there was absolute convergence in the EU-25 regions, meaning that the regions with lower per capita GDP grew at a higher speed during the period 1995–2002. The speed of regional income convergence was higher for the EU-15 than for the NMS. However, in most specifications we found that there was no evidence for convergence between the EU-15 regions if the country dummies were included in the model. Moreover, there were signs of regional income divergence for the new member states. This means that although there was an overall regional income convergence in the EU-25 countries, there was on average no convergence within the countries; the regional income disparities within the new member states even grew during the EU pre-enlargement period. If we want to widen these results and link them with theoretical considerations, it may be concluded that the harmonisation of the institutional frameworks may be one key factor in driving the country-level income convergence. On the other hand, the NEG suggested agglomeration and core-periphery patterns seem to dominate at regional level. As the rates of convergence for the two subgroups – the EU-15 and the NMS – were not considerably higher than for the EU-25 as a whole, we did not find support for the hypothesis of these groups as possible convergence clubs. However, as the clear core-periphery pattern has appeared some unidentified convergence regimes still appear to exist.

Table 3. *Beta*-convergence (absolute and conditional) in EU-15 and NMS regions in 1995–2002

	Linear model (OLS)		Spatial error model		Spatial lag model	
	Values in EUR					
Country dummies	No	Yes	No	Yes	No	Yes
GDP per capita 1995	–0.214*** (0.016)	–0.017 (0.013)	–0.228*** (0.017)	–0.032 (0.017)	–0.264*** (0.015)	–0.0376** (0.016)
NMS x GDP per capita 1995	0.028 (0.041)	0.142** (0.041)	0.037 (0.042)	0.154*** (0.041)	0.062 (0.044)	0.1595*** (0.040)
R^2	0.393	0.855	0.393	0.849	0.479	0.858
Speed of convergence – EU15	0.034	0.002	0.037	0.005	0.044	0.005
Half-life – EU15	22.3	293.0	20.9	150.0	18.0	128.7
Speed of convergence – NMS	0.029	–0.017	0.030	–0.016	0.032	–0.016
Half-life – NMS	25.7		25.1		23.7	
	Value in PPS					
GDP per capita 1995	–0.097*** (0.015)	–0.016 (0.013)	–0.085*** (0.015)	–0.033* (0.016)	–0.091*** (0.016)	–0.036* (0.016)
NMS x GDP per capita 1995	0.082** (0.030)	0.142*** (0.041)	0.072* (0.029)	0.155*** (0.041)	0.077** (0.030)	0.158*** (0.041)
R^2	0.125	0.430	0.125	0.413	0.127	0.438
Speed of convergence – EU15	0.015	0.002	0.013	0.005	0.014	0.005
Half-life – EU15	49.7	295.4	56.7	148.2	53.0	134.4
Speed of convergence – NMS	0.002	–0.017	0.002	–0.016	0.002	–0.016
Half-life – NMS	323.1		372.9		346.2	

Robust standard errors in the parentheses under the estimated coefficients
Significance levels – *** – $p<0.001$, ** – $p<0.01$, * – $p<0.05$
Source: authors' calculations based on data from *Eurostat*; see details in Annex 2. For more information about the full set of the estimated convergence equations see Annexes 3 and 4.

Secondly, there is evidence for spatial effects. ML tests on our OLS specifications indicated a clear spatial dependence when using our weight matrix (see Appendix 2, table A2 and Appendix 3, table A5). There are several possible reasons with a robust theoretical background for positive spatial autocorrelation to exist. We believe one of the most important of them to be technological spillovers and the fact that the intensity of such spillovers fades with distance. As shown by Paci and Pigliaru (2001) these spillovers are strong enough to play a role that can not be ignored in an econometric analysis of the convergence process in Europe.

When spatial effects are taken into account, the speed of convergence is slightly higher when GDP in euros is used and about the same when GDP in PPS is used. These results contradict somewhat some earlier empirical studies which have found that taking spatial effects into account reduces convergence (e.g. Rey, Montouri (1999), Lim (2003), Arbia, Basile, Piras (2005)). Of course we should consider that the empirical results derived from the application of spatial and non-spatial models are not fully comparable, and the coefficient β in the SLM is different from that in the OLS-model. While the latter is a measure of the direct marginal effects of a change in the dependent variable only, the former also includes the indirect and induced effects of the spatial multiplier process. Similarly, the nature of the spatial effects captured by the SEM is also a global one and follows a spatial multiplier process across the whole sample of regions (see also Abreu et al. (2004)). The estimations are also sensitive to a variety of factors such as the design of the weight matrix, the regional level of aggregation and the cross-section itself.

The empirical results allow us to conclude that the catching up by the NMS at the national level seems to be driven mainly by a few high growth regions: Prague with 152.8% of the EU-25 average, Warsaw with 132.0%, Budapest 124.0%, Bratislava 119.5%, Ljubljana 106.6%; Tallinn 71.3%, Riga 70.1% and Vilnius 60.1% in 2002 (Eurostat, 2006). Furthermore, regional development in the EU-15 has mainly been characterised by increasing disparities between the central and peripheral regions, for example quick growth in the “blue banana” regions, which range from northern Italy to the south of the United Kingdom. The less prosperous regions are situated in the peripheral parts of southern Europe, the north of the United Kingdom and eastern Germany.

The results of our analysis are also in accordance with the findings of Niebuhr and Schlitte (2004), which are based on the NUTS 2 level data of GDP *per capita* (Euro) during the period 1995–2000. The findings of several other studies also indicated that the high growth regions coincide essentially with highly competitive agglomerations and thus the regions that are already marked by a relatively high GDP *per capita* (see Tondl and Vuksic, 2003). The decline of income disparities between the countries is often accompanied by increasing regional disparities within the member states, which underlines the need to improve conditions for economic growth at both national and regional levels.

CONCLUSION

The results of the income analysis in the EU countries and their NUTS 3 level regions show significant regional disparities in both groups of countries, the old (EU-15) and new member states (NMS). Income disparities were considerably higher in the EU-15 countries than in the new member states, but in the latter the growth of disparities was remarkable during the period under observation. We also noticed that the speed of regional income convergence processes was slow as shown by *beta*-convergence analysis. The average speed of absolute convergence in terms of euros and in PPS units was higher for the EU-15 than for the NMS. Taking national effects into account reveals that the general catching up process was driven mainly by country-specific effects. This is particularly the case in the NMS. When regions are allowed to converge towards country-specific steady state levels of per capita income, the convergence rate across regions in the NMS becomes negative. Hence, in the course of the general catching up by the NMS, regional disparities within countries have increased. This can be explained by the high dynamics in the regions which happened to already be relatively rich at the outset in 1995. Predominantly, the richest and most dynamic regions in the NMS were the capital regions and their hinterlands as well as some other metropolitan areas. Consequently, many remote and rural regions have lagged behind the relatively rich and dynamic growth leaders.

Overall, the estimations of the spatial econometric models show that spatial dependence across regions does matter. However, since spatial autocorrelation seems to be sufficiently captured by country dummies, the results demonstrate that national macroeconomic factors seem to be more important for regional growth than spatial interaction. The simultaneous processes of the NMS generally catching up towards the EU-15 on the one hand, and regional disparities increasing within the NMS on the other hand hint at the existence of a trade-off between high growth rates at the national level and regional convergence within countries in the NMS. This possible relationship between national growth and regional inequality within countries should be considered by EU cohesion policy when pursuing the community objectives. We agree with Tondl (2001) that the level of economic integration in wealthier EU-15 countries is relatively advanced and that the forces that promote convergence in New Growth Theory and integration theory have replaced the forces that drove divergence in the 1980s. However, this only seems to be the case at country level when the harmonisation of institutional frameworks and spatial spillovers drive convergence, and these forces seem not to have prevailed yet at regional level within countries, particularly in the NMS. However, if it can be expected (as evidenced by our findings of existing spatial interactions) that, sooner or later, the dynamics of the relatively rich metropolitan areas in the NMS will spill over to rural and more remotely situated regions, then all regions in these countries might benefit in the future. Therefore, it might be inefficient to support only those regions with low income levels as it is currently done by the EU. In order to pursue the community objectives, EU structural policy has to find the right balance between preventing deterioration in some regions and promoting regional dynamics and growth poles.

As one of the key limitations of the paper, the short time series should be mentioned. This means that some caution is needed when drawing conclusions from the speed of convergence and half-life findings. Furthermore, it may be the case that the results are quite sensitive to the spatial weight matrix chosen, which would make it problematic to compare them with the findings from papers with contiguity matrices as weights.

In addition to country-specific dummies, many other factors that may affect regional income levels should be considered in further analyses. In particular, adding some region-specific variables (for instance human capital) into the regression may give some new insights to the topic.

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APPENDIX 1. Description of data

GDP per capita

The GDP *per capita* is from the general and regional statistics database of Eurostat, extracted on November 2005. We use GDP *per capita* in Purchasing Parity Standard (PPS) units (PPP adjusted) and at current marked prices, in ECU up to 12.12.1998 and in EUR from 01.01.1999. GDP in PPS is calculated using country-specific (not regional) PPP conversion rates, which means that variation of prices within countries is not taken into account.

In the descriptive analysis of income disparities we use 1214 NUTS 3 regions. Because of data problems, we use 824 regions in *beta*-convergence analysis (growth models). We have excluded the regions of Cyprus, Malta and Latvia, because we had no data with which to construct the weight matrix. We also use NUTS 2 level data for Poland and the so-called "planning regions" for Germany for similar reasons. Finally, we did not have information on 8 oversees regions (4 in France and 4 in Spain), but they have hardly any significant interactions with the other regions in the EU.

Table A1. EU-25 countries and number of regions used in the models

Country	Classification	Number of regions used
Austria	NUTS 3	35
Belgium	NUTS 3	43
Czech Republic	NUTS 3	14
Germany	Planning regions	97
Denmark	NUTS 3	15
Estonia	NUTS 3	5
Spain	NUTS 3	48
Finland	NUTS 3	20
France	NUTS 3	96
Greece	NUTS 3	51
Hungary	NUTS 3	20
Ireland	NUTS 3	8
Italy	NUTS 3	103
Lithuania	NUTS 3	10

Country	Classification	Number of regions used
Luxembourg	NUTS 3	1
Netherlands	NUTS 3	40
Poland	NUTS 2	16
Portugal	NUTS 3	28
Sweden	NUTS 3	21
Slovenia	NUTS 3	12
Slovakia	NUTS 3	8
United Kingdom	NUTS 3	133
Total		824

APPENDIX 2. Estimation results from econometric models – data in Euros

Table A2. Linear model (OLS estimates), GDP in EUR

	EU				EU15		NMS	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Intercept	2.401*** (0.095)	0.114 (0.131)	2.391 (0.149)	1.414 (0.211)	2.391*** (0.149)	0.341* (0.132)	2.178*** (0.312)	-0.446 (0.326)
Dummy for new member states (NMS)			–0.214 (0.343)	–1.186*** (0.329)				
GDP_1995	–0.215*** (0.010)	0.006 (0.013)	–0.214*** (0.016)	–0.017 (0.013)	–0.214*** (0.016)	-0.017 (0.013)	-0.187*** (0.038)	0.125** (0.040)
NMS* GDP_1995			0.028 (0.041)	0.142** (0.041)				
Country dummies	No	Yes	No	Yes	No	Yes	No	Yes
Number of obs.	824	824	824	824	739	739	85	85
R^2	0.392	0.851	0.393	0.855	0.213	0.811	0.312	0.838
Tests for spatial error	+	+	+	+	+	+	+	
Moran's I	129.827 (p=0.000)	9.610 (p=0.000)	133.635 (p=0.000)	9.929 (p=0.000)	139.541 (p=0.000)	10.210 (p=0.000)	61.678 (p=0.000)	-1.116
Lagrange multiplier	6999.510 (p=0.000)	9.056 (p=0.003)	7145.118 (p=0.000)	9.928 (p=0.002)	7452.461 (p=0.000)	11.291 (p=0.001)	45.349 (p=0.000)	0.091 (p=0.763)

	EU				EU15		NMS	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Robust Lagr. multip	6822.117 (p=0.000)	6.814 (p=0.009)	6952.642 (p=0.000)	7.104 (p=0.009)	7189.292 (p=0.000)	8.315 (p=0.004)	53.353 (p=0.000)	0.902 (p=0.342)
Tests for spatial lag		+		+	+	+		+
Lagrange multiplier	179.420 (p=0.000)	12.420 (p=0.000)	194.434 (p=0.000)	18.122 (p=0.000)	279.667 (p=0.000)	17.511 (p=0.000)	1.317 (p=0.251)	5.764 (p=0.016)
Robust Lagr. multip	2.027 (p=0.155)	10.178 (p=0.001)	1.959 (p=0.162)	15.298 (p=0.001)	16.499 (p=0.000)	14.535 (p=0.000)	9.320 (p=0.002)	6.575 (p=0.010)
Speed of convergence	0.035	–.0009	$0.034^{\#}$	$0.002^{\#}$	0.034	0.002	0.029	-0.017
Half-life	22.2		$22.3^{\#}$	$293.0^{\#}$	22.3	293.0	25.6	

Robust standard errors are in the parentheses under the estimated coefficients; p-values in the parentheses under test-statistics.

Significance levels – *** – p<0.001, ** – p<0.01, * – p<0.05

$^{\#}$ – speed of convergence and half-life for EU15

All estimations are done in Stata. We used tools for spatial data analysis in Stata (ado files *spatwmat*, *spatreg, spatdiag*, etc) written by Maurizio Pisati (University of Milano), version 1.0. Stata Technical Bulletin 60 (2001).

Table A3. Spatial error model, GDP in EUR

	EU				EU15		NMS	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Intercept	2.492***	0.033	2.528***	0.502**	2.623***	0.501**	1.348***	–0.339*
	(0.104)	(0.040)	(0.169)	(0.169)	(0.171)	(0.170)	(0.228)	(0.133)
Dummy for new member state (NMS)			–0.295	0.181				
			(0.352)	(0.983)				
GDP_1995	–0.224***	0.015***	–0.228***	–0.032	–0.237***	–0.031	–0.184***	0.141***
	(0.011)	(0.003)	(0.017)	(0.017)	(0.018)	(0.017)	(0.029)	(0.030)
NMS* GDP_1995			0.037	0.154***				
			(0.042)	(0.041)				
Country dummies		yes		yes		yes		yes
Squared correlation between actual and predicted GDP	0.392	0.847	0.393	0.849	0.213	0.803	0.312	0.835
Skewness/Kurtosis test for Normality	109.62	52.78	109.51	42.77	104.10	41.55	10.84	7.76
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.004)	(0.021)
Lambda	0.016*	0.843***	0.017*	0.123*	0.029***	0.123*	–0.795**	–1.011
	(0.008)	(0.186)	(0.008)	(0.050)	(0.008)	(0.052)	(0.255)	(0.682)
Tests for lambda=0								

	EU				EU15		NMS	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Wald test	4.126 (p=0.042)	20.657 (p=0.000)	4.520 (p=0.034)	6.081 (p=0.014)	13.725 (p=0.000)	5.682 (p=0.017)	9.684 (p=0.002)	2.200 (p=0.138)
LM test	6999.510 (p=0.000)	9.056 (p=0.003)	7145.118 (p=0.000)	9.928 (p=0.002)	7452.461 (p=0.000	11.291 (p=0.001)	45.349 (p=0.000)	0.091 (p=0.763)
Speed of convergence	0.036	–0.002	0.037#	0.005#	0.039	0.005	0.029	–0.019
Half-life	21.3		20.9#	150.0#	20.1	154.5	26.0	

Robust standard errors are in the parentheses under the estimated coefficients; p-values in the parentheses under test-statistics. Significance levels – *** – p<0.001, ** – p<0.01, * – p<0.05; # – speed of convergence and half-life for EU15
Lambda – spatial autoregressive error coefficient

Table A4. Spatial lag model, GDP in EUR

	EU				EU15		NMS	
	(1)	(2)	(3)	(4)	(1)	(2)	(1)	(2)
Intercept	2.535*** (0.095)	0.081*** (0.003)	2.690*** (0.144)	0.833*** (0.123)	2.636*** (0.139)	0.079*** (0.003)	2.252*** (0.323)	0.084*** (0.008)
Dummy for new member state (NMS)			–0.533 (0.364)	–1.317*** (0.326)				
GDP_1995	–0.247*** (0.010)	–0.009 (0.015)	–0.264*** (0.015)	–0.0376** (0.016)	–0.258*** (0.015)	–0.036* (0.015)	–0.190*** (0.038)	0.124*** (0.038)
NMS* GDP_1995			0.062 (0.044)	0.1595*** (0.040)				
Country dummies		yes		Yes		yes		yes
Squared correlation between actual and predicted GDP	0.479	0.853	0.479	0.858	0.386	0.816	0.322	0.844
Skewness/Kurtosis tests for Normality	78.52 (0.000)	52.69 (0.000)	80.36 (0.000)	49.82 (0.000)	65.59 (0.000)	44.56 (0.000)	11.21 (0.004)	8.54 (0.014)
Rho	0.579*** (0.053)	0.184* (0.078)	0.590*** (0.053)	0.221*** (0.078)	0.673*** (0.050)	0.223** (0.081)	–0.508 (0.612)	0.575 (0.335)
Tests for rho=0								

	EU				EU15		NMS	
	(1)	(2)	(3)	(4)	(1)	(2)	(1)	(2)
Wald test	117.741 (p=0.000)	5.542 (p=0.019)	117.741 (p=0.000)	8.092 (p=0.004)	182.258 (p=0.000)	7.527 (p=0.006)	0.688 (p=0.407)	2.942 (p=0.086)
LM test	179.420 (p=0.000)	12.420 (p=0.000)	179.420 (p=0.000)	18.122 (p=0.000)	279.667 (p=0.000)	17.511 (p=0.000)	1.317 (p=0.251)	5.764 (p=0.016)
Speed of convergence	0.041	0.001	$0.044^{\#}$	$0.005^{\#}$	0.043	0.005	0.030	-0.017
Half-life	19.3	558.3	$18.0^{\#}$	$128.7^{\#}$	18.4	132.7	25.2	

Robust standard errors are in the parentheses under the estimated coefficients; p-values in the parentheses under test-statistics. Significance levels – *** – p<0.001, ** – p<0.01, * – p<0.05; $^{\#}$ – speed of convergence and half-life for EU15
Rho – scalar spatial autoregressive parameter

APPENDIX 3. Estimation results from econometric models – data in PPS

Table A5. Linear model (OLS estimates), GDP in PPS

	EU				EU15		NMS	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Intercept	1.219*** (0.108)	0.218 (0.129)	1.247*** (0.148)	0.440*** (0.131)	1.247*** (0.148	0.440*** (0.130)	0.535* (0.229)	–0.901* (0.364)
Dummy for new member states (NMS)			–0.712** (0.271)	–1.081** (0.363)				
GDP_1995	–0.094*** (0.011)	0.007 (0.013)	–0.097*** (0.015)	–0.016 (0.013)	–0.097*** (0.015)	–0.016 (0.013)	–0.015 (0.026)	0.125** (0.040)
NMS* GDP_1995			0.082** (0.030)	0.142*** (0.041)				
Country dummies		yes		Yes		yes		yes
Number of obs.	824	824	824	824	739	739	85	85
R^2	0.104	0.416	0.125	0.430	0.079	0.416	0.004	0.488
Tests for spatial error	+	+	+	+	+	+/–	+	
Moran's I	30.254 (p=0.000)	9.511 (p=0.000)	32.860 (p=0.000)	9.832 (p=0.000)	33.041 (p=0.000)	10.106 (p=0.000)	36.312 (p=0.000)	–1.118
Lagrange multiplier	373.269 (p=0.000)	8.786 (p=0.003)	429.133 (p=0.000)	9.652 (p=0.002)	416.409 (p=0.000)	10.983 (p=0.001)	16.163 (p=0.000)	0.091 (p=0.763)

	EU				EU15		NMS	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Robust Lagr. multip	381.936 (p=0.000)	6.819 (p=0.009)	436.722 (p=0.000)	6.934 (p=0.008)	419.470 (p=0.000)	8.147 (p=0.004)	16.701 (p=0.000)	1.379 (p=0.240)
Tests for spatial lag	+			+		+/–		+
Lagrange multiplier	2.854 (p=0.091)	6.706 (p=0.010)	1.264 (p=0.261)	11.543 (p=0.001)	0.001 (p=0.978)	11.044 (p=0.001)	0.116 (p=0.733)	4.252 (p=0.039)
Robust Lagr. multip	11.522 (p=0.001)	4.739 (p=0.029)	8.852 (p=0.003)	8.824 (p=0.003)	3.062 (p=0.080)	8.209 (p=0.004)	0.654 (p=0.419)	5.541 (p=0.000)
Speed of convergence	0.014	–0.001	$0.015^{\#}$	$0.002^{\#}$	0.015	0.002	0.002	–0.017
Half-life	51.4		$49.7^{\#}$	$295.4^{\#}$	49.7	295.4	329.9	

Robust standard errors are in the parentheses under the estimated coefficients; p-values in the parentheses under test-statistics.
Significance levels – *** – $p<0.001$, ** – $p<0.01$, * – $p<0.05$; $^{\#}$ – speed of convergence and half-life for EU15.

Table A6. Spatial error model, GDP in PPS

	EU				EU15		NMS	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Intercept	1.089*** (0.110)	0.293 (0.192)	1.123*** (0.142)	0.604*** (0.161)	1.176*** (0.145)	0.604*** (0.163)	0.535* (0.232)	-0.582** (0.203)
Dummy for new member state (NMS)			–0.622* (0.263)	4.379 (3.936)				
GDP_1995	–0.081*** (0.011)	–0.001 (0.020)	–0.085*** (0.015)	–0.033* (0.016)	–0.090*** (0.015)	–0.032 (0.016)	–0.015 (0.033)	0.131*** (0.030)
NMS* GDP_1995			0.072* (0.029)	0.155*** (0.041)				
Country dummies	No	Yes	No	Yes	No	Yes	No	Yes
Squared correlation between actual and predicted GDP	0.104	0.405	0.125	0.413	0.079	0.358	0.004	0.455
Skewness/Kurtosis tests for Normality	118.28 (0.000)	45.07 (0.000)	109.50 (0.000)	42.81 (0.000)	116.11 (0.000)	41.58 (0.000)	2.76 (0.251)	6.40 (0.041)
Lambda	–0.034* (0.014)	0.157 (0.112)	–0.027* (0.013)	0.101* (0.040)	–0.015 (0.012)	0.101* (0.041)	0.003 (0.652)	-0.893 (0.483)
Tests for lambda=0								
Wald test	6.060 (0.014)	1.983 (0.159)	4.434 (0.035)	6.467 (0.011)	1.674 (0.196)	5.986 (0.014)	0.000 (0.996)	3.422 (0.064)

	EU				EU15		NMS	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
LM test	373.269 (0.000)	8.786 (0.003)	429.133 (0.000)	9.652 (0.002)	416.409 (0.000)	10.983 (0.001)	16.163 (0.000)	0.091 (0.763)
Speed of convergence	0.012	0.000	$0.013^{\#}$	$0.005^{\#}$	0.013	0.005	0.002	-0.018
Half-life	59.7	6967.4	$56.7^{\#}$	$148.2^{\#}$	53.5	152.3	331.4	

Robust standard errors are in the parentheses under the estimated coefficients; p-values in the parentheses under test-statistics.

Significance levels – *** – $p<0.001$, ** – $p<0.01$, * – $p<0.05$; $^{\#}$ – speed of convergence and half-life for EU15

Lambda – spatial autoregressive error coefficient

Table A7. Spatial lag model, GDP in PPS

	EU				EU15		NMS	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Intercept	1.166*** (0.111)	0.295* (0.139)	1.200*** (0.150)	0.611*** (0.138)	1.248*** (0.149)	0.568*** (0.144)	0.525* (0.236)	-0.922** (0.339)
Dummy for new member state (NMS)			–0.666* (0.270)	–1.273*** (0.359)				
GDP_1995	–0.086*** (0.012)	–0.006 (0.015)	–0.091*** (0.016)	–0.036* (0.016)	–0.097*** (0.016)	–0.035* (0.016)	–0.014 (0.026)	0.124** (0.038)
NMS* GDP_1995			0.077** (0.030)	0.158*** (0.041)				
Country dummies	No	Yes	No	Yes	No	Yes	No	Yes
Squared correlation between actual and predicted GDP	0.107	0.421	0.127	0.438	0.079	0.387	0.005	0.498
Skewness/Kurtosis tests for Normality	116.04 (0.000)	52.94 (0.000)	107.59 (0.000)	49.92 (0.000)	116.50 (0.000)	44.69 (0.000)	2.72 (0.256)	9.20 (0.010)
Rho	–0.068 (0.045)	0.168 (0.093)	–0.045 (0.044)	0.219* (0.092)	0.001 (0.044)	0.220* (0.096)	0.110 (0.548)	0.458 (0.426)
Tests for rho=0								
Wald test	2.265 (0.132)	3.296 (0.069)	1.046 (0.306)	5.661 (0.017)	0.001 (0.981)	5.227 (0.022)	0.040 (0.841)	1.154 (0.283)

	EU				EU15		NMS	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
LM test	2.854 (0.091)	6.706 (0.010)	1.264 (0.261)	11.543 (0.001)	0.001 (0.978)	11.044 (0.001)	0.116 (0.733)	4.252 (0.039)
Speed of convergence	0.013	0.001	$0.014^{\#}$	$0.005^{\#}$	0.015	0.005	0.002	–0.017
Half-life	55.9	788.2	$53.0^{\#}$	$134.4^{\#}$	49.6	139.6	335.9	

Robust standard errors are in the parentheses under the estimated coefficients; p-values in the parentheses under test-statistics.

Significance levels – *** – $p<0.001$, ** – $p<0.01$, * – $p<0.05$; $^{\#}$ – speed of convergence and half-life for EU15

Rho – scalar spatial autoregressive parameter

KOKKUVÕTE

Riikide ja regioonide vaheline tulutasemete konvergents on olnud viimaste kümnendite jooksul majandusteadlaste seas kõrgendatud huvi allikas. Teema aktuaalsusest annab tunnistust fakt, et ebavõrdsuse vähendamine kuulub Euroopa Liidu regionaalpoliitika olulisemate prioriteetide hulka. Informatsioon konvergentsiprotsesside kohta on tähtis otstarbekate poliitikate kujundamisel ja vajalike institutsionaalsete muudatuste läbiviimisel saavutamaks tasakaalustatud ning jätkusuutlikku majandusarengut. Käesoleva uurimuse eesmärgiks oli hinnata tulutasemete konvergentsi nn idalaienemisele eelneval perioodil (1995–2002) nii Euroopa Liidus tervikuna, kui ka eraldi vanade (EL15) ja uute liikmesriikide (ULR) riikide rühmas. Eesmärgi saavutamiseks vaadeldi mitmeid konvergentsi teoreetilisi käsitlusi, tehti kokkuvõte varasematest empiirilistest tulemustest ning analüüsiti alternatiivseid konvergentsi hüpoteese ja testimismetoodikaid. Lõpuks anti ülevaade ruumiökonomeetria meetoditest ning kasutati neid empiirilises konvergentsianalüüsis.

Konvergentsi võib defineerida kui ühtlustumist vaadeldavate objektide või nähtuste omaduste vahel. Tulutasemete regionaalne konvergents tähendab seega erinevate regioonide tulutasemete (*per capita* SKP tasemete) ühtlustumist. Teoreetilise külje pealt kerkivad konvergentsianalüüsides esile kaks konkureerivat teooriat: neoklassikaline kasvuteooria ja endogeense kasvu teooria. Esimene neist on oluliseks tagapõhjaks nn konvergentsi optimismile ja teine pessimismile. Olulisi aspekte konvergentsi kohta pakuvad ka Uus Majandusgeograafia ning integratsiooniteooria. Tihtipeale on mööda vaadatud institutsionaalse kasvuteooria seisukohtadest, ilma milleta aga – vähemalt selle teooria poolehoidjate arvates – on adekvaatne konvergentsianalüüs mõeldamatu. Kindlat vastust konvergentsiprotsessi suuna kohta majandusteooria seega anda ei suuda, selge on vaid majanduskasvu ja majandusarengu konvergentsiprotsesside mõjutegurite paljusus ja mitmekesisus.

Regionaalse tulutasemete konvergentsi empiiriliste analüüside populaarsus on hüppeliselt kasvanud alates 1990. aastatest. Tavaliselt on neis keskendutud absoluutse ja/või tingimusliku konvergentsi hüpoteesi testimisele, harvem uuritud klubikonvergentsi võimalust. Absoluutse konvergentsi hüpoteesi korral SKP tasemed inimese kohta eri riikides (regioonides) ühtlustuvad pikal perioodil omavahel, olenemata esialgsetest tingimustest. Tingimusliku konvergentsi hüpoteesi järgi on konvergentsi esinemiseks vaja ka sarnaseid struktuurseid parameetreid (nagu tehnoloogia, valitsuse poliitika, haridustase jms), esialgsed tingimused ei mängi aga endiselt rolli. Klubikonvergentsi hüpoteesi korral seevastu konvergeeruvad omavahel vaid sarnaste lähtetingimustega regioonid (või riigid), moodustades seeläbi nn konvergentsiklubisid. Empiiriliselt on erinevusi tingimusliku ja klubikonvergentsi vahel keeruline testida.

Traditsioonilised metoodikad konvergentsi testimiseks on beeta *(β) –* ja sigma *(σ)–*konvergentsi analüüsid. *β*-konvergents tähistab olukorda, kus vaesemad riigid või regioonid kasvavad kiiremini kui rikkamad ning väljendub negatiivse seosega tulude kasvumäära ja lähtetaseme vahel. *σ*-konvergentsiga on tegu, kui riikide või regioonide vahelised tuluerinevused ajas vähenevad. Seda väljendatakse vaadeldavate majanduste vahelise tulujaotuse dispersiooni vähenemisega uuritaval perioodil. Enamasti on regionaalse tulutasemete konvergentsi analüüsides jõutud ühtlustumist toetava tulemuseni, ehkki samas on leitud, et *per capita* SKP erinevuste dünaamika võib olla väga erinev olenevalt vaadeldavast ajaperioodist ning uuritavast majanduste rühmast. Vastuolulisi tulemusi on saadud ka riikide vahelise ja riigisisese konvergentsi analüüsides. Üheks väheseks üldiseks järelduseks neist tundub olevat konvergentsi toimumine vaid üksikute riikiderühmade korral mitte aga kogu maailma riikide vahel.

Paraku käsitletakse enamuses empiirilistest analüüsidest vaadeldavaid majandusi kui “isoleeritud saari” ignoreerides võimalikke ruumilisi mõjusid. Reaalsuses esinevad aga erinevate regioonide vahel vastastikused mõjud ning nende eiramine regressioonimudelis võib viia väärate tulemuste ning järeldusteni. Enamasti erinevate vaatluste omavaheline mõju väheneb vahemaa kasvades. Ruumiliste mõjude all mõistetakse eelkõige ruumilist sõltuvust (ruumilist autokorrelatsiooni) ja ruumilist heterogeensust. Ruumiline autokorrelatsioon tähendab, et vaatluse väärtus mingis ruumipunktis sõltub teiste vaatluste väärtustest teistes ruumipunktides. Enamasti, nagu ka käesolevas uurimuses, on tegu positiivse autokorrelatsiooniga, mille korral sarnased vaatluste tulemused langevad kokku sarnase geograafilise asukohaga. Ruumiline heterogeensus tähendab, et majanduslikud seosed ei ole ruumis stabiilsed. Ruumiliste mõjude olemasolu testimiseks regressioonimudelis on populaarseimateks vahenditeks *Moran'i I* ning *Lagrange Multiplier* testid. Ruumiliste mõjude eksisteerimise korral tuleb neid regressioonianalüüsis arvesse võtta spetsiaalseid mudeleid ning nende hindamiseks sobivaid meetodeid kasutades.

Käesolevas töös sai kinnitust paljudest varasemates uurimustest leitud asjaolu, et traditsiooniline *kasvu-lähtetaseme* regressioon ei ole sobiv regionaalse tulutasemete konvergentsi analüüsiks. Euroopa Liidu regioonide *per capita* SKP tasemete vahel esineb oluline ruumiline sõltuvus, mille arvesse võtmiseks on koostatud ruumilise vea ja ruumilise lükkega mudelid. Empiirilisest analüüsist selgus, et absoluutne tulutasemete konvergents regionaalsel tasandil on vaadeldud riikide rühmades toimunud. Tingimusliku konvergentsi hüpotees leiab kinnitust aga vaid EL15 riikide puhul, uutes liikmesriikides on analüüsitaval perioodil regionaalsed tuluerinevused suurenenud. Kuna absoluutse konvergentsi hüpotees leidis kinnitust, tingimusliku konvergentsi hüpotees enamikul juhtudel aga mitte, siis võib järeldada, et konvergents on toimunud küll riikide vahel, kuid mitte regioonide vahel riikide siseselt. Kiire majanduskasvuga on reeglina kaasnenud regionaalsete tuluerisuste suurenemine. Eelkõige toimub areng suurlinnade ümber olevates regioonides; ülekandeefektid (*spillover*) vaesematesse piirkondadesse küll toimuvad, kuid aeglaselt.

Läbiviidud analüüsi tulemused kinnitavad regionaalpoliitika jätkuvat olulisust Euroopa Liidu liikmesriikide ja regioonide majandusarengu toetamisel. Suuremat tähelepanu tuleb pöörata liikmesriikide sisesele ebavõrdsuse põhjuste ja võimalike tagajärgede analüüsimisele. Regionaalpoliitiliste meetmega tuleb eelkõige toetada vaesemaid piirkondi, kuid samas tuleb luua tingimusi ka rikkamate piirkondade kiire arengu toetamiseks ning seda eeldusel, et ülekandeefektide (*spillove*r) kaudu saavad rikkamate piirkondade edust osa ka mahajäänumad piirkonnad. Rõhuasetus peab olema tingimuste loomisel selleks, et vaesemad regioonid suudaksid efektiivselt kasutusele võtta rikkamates regioonides loodud innovatsioone ning seeläbi pikaajalises perspektiivis regionaalne ebavõrdsus väheneks. Uurimistöö järgnevates etappides on kavas tingimusliku konvergentsi hüpoteeside testimisel lisaks riikide efekte iseloomustavatele fiktiivsetele muutujatele arvesse võtta ka mitmeid muid regionaalset tulutaset mõjutavaid tegureid, nagu tööhõive, tehnoloogiline tase, inimkapital jms.