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ABSTRACT[1]

This paper deals with the development of disparities in regional per capita GDP and convergence processes in the enlarged EU. A cross-section of 861 regions is analysed for the period from 1995 to 2003. Firstly, we apply Theil's index of inequality in order to show the development of between- and within-country disparities. Secondly, we conduct a formal β-convergence analysis, taking into account the effects of spatial dependence and controlling for national effects. The analyses show that poorer regions mainly situated in the European periphery have tended to grow faster than the relatively rich regions in the centre of Europe. However, the convergence process has been driven mainly by national factors. In the course of this process, regional disparities within the new member countries have actually increased. Furthermore, we find that spatial growth spillovers lose relevance when crossing a national border. Thus, border impediments still matter for the intensity of economic cross-border integration in the EU.

Keywords: regional inequality, convergence, EU-25, regional interactions, spatial econometrics

JEL-Classification: R11, O11, C21

1 INTRODUCTION

EU eastward enlargement brings about the obligation for EU policy to deal with a considerably increased range of income disparities within the EU. Considering the community's objective to enhance economic and social cohesion (Article 2 of the Treaty on European Union), this presents a challenging task. Cohesion policy, the second largest item in the EU budget, has to be adjusted to this change in the scale of disparities. Information on the development of regional disparities and the speed of convergence is therefore of utmost importance for EU policy.

The issue of regional convergence has been the subject of a lot of empirical research since the beginning of the 1990s. Despite the great interest in this matter, information on regional convergence in the enlarged EU is still relatively scarce. Due to data restrictions, previous empirical research on regional convergence in Europe focussed on EU-15 regions. This paper aims at providing more distinct information on regional convergence processes in the enlarged EU. Special attention is paid to differences in regional growth processes between the EU-15 and the new member states (NMS) and to the role of national effects and the development of regional within-country disparities. Regional convergence and income inequality will be analysed for the period between 1995 and 2003 at a comparatively low level of regional aggregation comprising 861 regions of the EU-25. Firstly, reference will be made to the development of regional disparities by applying Theil's Index of Inequality, which allows to decompose overall inequality into between-country and within-country components. Secondly, a formal convergence analysis will be conducted, applying the well-known concept of β-convergence. Since spatial dependence was found to be influential on regional growth in recent convergence literature, spatial econometric techniques will be applied in order to control for such effects in our data set.

The paper consists of six main sections. In the next section we address empirical and theoretical considerations which are relevant to our analysis. Section 3 describes the dataset and discusses the regional system subject to this analysis. Recent developments of regional income disparities are explored in section 4, followed by a β-convergence analysis in section 5. Finally, our conclusions are presented in section 6.

2 THEORETICAL AND EMPIRICAL CONSIDERATIONS

The concept of β-convergence is based on the traditional neoclassical growth model and postulates that relatively poor economies grow faster than relatively rich ones. If regions differ only in initial income levels and capital endowment per worker, they converge towards an identical level of per capita income. This is referred to as absolute β-convergence. By contrast, conditional convergence emphasises spatial heterogeneity in growth factors leading to different growth paths. In the case of conditional convergence, where regions are marked, for example, by differences in technology, economic structures or qualification of the work force, regions converge towards different steady-state income levels.

Plenty of studies investigating regional convergence in Europe have been carried out since the beginning of the 1990s (e.g. Barro and Sala-i-Martin 1995, Armstrong 1995, Tondl 2001, Cuadrado-Roura 2001, Baumont et al. 2003, Arbia and Piras 2005, Meliciani and Peracchi 2006). Since regional convergence is a long run phenomenon, convergence studies usually observe longer time spans of 15 years or more. Analyses observing regional convergence over a couple of decades found varying rates of convergence over time, showing that the speed of convergence over shorter periods may deviate significantly from the long run average (e.g. Barro and Sala-i-Martin 1995, Armstrong 1995, Cuadrado-Roura 2001). However, a long run convergence analysis covering the enlarged EU is not feasible at the time. Due to the change in accounting conventions and the fundamental change in modes of production in Central and Eastern European (CEE) countries during the transition to market economies, income data for the time before the middle of the 1990s cannot be reasonably interpreted (Fischer and Stirböck 2004). As a consequence, empirical analysis on regional convergence in the enlarged EU can show recent developments, but it cannot identify long term trends. Though the explanatory power for long run developments is limited, we think that analysing the period after 1995 may provide important insights into recent tendencies in the development of income disparities in the enlarged EU.

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With respect to EU policy, which aims at regional equity, absolute convergence is the appropriate concept to be used. However, considering the variety of regions in Europe, including large structural differences, conditional convergence might be more realistic. In this paper, absolute and conditional convergence models will be estimated. A frequently applied method for testing conditional convergence is the concept of club convergence, in which steady states are allowed to differ across groups of relatively homogenous economies (e.g. Quah 1996). Analysing regional convergence in the enlarged EU, Fischer and Stirböck (2004) identify two convergence clubs, one club consisting of poorer regions in the NMS and the southern periphery of Western Europe and the other one consisting of the relatively rich Central and Northern European regions of the EU-15. Feldkircher (2006) as well as Niebuhr and Schlitte (2004) find strong evidence for country-specific effects on regional growth in the enlarged EU. The crucial role played by national specifics, such as differences in national policies, legislation, tax systems, etc. has been stressed in several studies on regional growth and convergence (e.g. Armstrong 1995, Cuadrado-Roura 2001). Besides testing the absolute convergence hypothesis, we test for conditional convergence, allowing regions to converge towards country-specific steady-state income levels.[2] Therefore, we test regional convergence that takes place within the individual member states.

Though the economic development of a region is likely to be influenced by neighbouring regions, most convergence studies of the 1990s assumed growth rates to be independent across regions. Since the end of the 1990s various convergence studies have found evidence for serious model misspecifications if spatial interdependencies of regional growth are ignored (see Abreu et al. 2005). Therefore, convergence estimation in this paper will take into account spatial autocorrelation by applying the Spatial Error Model (SEM) and the Spatial Lag Model (SLM) suggested by Anselin (1988).

A specific problem associated with β-convergence is that it does not necessarily imply a reduction in the variation of regional income levels over time (see Barro and Sala-i-Martin 1995). Hence, a negative correlation between initial income levels and subse-

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[2] We are aware that a control for national effects does not capture spatial heterogeneity comprehensively. For example, being an agglomerative or a rural area surely influences the economic development of a

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quent growth rates does not prove a declining level of inequality. However, *β*-convergence is a frequently used concept because it makes it possible to control for various effects on the convergence process. Nevertheless, it can be useful to explore the data on the development of regional income disparities while conducting a formal *β*-convergence analysis. Therefore, the concept of σ-convergence is frequently applied in convergence literature. σ-convergence takes place if the dispersion of income levels decreases over time (Barro and Sala-i-Martin 1995). We apply Theil's index of inequality (Theil 1967) because it makes it possible to decompose overall inequality into within-country and between-country components, which is very useful for the purpose of analysing the development of regional within-country disparities in the context of the general catching-up process that is taking place in the enlarged EU. Theil's inequality measure is derived from information theory and can be associated with the strand of literature dealing with inequality (see Cowell 1995).

3   DATASET AND REGIONAL SYSTEM

In regional convergence analysis, it has to be kept in mind that the level of regional aggregation chosen may affect the outcome. Applying the same analysis on different spatial scales may yield different results (Arbia 2006). Except for very few studies employing relatively low levels of spatial aggregation (e.g. Niebuhr 2001, Arbia et al. 2005, Petrakos and Artelaris 2006), regional disparities and convergence processes in Europe have thus far been analysed at the NUTS-2 level or higher levels of regional aggregation.[3] This can be explained by the improved data availability at higher levels of regional aggregation for observations in Western Europe. In principle, however, the choice for the level of spatial aggregation is somewhat arbitrary. On the one hand, using large spatial units of observation hides spatial heterogeneity and spatial interaction, which might be present within the observed regions. On the other hand, a very low level of regional aggregation increases the danger of slicing functional regions into parts. In

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region (see Bräuninger and Niebuhr 2005).

[3] NUTS (Nomenclature of Statistical Territorial Units) are spatial units used by EUROSTAT. While spatial units in NUTS-0 are countries, the level of spatial aggregation decreases with the levels 1, 2 and 3.

the latter case, economic activities within a homogenous, functional region may be wrongly detected as spatial autocorrelation (see also Ertur and Le Gallo 2003).

This analysis is conducted at a relatively low level of regional aggregation for two reasons. Firstly, as suggested by Bräuninger and Niebuhr (2005), there might be economic spillover effects which cannot be observed in a sample of NUTS-2 regions due to their short range. Secondly, many of the NUTS-2 regions are relatively large and combine very heterogeneous areas, such as highly agglomerated and very rural regions. The Baltic States, where the NUTS-2 level equals the county-level, are good examples for diverse regional structures within NUTS-2 regions. Our cross-section consists basically of NUTS-3 level regions of the EU-25. Only in the case of Germany do we use 97 so-called planning regions (*"Raumordnungsregionen-ROR"*) which comprise several NUTS-3 regions.[4] Overall, we analyse 861 regions, of which 739 belong to the EU-15 and 122 to the NMS.[5]

To measure income, we use GDP per capita data adjusted for purchasing power standards (PPS), taken from the Eurostat database.[6] Data in PPS are adjusted for differences in national price levels, but not for differing price levels within countries. Although there are considerable regional within-country differences in price levels, we think data in PPS provide a better approximation for regional wealth than data in euros. Furthermore, GDP in PPS is used to determine the eligibility of regions for support from the EU structural funds in the range of Objective 1. GDP data are collected in the place of residence. When using small regional units, the commuting of workers between their place of residence and place of work may pose a problem for the analysis. However, convergence analyses are typically conducted with GDP data. For example, using GDP per employee data might ease the commuting problem, but it creates another one: Pro-

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[4] German NUTS-3 regions are relatively small and very numerous compared to other European NUTS-3 regions. The inclusion of 439 German NUTS-3 regions would have increased the influence of German regions in the analysis significantly.

[5] See more detailed information on the cross-section in the appendix.

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

ductivity can be detached from actual regional growth. During structural changes in particular, decreasing employment may lead to increasing GDP per employee.

4 DEVELOPMENT OF REGIONAL DISPARITIES IN THE EU

4.1 Spatial distribution of income levels and growth

Figure 1 displays regional per capita incomes relative to the EU-25 average income level in 1995. 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 Southern England to Northern Italy. In the EU-15, regions with income levels below 75% of the EU-25 average can be found mainly in the southern periphery. Most noticeable, however, is an east-west gradient. In 1995, a bit more than two thirds of all regions in the NMS had income levels below 50% of the EU-25 average. Only the five capital regions Prague (126%), Bratislava (95%), Ljubljana[7] (94%), Budapest (89%) and Warsaw (89%) as well as Cyprus (82%) had income levels above 75%.

However, the spatial pattern of per capita growth between 1995 and 2003 is more dynamic in the periphery, indicating a general catching-up process (see figure 2). Most regions in Spain, Greece, Ireland, Finland and in the NMS experienced growth rates above the average EU-25 growth rate. Relatively few regions within the "blue banana", mainly in the London area and in the Netherlands, displayed above average per capita growth.

Strikingly, a closer look at regional growth rates in the NMS reveals particularly strong dynamics in the relatively rich agglomerations – mainly the capital regions and their peripheries. The capital cities Warsaw (139%), Prague (138%), Budapest (122%), Bratislava (116%) and Ljubljana (109%) clearly achieved above average income levels in

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[7] The actual name of the region is Osrednjeslovenska. It comprises Ljubljana and surrounding regions.

2003. This suggests that the general catching-up of the NMS could have been accompanied by increasing regional within-country disparities in the NMS.

Figure 1: Regional income levels relative to the EU-25 average
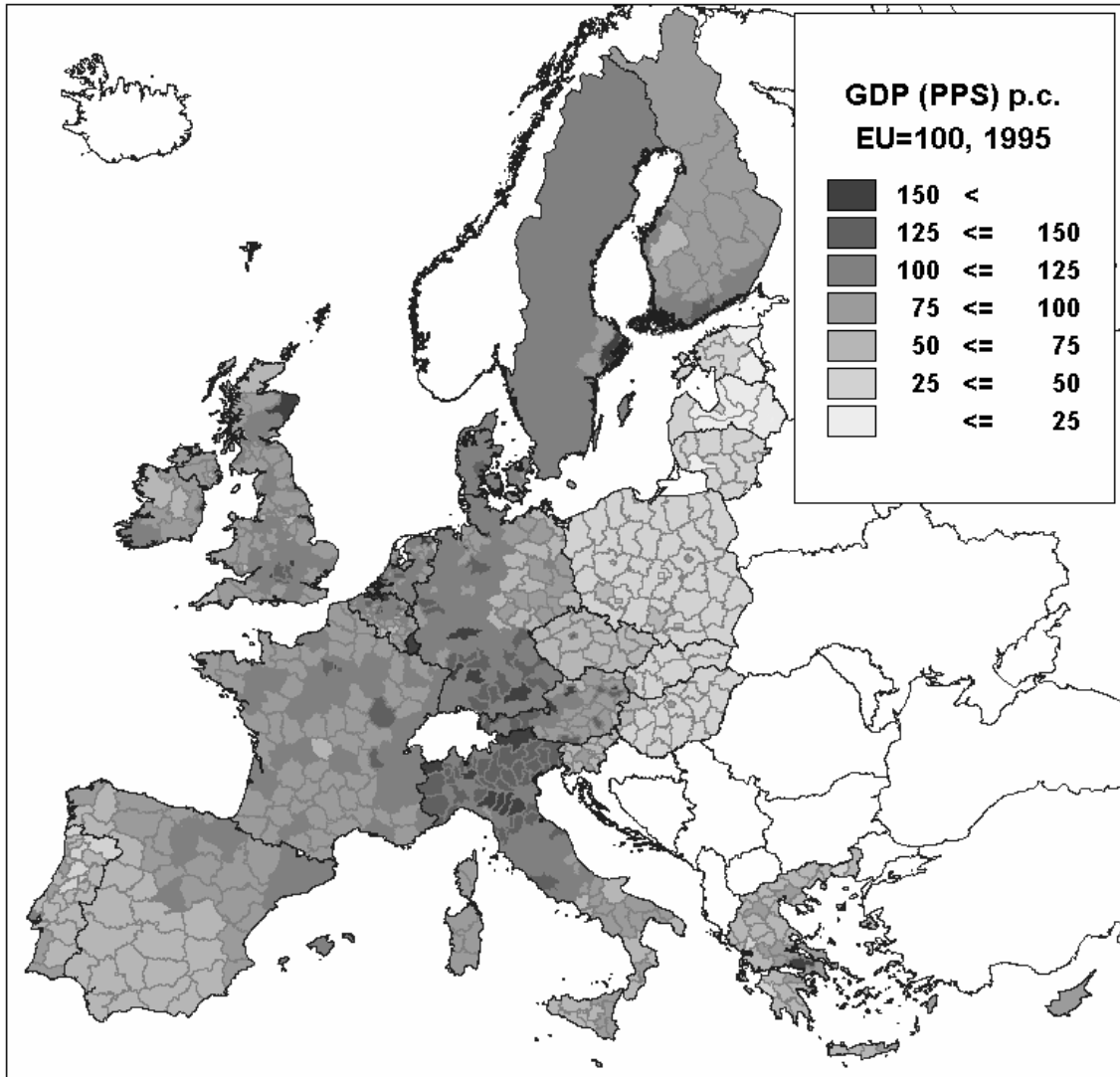
Source: Eurostat 2007, own calculations.

Figure 2: Regional per capita growth relative to the EU-25 average
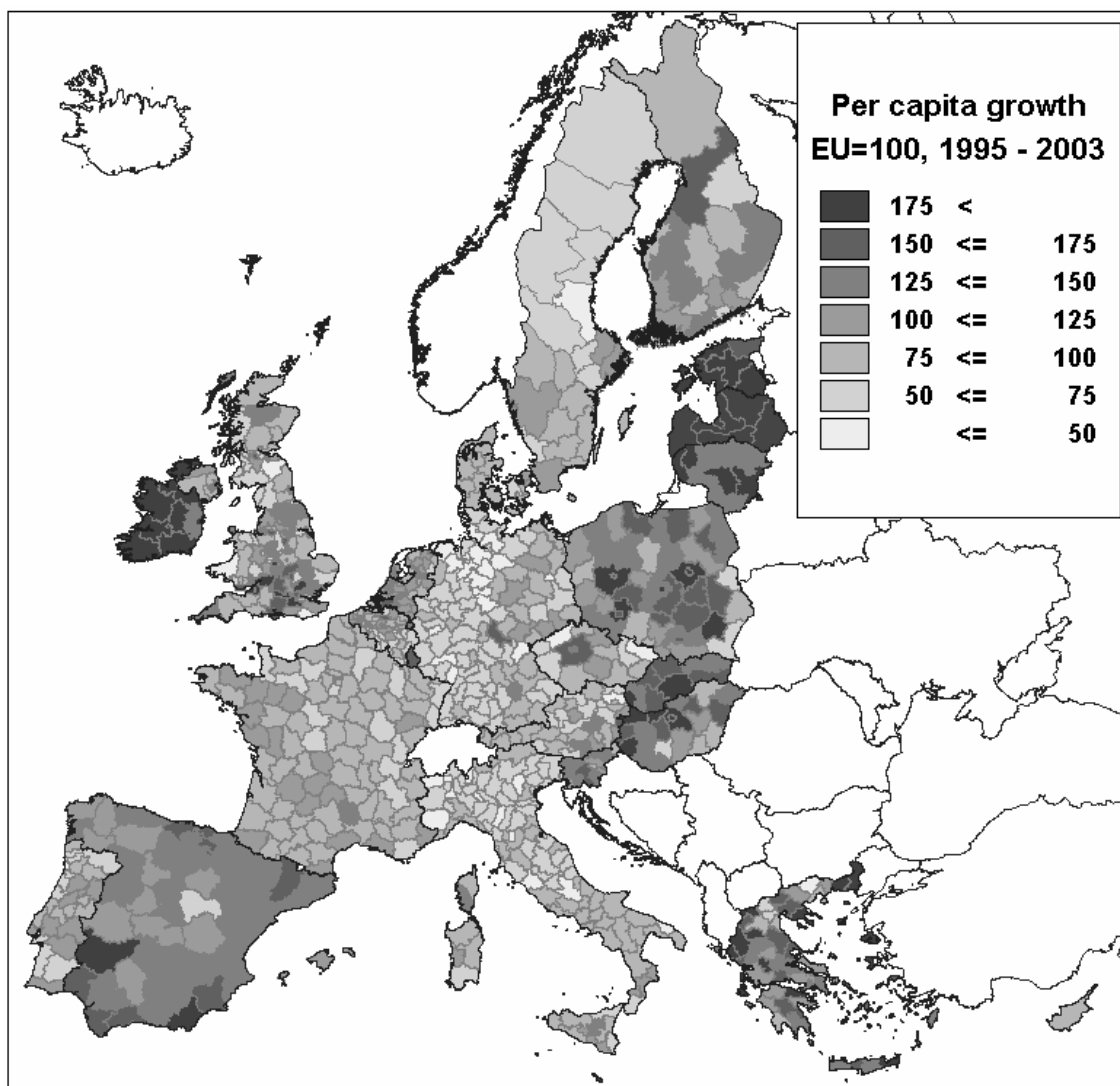
Source: Eurostat 2007, own calculations.

4.2 Between- and within-country inequality

This section explores the issue of differences in the development of overall regional inequality in the EU and the development of regional inequalities within the individual member states. To this purpose, we divide regional inequality into within-country and

between-country disparities using the population-weighted version of Theil's index of inequality.[8]

$$T_{total} = \sum_{i} \left(\frac{N_i}{N} \right) \ln \left(\frac{N_i/N}{Y_i/Y} \right) \tag{1}$$

where

N – population in all regions,

N_i – population in region i,

Y – total GDP in all regions,

Y_i – total GDP in region i,

Theil's index relates regional income shares of the total sample population's income Y_i/Y to regional population shares of the total sample population N_i/N. When population shares equal the respective income shares in all regions, incomes are distributed completely evenly, hence Theil's index equals zero. The properties of Theil's index make it possible to break down total inequality in such a way that the weighted sum of the components matches the index for overall inequality. The left-hand term on the right-hand side of equation (2) expresses the between-country component $T_{between}$. It equals the expression in equation (1) except that observational units are countries instead of regions. The within-country component T_{within} is given by the right-hand term on the right-hand side of the equation. It contains the population-weighted sum of indices for regional inequality within each country.

$$T_{total} = \sum_{j} \left(\frac{N_j}{N} \right) \ln \left(\frac{N_j/N}{Y_j/Y} \right) + \sum_{j} (N_j/N) * \sum_{i} \left(\frac{N_i}{N_j} \right) \ln \left(\frac{N_i/N_j}{Y_i/Y_j} \right) \tag{2}$$
$$= T_{between} + T_{within}$$

where

N_j – population in country j,

_____

Y_j – total GDP in country j,

Figure 4 displays the development of income inequality in the EU-25 from 1995 to 2003. It shows that both inequality between countries and inequality within countries are very significant. Furthermore, this period is marked by a continuous decline in total income inequality. However, the reduction in overall inequality was driven exclusively by the between-country component. At the same time, the size of within-country inequality has increased slightly.

Figure 3:   Inequality within and between countries of the EU-25
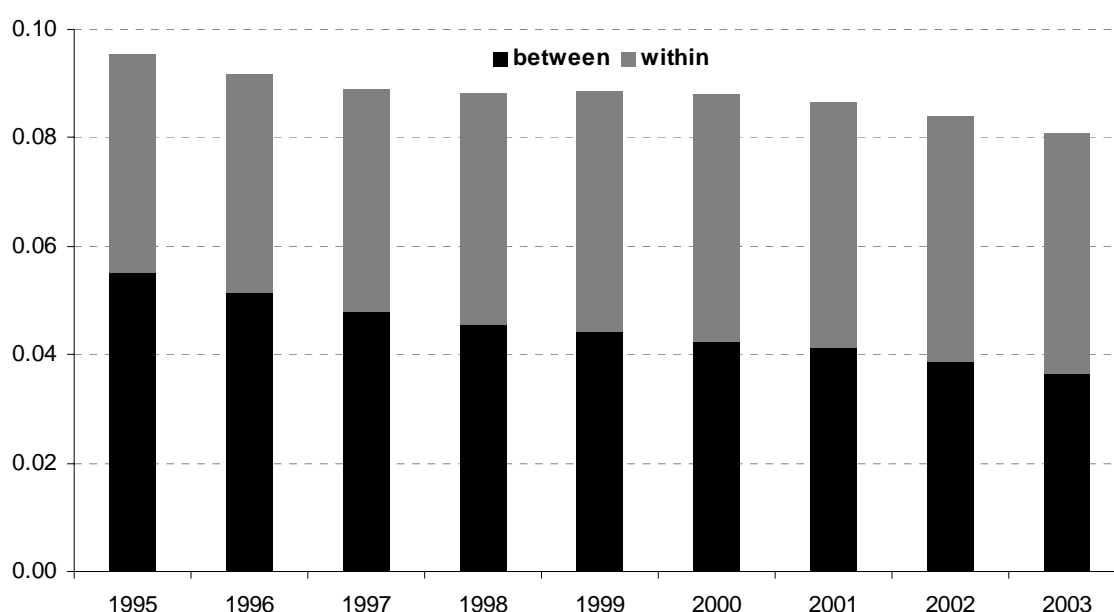
Source: Eurostat 2007; own calculations.

Regarding income inequality separately in the EU-15 and the NMS, disparities between countries are shown to be less important than disparities within countries (see figures 4 and 5). Hence, within the EU-15 and the NMS differences in per capita income across countries are much less important. Therefore, the magnitude of the between-country component in the EU-25 is mainly due to differences in income levels between old and new member states. However, Theil's index shows distinctly different developments in income inequality between the EU-15 and the NMS. The EU-15 experienced a small

sensitive to changes at the bottom of the income distribution than the income weighted first measure (see Duro 2003).

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decrease in inequality between countries, while the level of within-country disparities remained relatively constant. In the NMS, by contrast, decreasing between-country inequality was accompanied by a significant increase in within-country inequality, leading to an overall increase in income disparities.

Overall, the analysis shows that decreasing disparities in the EU between 1995 and 2003 were mainly a national phenomenon. Equalising processes on the country-level were accompanied by an increase in regional inequality within the individual NMS. These findings are consistent with Lammers (2002) and Tondl and Vuksic (2003), who conclude that there are metropolitan regions in the NMS which are driving national growth rates upwards. In particular, economically dynamic capital regions are responsible for a large share of national products while other regions lag behind.

Figure 4: Inequality within and between countries of the EU-15
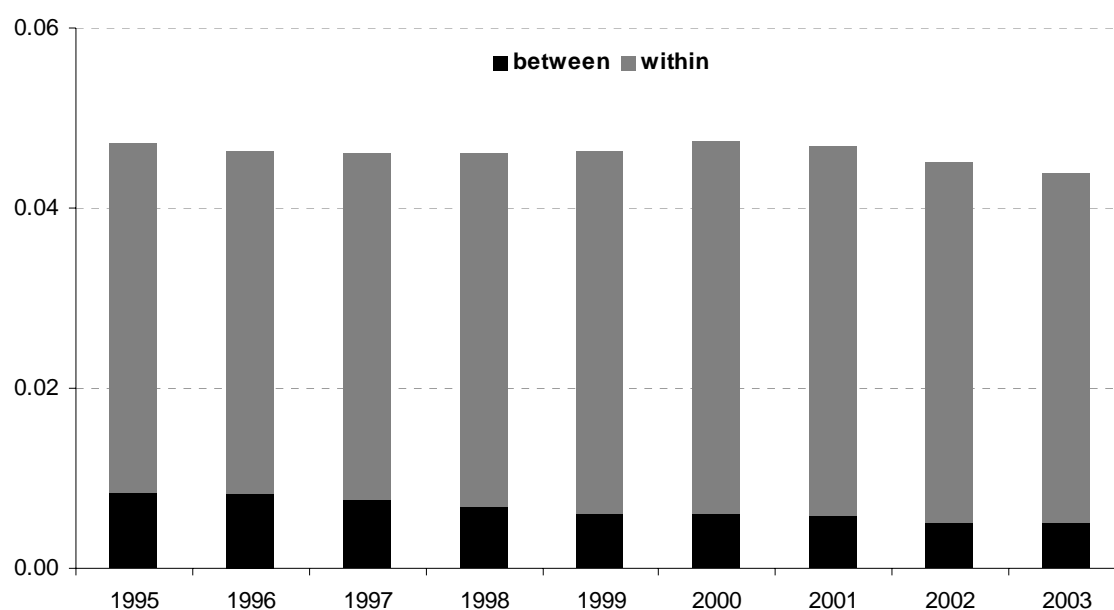
Source: Eurostat 2007; own calculations.

Figure 5: Inequality within and between countries of the NMS
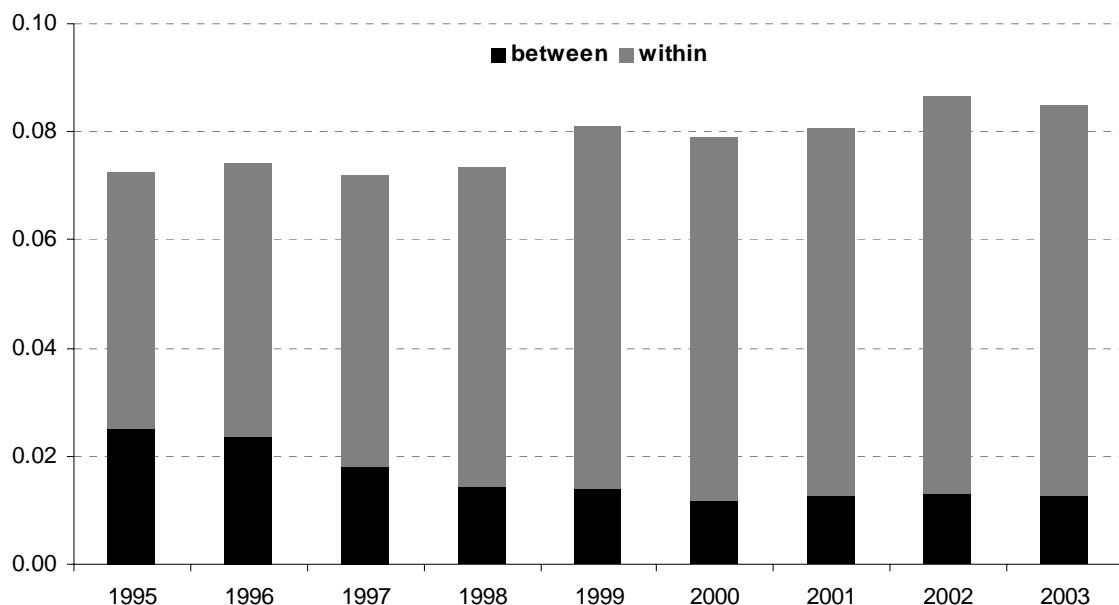
Source: Eurostat 2007; own calculations.

5   ESTIMATION

5.1   *β*-convergence

β-convergence is defined as a negative relationship between initial income levels and subsequent growth rates. In order to test for regional *β*-convergence, we use the common cross-sectional OLS approach with per capita income growth as the dependent variable and the initial income level as the explanatory variable. In a second estimation dummy variables for countries will be applied in order to account for country-specific effects. Therefore, we test for absolute and conditional convergence.

$$\ln(\frac{y_{i0+T}}{y_{i0}}) = \alpha_0 + \alpha_1 \ln(y_{i0}) + \sum_{j=1}^{N} \alpha_{2j} c_{ji} + \varepsilon_i \tag{3}$$

where

y_{i0} − initial GDP *per capita* in region i,

T − number of years in observation period,

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

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

ε_i – normally and independently distributed error term.

When the estimated coefficient α_1 is negative, poor economies tend to grow faster than rich ones. The annual rate of convergence β can be obtained from 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. Since convergence patterns are supposed to differ between the EU-15 and the NMS, separate models for both country groups will be estimated.

5.2 Spatial dependence

Spatial dependence can be taken into account by applying a spatial weight matrix W, which is supposed to capture spatial structure and the intensity of spatial dependence. The specification of the matrix may influence regression results. However, there are various ways to specify a spatial weight matrix. Because there is usually no a priori information about the exact nature of spatial dependence, the choice for the design of the spatial weight is somewhat arbitrary (see Niebuhr 2001, Ertur and Le Gallo 2003). A common approach is the concept of binary contiguity where the elements of the matrix $w_{ij}=1$ if region i and region j share a common border or are within a certain distance range to each other and $w_{ij}=0$ otherwise (e.g. Rey and Montouri 1999). We use a distance-based weight matrix W where distance is the squared inverse of the great-circle distance between the geographic centres of the regions. 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 distances can be interpreted as reflecting a gravity function (see Le Gallo et al. 2003). Furthermore, the distance matrix is row-standardized so that it is relative and not absolute distance that matters.

$$W = \begin{cases} w_{ij} = 0 & \text{if } i = j \\ w_{ij} = 1 / d_{ij}^2 & \text{if } d_{ij} \le D \\ w_{ij} = 0 & \text{if } d_{ij} > D \end{cases} \tag{4},$$

where

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

    d – distance between geographical centres of regions i and j;

    D – critical distance cut-off.

According to Anselin (2001), spatial autocorrelation[9] can be defined as a spatial clustering of similar parameter values. If similar parameter values - high or low – are spatially clustered there is a positive spatial autocorrelation present in the data. Conversely, a spatial proximity of dissimilar values indicates a negative spatial autocorrelation.

As a measure of the spatial clustering of income levels and growth in the EU, we use Moran's I-statistic:

$$I_t = \frac{N \sum_{i=1}^{N} \sum_{j=1}^{N} x_{i,t} x_{j,t} w_{i,j}}{N_b \sum_{i=1}^{N} x_{i,t}^2} \tag{5},$$

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).

When Moran's I is positive and significant, there is a tendency towards a spatial clustering of similar parameter values in the sample. We use Moran's I-statistic to check for

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[9] The terms 'spatial autocorrelation' and 'spatial dependence' are used as synonyms, although the authors acknowledge that the terms are not exactly identical in meaning. .

the spatial autocorrelation of regional growth rates and income levels. Table 2 shows the coefficient *I* using the weight matrix *W*. Different critical distance cut-offs were applied in order to check for sensitivity to changes in the spatial weight.

The results in table 1 show that there is strong evidence for spatial dependence among the regions in the EU. The coefficient *I* is highest with a cut-off distance of a hundred kilometres and decreases with increasing cut-off distances. However, the significance of the results (standardised z-values) increases up to a critical cut-off distance of 500 km and decreases thereafter. This leads to the conclusion that regional interaction over distances of more than 500 km are not relevant in terms of spatial autocorrelation. Therefore, a critical cut-off distance of 500 km will be used in the following analysis.

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

Critical distance cut-off (km)	Moran coefficient I (Standardised z-value)		
	$\ln\left(\dfrac{y_{i2003}}{y_{i1995}}\right)$	$\ln(y_{i1995})$	$\ln(y_{i2003})$
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 (see Anselin 1988). Ignoring the substantive form of spatial autocorrelation, which results from direct regional interaction, may lead to biased and inefficient estimates. The nuisance form of spatial dependence is restricted to the error term. It stems from measurement errors such as a wrongly specified regional system not reflect-

ing the spatial structure of economic activities adequately. Ignoring nuisance dependence may lead to inefficient estimates.

Anselin (1988) suggests two different model specifications in order to deal with the respective forms of spatial dependence. Both models are estimated with the maximum likelihood (ML-) method. In the spatial error model (SEM), spatial dependence is restricted to the error term. Hence, on average per capita income growth is explained adequately by the convergence hypothesis. Therefore, the SEM is an appropriate model specification for the nuisance form of spatial dependence:

$$\ln(\frac{y_{i0+T}}{y_{i0}}) = \alpha_0 + \alpha_1 \ln(y_{i0}) + \sum_{j=1}^{N} \alpha_{2j} c_{ji} + \varepsilon_i, \qquad \text{with } \varepsilon_i = \lambda[W \cdot \varepsilon]_i + u_i \ (6),$$

where

λ - spatial autocorrelation coefficient,

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

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

ε_i and u_i - normally and independently distributed error terms.

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

$$\ln(\frac{y_{i0+T}}{y_{i0}}) = \alpha_0 + \rho\left[W \cdot \ln(\frac{y_{0+T}}{y_0})\right]_i + \alpha_1 \ln(y_{i0}) + \sum_{j=1}^{N} \alpha_{2j} c_{ji} + \varepsilon_i \qquad (7)$$

where

ρ - the spatial autocorrelation coefficient,

$\left[W \cdot \ln(\frac{y_{0+T}}{y_0})\right]_i$ - the i-th element of the vector of weighted growth rates of other regions.

5.3 Estimation Results

The results of OLS estimation ignoring spatial dependence are presented in table 2. The EU-25 experienced a significant regional convergence of income levels at an average rate of 2% p.a. Such a convergence rate, which is frequently found in literature (e.g. Barro and Sala-i-Martin 1995), implies a half-life of 35 years. Regional convergence was a bit weaker within the EU-15 and clearly less pronounced within the NMS. The respective half-lives are 38 years in the EU-15 and 50 years in the NMS.

Taking national effects into account, estimated convergence rates decrease substantially. There is no significant convergence process going on within the countries of the EU-25, and the speed of within-country convergence in the EU-15 halves relative to the absolute convergence model. The rate of within-country convergence in the NMS even changes sign. Regional per capita incomes within the countries of the NMS actually diverge at a rate of 1.5% p.a. Hence, within individual NMS, richer regions tend to grow faster. Overall, the catching-up process in the EU-25 is predominantly a national phenomenon. Niebuhr and Schlitte (2004) obtain similar results when testing regional within-country convergence at the NUTS-2 level.

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**	1.473**	1.258**	0.553**	0.876**	-0.646
	(17.04)	(8.84)	(3.98)	(4.34)	(6.09)	(-1.60)
α_1	-0.130**	-0.119**	-0.092*	-0.020	-0.058**	0.112**
	(-13.36)	(-6.88)	(-2.52)	(-1.14)	(-3.89)	(2.58)
$R^2_{adj.}$	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
Convergence speed	2.0**	1.8**	1.4*	0.3	0.9**	-1.5**
Half-life	35	38	50	240	81	-
Jarque-Bera	389.54**	429.96**	9.50**	496.48**	540.82**	3.96
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.

The results of Moran's *I* test in table 2 show significant spatial autocorrelation in the residuals of all OLS estimations. Though commonly used, Moran's *I* is not very reliable and does not provide information about the form of spatial dependence (Anselin 1992). In order to identify the form of spatial autocorrelation, Lagrange Multiplier (LM-) tests are applied. According to the decision rule by Anselin and Florax (1995), spatial dependence is of the nuisance form 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. Conversely, the opposite would indicate that the substantive form of spatial autocorrelation is present in the data.

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 and consistent preference for either the substantive or the nuisance form. Furthermore, LM-tests may be unreliable in the presence of non-normality (see Anselin 1992). The Jarque-Bera test detects non-normality in almost all models. Seeing these potential problems, both the SEM and the SLM are tested in all cases (see tables 3 and 4).

Table 3:   SLM estimation results

	EU-25	EU-15	NMS	EU-25	EU-15	NMS
Country dummies		*no*			*yes*	
Number of regions	*861*	*739*	*122*	*861*	*739*	*122*
Intercept	0.485**	0.509**	0.346	0.343**	0.548**	-0.541**
	(5.72)	(4.31)	(1.35)	(2.82)	(4.24)	(-1.60)
α_1	-0.043**	-0.046**	-0.019	-0.014	-0.042**	0.101**
	(-5.23)	(-3.87)	(-0.69)	(-1.14)	(-3.23)	(2.89)
ρ	0.780**	0.782**	0.604**	0.410**	0.535**	0.508**
	(21.28)	(20.15)	(6.05)	(6.52)	(8.78)	(4.02)
AIC	-1640.1	-1473.2	-174.9	-1755.0	-1558.2	-197.8
Convergence speed	0.6**	0.7**	0.3	0.2	0.6**	-1.4**
Half-life	110	103	253	344	113	-
LM-test	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: SEM estimation results

Country dummies	EU-25	EU-15 *no*	NMS	EU-25	EU-15 *yes*	NMS
Number of regions	*861*	*739*	*122*	*861*	*739*	*122*
Intercept	0.781**	0.752**	0.268	0.518**	0.766**	-0.311
	(6.30)	(4.87)	(0.97)	(4.01)	(5.30)	(-0.98)
α_1	-0.041**	-0.045**	0.013	-0.017	-0.048**	0.076*
	(-3.62)	(-2.77)	(0.42)	(-1.30)	(-3.22)	(2.35)
λ	0.840**	0.809**	0.830**	0.495**	0.592**	0.540**
	(26.01)	(21.21)	(12.37)	(7.75)	(9.79)	(4.17)
AIC	-1636.1	-1467.4	-185.5	-1764.8	-1568.7	-199.0
Convergence speed	0.6**	0.7**	-0.2	0.2	0.7**	-1.0*
Half-life	116	105	-	283	99	-
LM-test	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 spatial lag coefficient ρ in the SLM as well as the spatial error coefficient λ in the SEM are highly significant. Furthermore, the Akaike Information Criterion (AIC) shows improved model-fits in all cases, indicating that regions are affected in their development by their neighbourhood.[10] Applying SEM and SLM estimations without control for country-specific effects yields very low convergence rates. 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. In the case of the NMS, LM-tests point to the nuisance form of spatial dependence. Considering the EU-25 and the EU-15 cases, LM-tests do not provide a clear-cut conclusion as to which of the two models is more suitable. However, compared with the convergence speed in the spatial models, OLS estimates seem to be biased. This leads to the conclusion that the substantive form of spatial autocorrelation is present in the data.[11]

When country dummies are included, estimations yield very 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 in individual NMS diverged. Also, the model fits do not vary remarkably from OLS models. This indicates that OLS

estimates are not seriously biased when national effects are taken into account. As a consequence, spatial lag dependence seems to be captured sufficiently by the employment of country dummies. Hence, national macroeconomic factors appear to be more influential on regional growth than spatial spillovers. To put it differently, spatial spillovers seem to stop at national borders. Similar results were found by Bräuninger and Niebuhr (2005) and Geppert et al. (2005) for NUTS-2 regions in Western Europe and by Feldkircher (2006) for NUTS-2 regions in the enlarged EU.

6   CONCLUSIONS

Examining regional income levels of NUTS-3 regions across the enlarged EU shows significant regional disparities in both the EU-15 and the NMS. There is a core-periphery structure with relatively high income levels in the centre of the EU and relatively low income levels in peripheral regions. Furthermore, the spatial structure of income levels in the EU is marked by an east-west gradient, with comparatively low income levels in the NMS. However, regional growth rates tend to be higher in the periphery, especially in the NMS, indicating a catching-up process. Inequality analysis by means of Theil's inequality index shows a decrease in total income inequality in the EU. This development, however, is mainly due to diminishing income disparities at the country level. While the level of within-country inequality remains relatively constant, the NMS experience a significant increase in regional within-country inequality.

These findings are confirmed by formal β-convergence analysis. OLS estimation results show a significant absolute convergence at an annual rate of 2% between 1995 and 2003. At the same time, catching-up processes were a bit less pronounced in the EU-15 and the NMS. However, taking national effects into account, the general convergence process was shown to be driven mainly by country-specific effects, i.e. national policies,

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[10] The R^2 in ML-estimations is only a pseudo measure and therefore not suitable for comparison to OLS. Thus, the AIC is used instead (see Anselin 1995).

[11] It should be noted that a direct comparison of β-coefficients between the SLM and OLS models is not quite correct because the estimated speed of convergence in the SLM also takes into account indirect and induced effects (see Abreu et al. 2005 or Pace and Le Sage 2006).

legislation, tax systems etc. This is particularly the case in the NMS, where institutional changes in the course market liberalisation have been large as compared to Western Europe. 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 a general catching-up of the NMS regional within-country disparities in the NMS have increased. Considering spatial dependence in the convergence estimations shows that regions cannot be regarded as isolated entities in absolute convergence processes. Both spatial lag dependence and spatial error dependence matter. However, in the conditional convergence models the effects of spatial spillovers are sufficiently captured by country dummies. This demonstrates that national macroeconomic factors have a greater influence on regional growth than spatial interaction. In other words, spatial growth spillovers seem to stop at national borders, which indicates that border impediments still matter for the intensity of economic cross-border integration in the EU.

Regarding the short length of the period under observation, these results cannot be interpreted as an indication for long-run development. It is possible, for example, that forces driving regional inequality in the individual NMS will cease in the long run. However, the analysis shows that there might be a trade-off between convergence on the national level and regional within-country convergence in the NMS which might challenge the objective of economic and social cohesion pursued by the European Commission.

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APPENDIX

Table A1: The regional cross-section

	Number of regions	**Classification**
EU-25	*861*	*NUTS-3/ROR*
EU-15	*739*	*NUTS-3/ROR*
Belgium	43	NUTS-3
Denmark	15	NUTS-3
Germany	97	ROR
Finland	20	NUTS-3
France*	96	NUTS-3
Greece	51	NUTS-3
Ireland	8	NUTS-3
Italy	103	NUTS-3
Luxembourg	1	NUTS-3
Netherlands	40	NUTS-3
Austria	35	NUTS-3
Portugal**	28	NUTS-3
Spain***	48	NUTS-3
Sweden	21	NUTS-3
United Kingdom	133	NUTS-3
EU-10	*122*	*NUTS-3*
Estonia	5	NUTS-3
Latvia	6	NUTS-3
Lithuania	10	NUTS-3
Malta	1	NUTS-2
Poland	45	NUTS-3
Slovakia	8	NUTS-3
Slovenia	12	NUTS-3
Czech Republic	14	NUTS-3
Hungary	20	NUTS-3
Cyprus	1	NUTS-3

* French overseas departments Guadeloupe, Martinique, French Guyana and La Reunion.
** Excluding Acores and Madeira.
*** Excluding Canary islands as well as Ceuta and Mellila.

NUTS – Nomenclature of Statistical Territorial Units of EUROSTAT; ROR – Raumordnungsregionen (Planning Regions) of the Bundesamt für Bauwesen und Raumordnung.

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