Regional income disparities and convergence in EU: catching up or falling behind?

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Abstract
The paper deals with exploring regional income disparities and convergence in the EU-25 new (EU-8) and old (EU-15) member states and their NUTS3 level regions during the period 1995-2003. We explore development of regional income disparities and their decomposition into between country and within country regional inequality components. Spatial econometric methods are applied in order to estimate β-convergence identifying also existing spatial interaction and controlling the eventual effects of spatial autocorrelation on the estimation results. The estimators of the spatial econometric models show that spatial dependence across regions matters. The results of the analyses show that poorer regions, which are situated mainly in the European periphery, have tended to grow faster than the relatively rich European core. However, the catching-up process has been painfully slow and it has been driven mainly by national factors. In the course of slow general catching-up process regional disparities within the EU new member states (NMS) have increased remarkably. The forces that drive regional convergence seem to have not yet prevailed in NMS.

JEL-Classification: R11, O11, C23, C21

Keywords: regional disparities, convergence, regional policy, spatial econometrics

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1. Introduction

European Union, which is one of the world's most prosperous economic areas, has large economic disparities between its member states and regions. Therefore regional income inequality and convergence is a continually important field of research, giving additional information for the development of regional policies in the European Union. The essential argument for the EU regional policy is the insight that a balanced regional development is a prerequisite for social cohesion and an increase in the competitiveness of countries and regions. This paper deals with the analysis of the development of regional disparities in income levels and convergence processes in the EU-25 mainly during the period 1995-2003. We analyse income disparities at a low level of regional aggregation using mainly

NUTS-3 level data.[1] The GDP per capita in purchasing power standards (PPS) of the NUTS-3 regions are used as the proxies of regional income in order to analyze income disparities and convergence. We measure the level of income inequality and its decomposition by the Theil index distinguishing between and within country inequality as components of the overall income inequality.

In order to assess income convergence in EU-25 countries and their regions we use models of absolute and relative location. While absolute location refers to the impact of being located at a particular point of space, relative location refers to the effect of neighbourhoods. The respective non-spatial econometric techniques ordinarily focus on models of absolute location, while spatial econometric techniques concentrate on models of relative location exploring spatial dependence. These two groups of estimation techniques are complementary. We focus on the empirical testing of absolute and conditional convergence hypothesis implementing both non-spatial - simple OLS, including country dummies for capturing spatial heterogeneity - and spatial - Spatial Lag Models (SLM) and Spatial Error Models (SEM) - estimation techniques.

The paper consists of seven main sections. In section 2 a brief overview of theoretical framework and some empirical results of the previous studies about regional income disparities and convergence are given. Section 3 explains data. Section 4 explores development of regional income disparities and presents the results of regional income disparities decomposition into between country and within country contributions to overall income disparities. In sections 5 and 6 regression models used to test for β-convergence and the main empirical results of convergence analysis are presented. Finally, section 7 concludes.

2. Theoretical and empirical considerations

The concept of convergence has been a central issue around which the recent decades' growth literature has evolved (see Islam, 2003). The question is whether the income levels of poorer countries are converging to those of the richer countries or not. Economic theory does not give a unique answer to what is the direction of income convergence processes. Both convergence and divergence may occur.

Neoclassical growth theory predicts a decrease in disparities of income levels because of decreasing returns to capital. Furthermore, intensified factor mobility and trade in the course of European integration are supposed to accelerate the convergence process. Therefore neoclassical growth theory represents a very optimistic point of view. Less optimistic in this respect are the implications of new (endogenous) growth theory (NGT) or New Economic Geography (NEG). In both monopolistic structures and externalities allow for persistent divergence processes. In the former human capital plays an important role in generating innovation processes that allows some regions to yield constantly higher growth rates than other regions. NEG (Krugman 1991a) claims that location and agglomeration are playing an important role in the economic activity of a region. The spatial distribution of production in NEG-Models depends on the relative strengths of centripetal forces that promote centralisation and centrifugal forces that foster decentralisation of economic activity. Krugman's Core-Periphery Model (1991b), for example, suggests that in the course of economic integration, decreasing transport costs to a medium level support the production in central places. However, when economic

[1] NUTS – Nomenclature of Statistical Territorial Units of EUROSTAT.

integration proceeds further to a higher level and transport costs become very low (zero) then the model predicts economic production to spread evenly across space.

In general, the relationship between economic development and income inequality is still not clear. In 1955 Simon Kuznets introduced the hypothesis of an inverted-U relationship between economic development and inequality which has been called the Kuznets Curve ever since. According to this hypothesis income inequality ordinarily rises in the early stages of economic development and declines in the latter. Later empirical studies offer different results. In the 1990-s there was some consensus that inequality is harmful for economic growth (e.g. Alesina and Rodrik, 1994). These studies were mainly carried out at the country level and the conclusions were that the economies with a higher level of initial inequality are likely to experience lower growth rates in the long run. Using more sophisticated research methodologies and different datasets some authors got also results, which predicted a positive relationship between inequality and growth (e.g. Deiniger and Squire 1996). Forbes (2000) found a positive relationship between inequality and growth concluding that the results of the growth-inequality relationship studies remarkably depend on the datasets and estimation techniques used. Differences between the results of the studies that are based on panel data and those that are based on cross-section data could be explained as follows 1) panel techniques look at changes within countries over time, while cross-section studies look at differences between countries with the possibility that the within-country and cross-country relationship might work through different channels; 2) panel studies look at the issue from a short-/medium-run viewpoint, while cross-section studies may investigate the relationship in the long-run period (*ibid*; see also Arbia et al. 2005).

There are several studies that give evidence for the importance of regional spillovers on growth- and convergence processes confirming that regional development is affected by spatial interactions (e.g. Fingleton 2004, López-Bazo et al. 2004, Le Gallo et al. 2003, Niebuhr 2001, Rey and Montouri 1999). Regions that are surrounded by rich neighbours, for example, have usually better chances for development than regions situated in a relatively poor neighbourhood. Therefore, regions cannot be regarded as isolated entities when convergence processes are analysed. While the role of spatial interaction was generally ignored in the empirical convergence literature for a long time, a growing number of convergence studies using spatial econometric techniques emerged during the last years (see Abreu et al. 2004). By the way, also implication of NEG suggests that the economic situation of a region depends on interrelations to its neighbours. Thus, neither economic theory nor previous empirical studies can give clear outlooks of regional income convergence processes in EU countries and their regions.

3. Data

We analyse the time period between 1995 and 2003, which can be seen as period of preparation for the NMS to join the EU in May 2004. The years under observation characterise the preparative period of the first so-called eastward enlargement in 2004. During this period the political decisions about the candidate and the acceding countries were made. The dataset we use is GDP per capita data measured in purchasing powers standards (PPS) taken from the Eurostat database.[2] Data in PPS are adjusted for

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[2] It should be noted that Eurostat warns against using PPS adjusted GDP values to calculate growth rates over years. However, we do not analyze the dynamics of single countries or regions, but the relative development of income levels between countries and regions, which should ease the problem.

differences in national price levels but not for differing price levels within countries. Despite there are considerable regional within-country differences in price levels as well, we use these data because we think that they still provide a better approximation for regional wealth than data in Euro. Furthermore, GDP in PPS is used to recognise eligibility of regions to be supported by EU structural funds in the range of Objective 1, which has the main priority of the European Union's cohesion policy helping areas lagging behind in their development (GDP is below 75% of the Community average).

We analyse regional disparities and convergence processes at a rather low level of aggregation across 861 regions in the EU-25. The sample comprises 97 so-called planning regions ("*Raumordnungsregionen-ROR"*) in Germany.[3] The rest of the sample consists of NUTS-3 regions of the remaining countries of the EU-25.[4] Furthermore, we conduct separate analyses for the 739 regions in the EU-15 and the 122 regions in the NMS since we assume that there are structural differences in the regional convergence processes across these groups of countries.

4. Regional income disparities and their decomposition

4.1. Regional income disparities and growth

There are large regional income disparities in the EU-25. In 2003 the top income level in Inner London West, UK is with 477% of the average income level of the EU-25 more than twenty times higher than the one of the poorest region Latgale, Latvia with 21%. Also in the two sub-samples, the EU-15 and the NMS, there is a wide range between the lowest and the highest income levels. The income level in the poorest region in the EU-15 – Tamega, Portugal - was with 37% thirteen times lower than the respective income level of the richest region. The income level in the richest region of the NMS – Warsaw, Poland – was with 139% 6.6 times higher than the average per capita income in Latgale.

Figure 1 displays regional per capita incomes relative to the EU-25 average income level in 2003. The spatial distribution of regional income levels in the EU-25 shows a centre-periphery-structure. Most of the relatively rich regions were situated along the so-called "blue banana", which ranges from Northern Italy to the southern part of England. In the EU-15 regions with income levels below 75% of the EU-25 average can be found mainly in the southern periphery.

The spatial pattern of per capita growth between 1995 and 2003 shows that regions in the periphery tended to grow faster (see figure 2). Most regions in Spain, Greece, Ireland, Finland and in the NMS experienced growth rates above the EU-25 average growth rate. Within the range of the "blue banana" relatively few regions, mainly in the area of London and in the Netherlands, reached above average per capita growth. This may indicate that a general catching-up process of the poorer periphery in the EU-25 as well as a catching-up process of the NMS towards the income level in the EU-15 had taken place.

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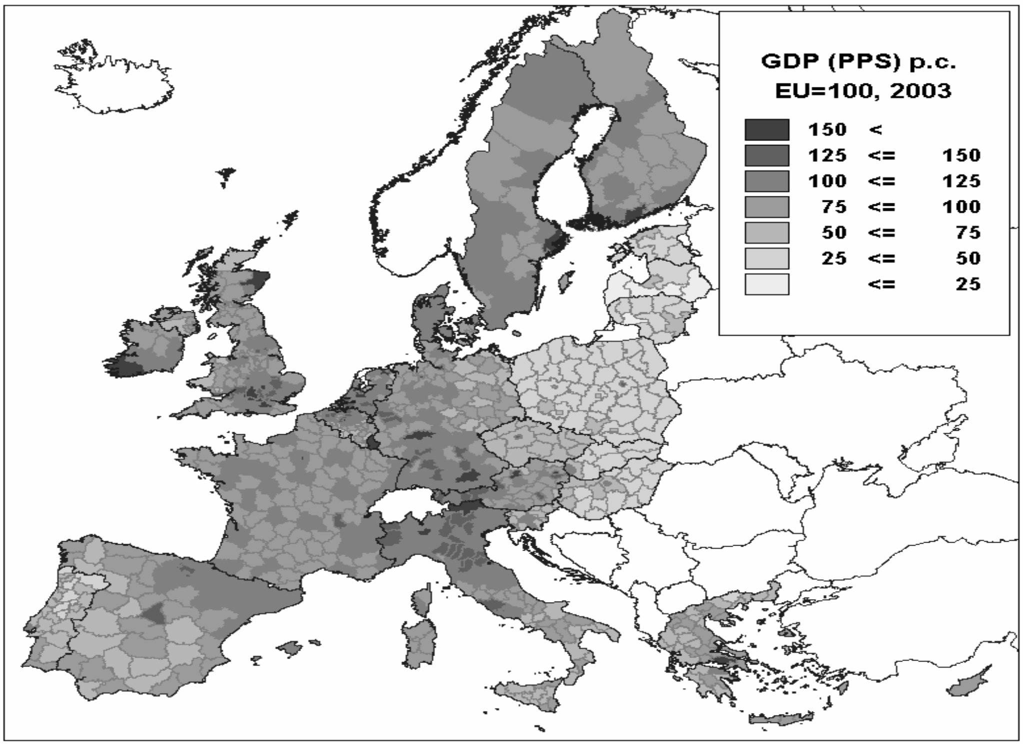
[3] German planning regions are functional regions that comprise several NUTS-3 regions.

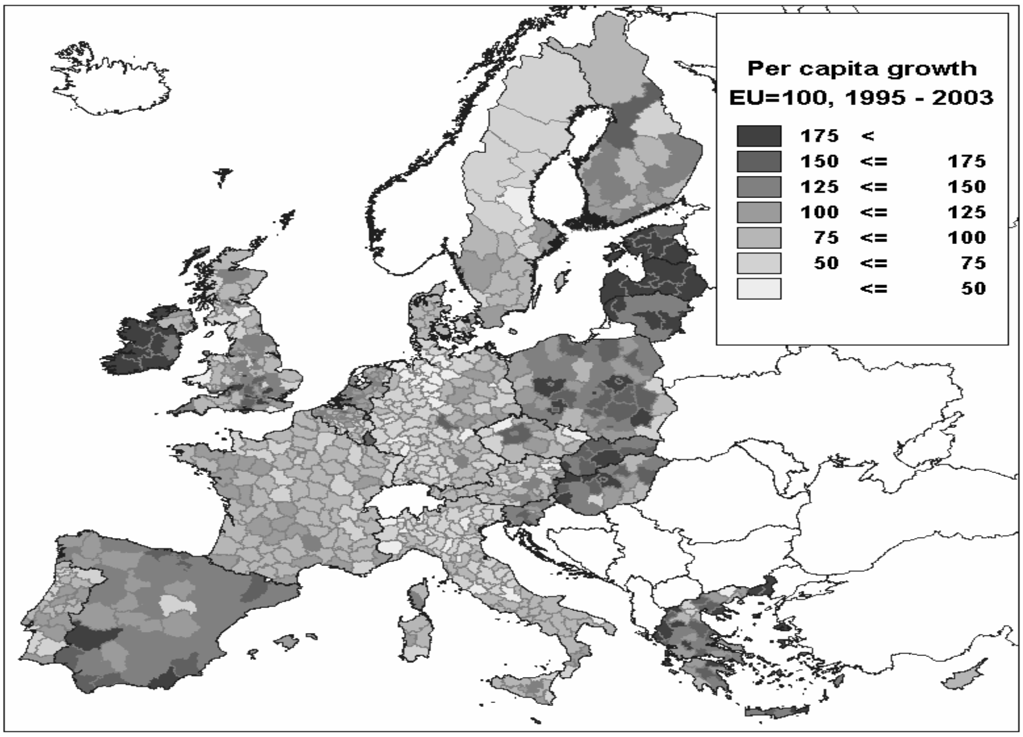
[4] Because of their geographically isolated position from the EU the following regions are not included in the sample: Canary islands as well as Ceuta and Mellila (both Spain), Acores and Madeira (both Portugal) as well as the French overseas departments Guadloupe, Martinique, French Guyana and La Reunion.

Figure 1. Regional income levels relative to the EU-25 average, 2003



Source: Eurostat 2006; own calculations.

Figure 2. Regional per capita growth relative to the EU-25 average, 1995 - 2003



Source: Eurostat 2006; own calculations.

However, there is a noticeable difference between the growth processes in the EU-15 and the NMS. While in the former group of countries the growth leading regions were mostly not amongst the richer regions in 1995 quite the opposite is the case in the latter. In each respective country of the NMS, in particular, the relatively rich agglomerations – mainly the capital regions – and their hinterland were among the most dynamic regions. Overall, the clustering of relatively rich regions in the centre of the EU-25 has weakened between 1995 and 2003. In the NMS, especially agglomerations and some regions, which are close to a border of a EU-15 country, approached the EU-25 average income level until 2003. The capitals Warsaw (139%), Prague (138%), Budapest (122%), Bratislava (116%) and Ljubljana (109%) reached clearly above average income levels in 2003.

4.2. Decomposition of regional disparities

In this part of our paper we use the Theil index in order to measure regional income disparities at the NUTS-3 level regions of EU-25 and decompose these disparities into between country and within country inequality components.

The overall regional income disparities can be measured by the following Theil index:

$$T_{overall} = \sum_i \left(\frac{N_i}{N}\right) T_i + \sum_i \left(\frac{N_i}{N}\right) \ln\left(\frac{N_i / N}{Y_i / Y}\right) = T_{within} + T_{between} \qquad (1)$$

Where

Y_{ij} – the income of the region j in the country i;

Y – the total income of all regions ($= \sum_i \sum_j Y_{ij}$);

N_{ij} – the population of the the region j in the country i;

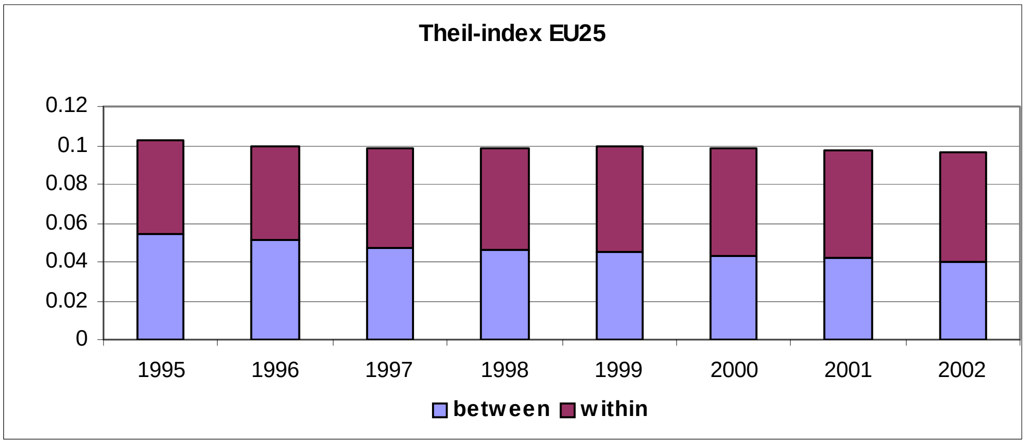
N - the total income of all regions ($= \sum_i \sum_j N_{ij}$); $T_i = \sum_j (\frac{N_{ij}}{N_i}) \ln(\frac{N_i / N_i}{Y_{ij} / Y_i})$.

Equation (1) is the ordinary Theil inequality decomposition in which the overall income inequality is the sum of the between-country and the within–country components. The within-country component characterizes the income inequality between the NUTS-3 regions in each country of the EU-25, while the between-country component measures the inequality between these countries.

Figure 3 illustrates the evolution of regional income disparities in EU-25. The overall income inequality has a bit decreased in EU-25 due to the decline in between country inequality. The patterns of the overall inequality decomposition differ between EU-15 and NMS (see figures 4 and 5). Both, the levels of overall income inequality and its within-country component slightly increased and between-country inequality slightly decreased in the EU-15 during the period under observation. In the NMS the overall inequality increased due to significant increase of the within-country inequality; at the same time the between country inequality decreased like in the EU-15. The within-country component is establishing more than 85% of the overall income inequality of the EU-15 countries and around 76% of the NMS.

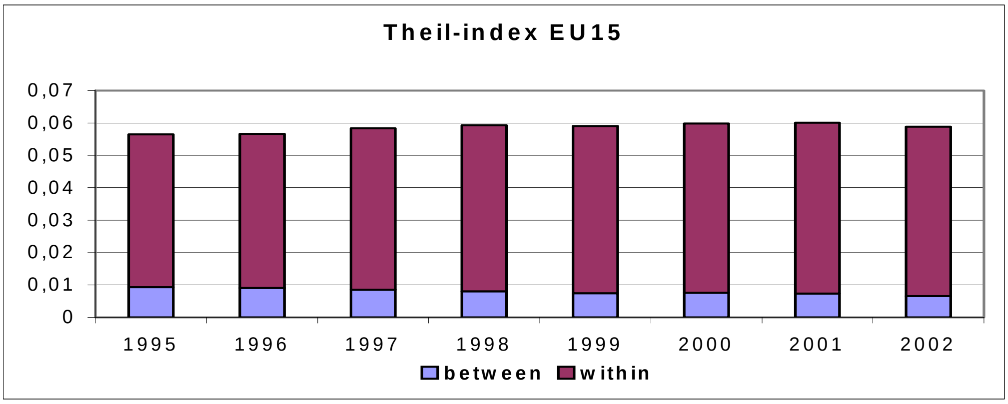
Thus, during the EU pre-enlargement period which is characterized by comparatively quick economic growth in the majority of accession countries, the income disparities between the countries declined but regional income disparities within the countries increased remarkably. We suppose that catching-up process of the NMS at the national level was mainly driven by a few high growth regions. In the following part of the paper we explore whether the regions of 25 converge or diverge.

Figure 3. Regional income inequality decomposition in EU-25, 1995-2002



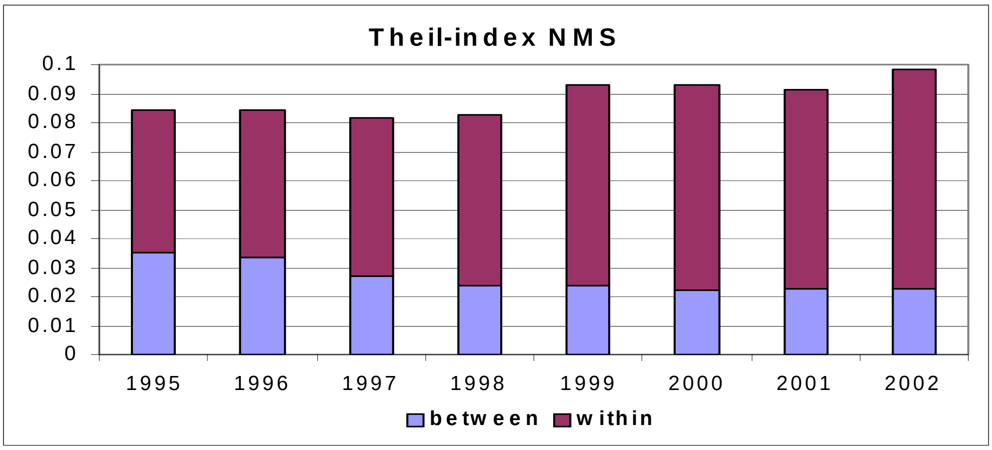
Source: Eurostat, authors' computations

Figure 4. Regional income inequality decomposistion in EU-15, 1995-2002



Source: Eurostat, authors' computations

Figure 5. Regional income inequality decomposition in NMS, 1995-2002



Source: Eurostat, authors' computations

5. Convergence analysis

5.1 Absolute and conditional β-convergence

If poorer economies grow faster than richer ones, there should also be a negative correlation between the initial income level and the subsequent growth rate. *β*-convergence is defined as a negative relation between the initial income level and the growth rate of income. At the same time we should also notice that a negative *β* from a growth-initial level regression does not necessarily imply a reduction in variation (σ-convergence) of regional income or growth rates over time (see Barro and Sala-i-Martin 1995).

When discussing convergence processes usually the distinction between absolute and conditional convergence is made. The absolute convergence hypothesis is based on the assumption that economies – countries or regions - converge towards the same steady state equilibrium. With similar saving rates poorer countries or regions experience faster economic growth than richer ones. This follows from the assumption of diminishing returns, which implies a higher marginal productivity of capital in a capital-poor country. The absolute convergence hypothesis argues that per capita incomes in different economies equalise in the long run and that expresses the so-called convergence optimism. In contrast, the concept of conditional convergence emphasises possible spatial heterogeneity in parameters that affect growth and lead to differences in the steady state. This requires that appropriate variables are included in the right side of the growth-initial level regression in order to control for these differences. The conditional convergence hypothesis assumes that convergence occurs if some structural characteristics - like the demographic situation, government policy, human capital endowment and employment rate, etc - have an impact on income growth. Hence, conditional convergence may occur even if the absolute convergence hypothesis is not valid. So conditional convergence processes may take place even if poor countries do not tend to grow faster than rich countries.

In order to test for regional convergence we use the common cross-sectional ordinary least squares (OLS) approach with the growth rate of per capita income as dependent variable and the initial income level as explanatory variable (both in natural logarithms). Since national characteristics were found to play an important role in growth and convergence processes we apply dummy variables for countries to control for country-specific effects (e.g. Niebuhr and Schlitte 2004; Bräuninger and Niebuhr 2005). This allows steady-states to differ between countries. Hence, the model with the inclusion of country dummies tests for conditional convergence, while the model without country dummies tests the hypothesis of absolute convergence. In the conditional convergence model, however, it is still assumed that regions within the same country approach the identical steady-state.[5]

$$\ln\left(\frac{y_{i2003}}{y_{i1995}}\right) = \alpha_0 + \alpha_1 \ln(y_{i1995}) + \sum_{j=1}^{N} \alpha_{2j} z_{ji} + \varepsilon_i \qquad (2)$$

where

y_{i1995} – GDP *per capita* (PPS) in region *i* in 1995 (initial year),

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[5] All estimations are carried out using SpaceStat 1.91.

y_{i2003} – GDP *per capita* (PPS) in region *i* in 2003 (final year),

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

α_0, α_1 and α_{2j} - parameters to be estimated,

ε_i – error term.

The annual rate of convergence β can be obtained using the equation $\beta = -\ln(1-\alpha_1)/T$, where *T* denotes the number of years between the initial and the final year of observation. Another common indicator to characterise the speed of convergence is the so-called half-life τ, which can be obtained from the expression: $\tau = \ln(2)/\beta$. The half-life shows the time that is necessary for half of the initial income inequalities to vanish. We estimate both, absolute and conditional convergence across regions in the EU. Since convergence patterns are supposed to differ between the EU-15 and the NMS we estimate separate models for both country-groups as well.

5.2 Spatial interactions

The OLS estimations of the equation (2) assume that all observations in the sample are independent from one another. Especially when a cross-section of regions rather than countries is analysed the consideration of spatial interaction is important. Ignored spatial dependence can lead to serious consequences in the estimation results in form of the omitted variables bias.

We should take into consideration that also NEG models emphasise the importance of relative location to regional development and there is empirical evidence that regions in a relatively dynamic and prosperous neighbourhood have a better chance to grow than those surrounded by poor and less dynamic regions (see e.g. Rey and Montouri 1999; Le Gallo et al. 2003; Egger and Pfaffermayr 2005). If it is the case, however, that growth processes across regions are interrelated and not covered by the explanatory variables the convergence relationship may be misspecified in equation (1).

Spatial interactions among regions can be modelled by means of the spatial weight matrix *W*, which is supposed to resemble the spatial structure and intensity of the spatial effects. There are various possibilities to design a spatial weight matrix. Though it may affect the estimation results the choice for the design of the spatial weight is somewhat arbitrary because the exact nature of the spatial effects is usually not known a priori. However, the possible consequences have to be kept in mind (see also Ertur and Le Gallo 2003).

A common approach is to use the concept of binary contiguity: the elements of the matrix w_{ij}=1 if region *i* and region *j* share a common border or are within a certain distance to each other and w_{ij}=0 otherwise (e.g. Ray and Montouri 1999). The weight matrix we use, however, will take distance into account by a decreasing weight the farther the distance between the regions *i* and *j* is. We use the squared inverse of the great circle distance between the geographic centres of the regions as spatial weight. Furthermore, we implement a critical distance cut-off, above which spatial interaction is assumed to be zero. The functional form of the squared inverse of the distances can be interpreted as reflecting a gravity function (compare Le Gallo et al. 2003). The distance matrix is row-standardized so that it is relative and not absolute distance that matters.

$$W = \begin{cases} w_{ij} = 0 \quad if\ i = j \\ w_{ij} = 1/d_{ij}^2 \quad if\ d_{ij} \le D \\ w_{ij} = 0 \quad if\ d_{ij} > D \end{cases} \qquad (3),$$

where

$w_{i,j}$ - spatial weight for interaction between regions *i* and *j*;

d – distance between centroids of regions *i* and *j*;

D – critical distance cut-off.

According to Anselin (2001), spatial autocorrelation[6] can be defined as a spatial clustering of similar parameter values. If there are more similar - respectively high or low - values clustered in one area than there could be by chance there is positive spatial autocorrelation in the parameter values. In the opposite case of spatial proximity of dissimilar values there is negative spatial autocorrelation.

As measure of spatial clustering of income levels and growth in the EU we use Moran's *I*-statistic. When Moran's *I* is positive and significant there is a tendency towards a clustering of similar parameter values in the sample.

$$I_t = \frac{N \sum_{i=1}^{N} \sum_{j=1}^{N} x_{i,t} x_{j,t} w_{i,j}}{N_b \sum_{i=1}^{N} x_{i,t}^2} \qquad (4),$$

where

$x_{i,t}$ - variable in question in region *i* and in year *t* (in deviations from the mean);

N – number of regions;

N_b - sum of all weights (since we use row-standardised weights N_b is equal to *N).*

We use Moran's *I*-statistics to check for spatial autocorrelation of regional growth rates and income levels in 1995 and 2003. Table 1 shows the Moran coefficient *I* using the weight matrix as specified above. Different critical distance cut-offs were applied in order to check for the sensitivity to changes in the spatial weight. Growth rates and income levels in both years are clearly more spatially clustered than they could have been by pure random. In all cases Moran's *I* is highly significant. Hence, there is strong evidence for spatial dependence among the regions in the EU. The coefficient *I* is highest with the lowest distance cut-off of a hundred kilometres and is decreasing with increasing distance cut-offs. However, the significance is lower with short distance cut-offs and highest with a cut-off at 500 km. With larger distance cut-offs both, the coefficient *I* and its significance, are decreasing. This indicates that the intensity of spatial dependence declines with larger distances between the respective regions. Regional interactions over a

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[6] We use here the terms of spatial autocorrelation and spatial dependence, though not fully correct, as synonyms.

distance of more than 500 km seem to be less important. Therefore we use 500 km as critical distance cut-off.

Table 1. Moran's *I*-test for spatial autocorrelation (randomization assumption)

Critical distance cut-off (km)	Moran coefficient I (Standardised z-value)		
	$\ln\left(\frac{y_{i2003}}{y_{i1995}}\right)$	$\ln(y_{i1995})$	$\ln(y_{i2003})$
100	0.54** (21.27)	0.75** (29.77)	0.67** (26.71)
200	0.51** (29.35)	0.74** (42.43)	0.66** (37.49)
300	0.48** (31.63)	0.72** (47.34)	0.63** (41.77)
400	0.45** (32.44)	0.70** (49.72)	0.61** (43.82)
500	0.44** (32.77)	0.68** (50.80)	0.60** (44.80)
600	0.42** (32.67)	0.65** (50.74)	0.58** (44.78)
700	0.41** (32.60)	0.63** (50.55)	0.56** (44.65)
800	0.40** (32.37)	0.62** (50.12)	0.55** (44.33)
900	0.39** (32.09)	0.60** (49.64)	0.53** (43.94)
1000	0.38** (31.82)	0.59** (49.13)	0.52** (43.54)
2000	0.34** (30.27)	0.52** (46.38)	0.47** (41.33)

** significant at the 0.01 level.

Spatial autocorrelation can appear in two different forms: the substantive form and the nuisance form of spatial dependence (see Anselin 1988). The former results from the direct regional interactions in the observed activity. Ignoring this form of spatial autocorrelation as in equation (1) may lead to biased estimates. The latter form of spatial dependence is restricted to the error term. It stems from measurement errors such as a wrongly specified regional system that does not reflect the spatial structure of the activities. Ignoring this form may lead to inefficient estimates.

In order to deal with these forms of spatially dependent observations, we estimate the spatial error model (SEM) and the spatial lag model (SLM) as suggested by Anselin (1988). Both models are estimated by maximum likelihood (ML). In these models spatial dependence is taken into account by the incorporation of the spatial weight matrix *W*.

We estimate the following spatial error model (SEM) including country dummies:

$$\ln(\frac{y_{i2003}}{y_{i1995}}) = \alpha_0 + \alpha_1 \ln(y_{i1995}) + \sum\nolimits_{j=1}^{N} \alpha_{2j} c_{ji} + \varepsilon_i \,,\ \text{with}\ \varepsilon_i = \lambda[W \cdot \varepsilon]_i + u_i \ (5),$$

where

λ - spatial autocorrelation coefficient,

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

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

α_0, α_1 and α_{2j} - parameters to be estimated,

ε_i and u_i - normally independently distributed error terms.

In the spatial error model spatial dependence is restricted to the error term, hence on average per capita income growth is explained adequately by the convergence hypothesis. The SEM, therefore, is an appropriate model specification for the so-called nuisance form of spatial dependence.

The spatial lag model (SLM) is suitable if the ignored spatial effects are of the substantive form, where regional growth is directly affected by the growth rates of the surrounding regions. The growth effects from the neighbouring regions are incorporated through the inclusion of a spatial lag of the dependent variable on the right-hand side of the equation:

$$\ln(\frac{y_{i2003}}{y_{i1995}}) = \alpha_0 + \rho\left[W \cdot \ln(\frac{y_{2003}}{y_{1995}})\right]_i + \alpha_1 \ln(y_{i1995}) + \sum_{j=1}^{N} \alpha_{2j} c_{ji} + \varepsilon_i \qquad (6)$$

where

ρ - the spatial autocorrelation coefficient,

W - the weight matrix and $\left[W \cdot \ln(\frac{y_{2003}}{y_{1995}})\right]_i$ is the i-th element of the vector of weighted growth rates of other regions; other denotations see by the equation (4).

6. Estimation results

6.1 The non-spatial estimations

The estimation results of the OLS regressions are presented in table 2. There was a significant process of absolute convergence across EU regions. In the EU-25 regional income levels converged at an average pace of 2% p.a.. At this speed it takes 35 years for half of the disparities to vanish. While the convergence speed in the group of the EU-15 countries was with a rate of 1.8% p.a. only slightly lower regional incomes in the NMS converged at a rate of 1.4% - only significant at the 5%-level. This implies half-lives of 38 years in the EU-15 and 50 years in the NMS.

The speed of convergence is considerably slower when country effects are taken into account. In the conditional models there is no significant convergence found in the EU-25, the convergence rate β in the EU-15 halves to 0.9% p.a. – which implies a half-life of 81 years - and in the NMS it changes even signs. In the NMS regional per capita incomes actually diverged at a rate of 1.5% p.a. when country dummies are employed. In the case of conditional convergence income levels are not assumed to converge to a unique long-term equilibrium but to individual – here country-specific – equilibria. Usually, the convergence process towards country specific steady-states could be expected to be faster, since steady-state levels in relatively poor countries should be lower than those in richer countries. Given that conditional convergence rates are lower than absolute convergence rates the catching-up process across EU-regions seems to be driven by national factors. Niebuhr and Schlitte (2004) came to the same results on the regional level NUTS-2.

The model-fits of the conditional convergence estimations are much better than those in the absolute convergence models. According to the adjusted R^2 initial income levels explain 20% of the differences in regional growth rates in the EU-25, only 9% in the EU-15 and 6% in the NMS, while 48%, 37% and 37% are explained in the conditional models for the EU-25, the EU-15 and the NMS respectively.

Table 2. OLS estimation results

	EU-25	EU-15	EU-10	EU-25	EU-15	EU-10
Country Dummies		*no*			*yes*	
No. of Regions	*861*	*739*	*122*	*861*	*739*	*122*
Intercept	1.583** (17.04)	1.473** (8.84)	1.258** (3.98)	0.553** (4.34)	0.876** (6.09)	-0.646 (-1.60)
α_1	-0.130** (-13.36)	-0.119** (-6.88)	-0.092* (-2.52)	-0.020 (-1.14)	-0.058** (-3.89)	0.112** (2.58)
$\mathbf{R}^2_{adj.}$	0.20	0.09	0.06	0.48	0.37	0.36
AIC	-1371.4	-1230.1	-151.1	-1721.3	-1483.3	-190.2
β	2.0**	1.8**	1.4*	0.3	0.9**	-1.5**
Half-life	35	38	50	240	81	-
Normality Jarque-Bera	389.54**	429.96**	9.50**	496.48**	540.82**	3.96
Heteroscedasticity						
Koenker-Bassett	1.47	1.29	4.42*	102.53**	60.41**	
Breusch-Pagan						14.70
Spatial Dependence						
Moran's I	21.68**	21.79**	6.12**	9.32**	14.15**	4.34**
LM_{Error}	451.90**	454.81**	30.25**	51.16**	149.60**	7.21**
Robust LM_{Error}	40.45**	10.46**	6.64**	9.90**	18.06**	0.08
LM_{Lag}	440.45**	473.91**	25.95**	41.26**	131.61**	9.03**
Robust LM_{Lag}	29.01**	29.56**	2.33	0.01	0.07	1.91

**significant at the 0.01 level *significant at the 0.05 level.

6.2 β-convergence and spatial dependence

The results of Moran's *I* test in table 2 show significant spatial autocorrelation in the residuals of all OLS-estimations. Though commonly used this test is not very reliable. Firstly, it picks up other specification errors such as heteroscedasticity or non-normal error terms (see Anselin 1992). Since the Jarque-Bera test (Jarque and Bera 1987) detects a problem with non-normal errors and the Koenker-Basset test (Koenker and Basset 1982) indicates a problem with heteroscedasticity this might be the case (see table 2). Secondly, Moran's *I* does not tell whether spatial autocorrelation is of the nuisance form or of the substantive form.

In order to identify the form of spatial autocorrelation we apply Lagrange multiplier (LM) tests. According to the decision rule by Anselin and Florax (1995) there is nuisance dependence if the *LM*-test for spatial error dependence (LM_{err}) is more significant than the test for spatial lag dependence (LM_{lag}) and the robust version of the LM_{err} – which is robust against the presence of spatial lag dependence - is significant as well. Conversely, the opposite would indicate the substantive form of spatial autocorrelation.

In the case of absolute convergence the *LM*-tests show a preference for spatial lag dependence in the EU-15 and spatial error dependence in the NMS. When national effects are considered the results clearly indicate spatial error dependence in the EU-15, while there is no clear result for the NMS. Overall the LM-tests do not provide a clear preference for either the substantive form or the nuisance form in all models. Additionally, the tests may also have picked up heteroscedasticity or non-normality. Therefore the results must be interpreted with caution (see Anselin 1992). Seeing these potential problems we test for all model specifications both the SLM and the SEM (see tables 3 and 4).

Table 3. Spatial lag model (SLM) estimation results

	EU-25	EU-15	EU-10	EU-25	EU-15	EU-10
Country Dummies		*no*			*Yes*	
Number of Regions	***861***	***739***	***122***	***861***	***739***	***122***
Intercept	0.485** (5.72)	0.509** (4.31)	0.346 (1.35)	0.343** (2.82)	0.548** (4.24)	-0.541** (-1.60)
α_1	-0.043** (-5.23)	-0.046** (-3.87)	-0.019 (-0.69)	-0.014 (-1.14)	-0.042** (-3.23)	0.101** (2.89)
ρ	0.780** (21.28)	0.782** (20.15)	0.604** (6.05)	0.410** (6.52)	0.535** (8.78)	0.508** (4.02)
AIC	-1640.1	-1473.2	-174.9	-1755.0	-1558.2	-197.8
β	0.6**	0.7**	0.3	0.2	0.6**	-1.4**
Half-Life	110	103	253	344	113	-
Heteroscedasticity Spatial Breusch-Pagan	17.77**	12.61**	2.75	288.94**	183.40**	13.55
Spatial Error Dependence Lagrange Multiplier	0.00	2.08	8.99**	7.68**	0.29	1.10

**significant at the 0.01 level. *significant at the 0.05 level.

Table 4. Spatial error model (SEM) estimation results

	EU-25	EU-15	EU-10	EU-25	EU-15	EU-10
Country Dummies		*no*			*Yes((*	
Number of Regions	***861***	***739***	***122***	***861***	***739***	***122***
Intercept	0.781** (6.30)	0.752** (4.87)	0.268 (0.97)	0.518** (4.01)	0.766** (5.30)	-0.311 (-0.98)
α_1	-0.041** (-3.62)	-0.045** (-2.77)	0.013 (0.42)	-0.017 (-1.30)	-0.048** (-3.22)	0.076* (2.35)
λ	0.840** (26.01)	0.809** (21.21)	0.830** (12.37)	0.495** (7.75)	0.592** (9.79)	0.540** (4.17)
AIC	-1636.1	-1467.4	-185.5	-1764.8	-1568.7	-199.0
β	0.6**	0.7**	-0.2	0.2	0.7**	-1.0*
Half-Life	116	105	-376	283	99	-
Heteroscedasticity Spatial Breusch-Pagan	19.10**	15.45**	0.15	291.10**	189.63**	15.11
Spatial Lag Dependency Lagrange Multiplier	0.03	1.48	0.89	0.02	5.33*	2.74

**significant at the 0.01 level. *significant at the 0.05 level.

The results of the SLM and the SEM show both significant spatial autocorrelation. The coefficients of the spatially lagged dependent variable (ρ) and of the lagged error (λ) are all statistically highly significant indicating that regions are affected in their development by neighbouring regions.

The estimations in both the SEM and the SLM without control for country specific effects yield considerably lower convergence rates than the OLS estimations.[7] In both spatial specifications the estimated rate of convergence is 0.6% in the EU-25 and 0.7% in the EU-15. These rates imply half-lives of more than a hundred years. In both models there was no significant convergence in the NMS. According to the Akaike Information

[7] It has to be noticed that the direct comparison of the β-coefficients of the spatial models and the OLS-model is not quite correct because the estimated speed of convergence in the former comprises also indirect and induced effects (compare Abreu et al. 2004 or Egger and Pfaffermayr 2005).

Criterion (AIC) the model-fits of the spatial estimations are remarkably better compared to the absolute convergence OLS estimations.[8]

When country dummies are included into the spatial models the estimations yield somewhat similar results to those of the conditional OLS estimations. There was a very slow process of conditional convergence taking place in the EU-15, while income levels within the countries of the NMS diverged.[9] Also the model-fits do not vary remarkably. This indicates that national (macroeconomic, political, institutional) factors are more influential on regional growth than the presence of spatial effects.[10] Similar results were found by Bräuninger and Niebuhr (2005) and Geppert et al. (2005). Thus, convergence occurs if some structural characteristics (like demographic situation, government policy, human capital, employment rate, etc) have impact on income growth.

7. Conclusions

The results of the EU-25 regional income (GDP per capita) analysis show significant regional disparities in both the EU-15 and the accession countries (the new member states (NMS) since May 2004) during the period under observation (1995-2003). There exists a core-periphery structure with relatively high income levels in the centre of the EU and low income levels in peripheral regions. At the same time, the comparison of growth rates shows that regional dynamics between 1995 and 2003 have tended to be higher in the periphery and especially in some regions of the NMS. The decomposition of the overall regional disparities measured by Theil index into between-country and within-country components in EU-25 and in two country groups (EU-15 and NMS) show a small decline of overall income inequality caused by the decline of between-country inequality. The share of the within-country component in overall regional inequality is increasing. The patterns of the overall inequality decomposition somewhat differ between the EU-15 and NMS. The decrease of the between country inequality is quicker in NMS than in EU-15. The NMS experienced quick economic growth but the catching-up process at the national level was mainly driven by a few high growth regions and therefore regional income disparities in majority of these countries increased.

The convergence analysis shows that the regional catching-up process was painfully slow. Taking national effects (expressed by country dummies) into account in the estimated convergence equations the results indicate 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 turns negative. This is because the most dynamic regions were mainly the capital regions and their hinterland as well as some other metropolitan areas. These regions happened to be already relatively rich at the outset in 1995. As a consequence many rather 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 matters. However, since spatial autocorrelation seems to be sufficiently

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[8] The R^2 in ML-estimations is only a pseudo-measure and therefore not suitable for comparison to OLS. Therefore we the the AIC (see Anselin 1995).

[9] Though only significant at the 5%-level in the SEM.

[10] The spatial Breusch-Pagan test detects heteroscedastic error terms in estimations for the EU-25 and the EU-15, which requires some caution with interpreting the results.

captured by country dummies the results demonstrate that national macroeconomic and other factors (political, institutional, social) seem to be more important. The possible relationship between national growth and regional within-country inequality should be considered in the cohesion policy of the EU. According to Tondl (2001) the economic integration in wealthier EU-countries is so advanced that those forces that promote convergence in NGT and NEG have replaced the forces that drove divergence in the 1980s. We agree with this viewpoint. The forces that drive regional convergence seem to have not yet prevailed in NMS. However, if it can be expected that the dynamics of growth centres in the NMS spillover to rural, more remotely situated regions sooner or later it might be inefficient to support only those regions with low income levels. EU structural policy has to find the right balance between preventing deterioration in some regions and promoting regional dynamics and growth poles.

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