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# Income Distribution Dynamics in The European Union: Exploring (In)Stability Measures within Geographical Clusters\*

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## 1 Introduction

The study of regional inequalities between and within countries has been an area of continuous research for many decades. Since Baumol's (1986) study based on Robert Solow's seminal work (solow1956), others have investigated the convergence dynamic between countries and regions. The addition of other social-economic variables has, since then, been one strategy used in order to extend the model in order to fulfil one of its main goals, to explain growth dynamics across time and/or space.

In this paper, it will be argued that traditional  $\beta$  and  $\sigma$  convergence approaches do not provide evidence related with dynamics of the whole regional income distribution (Lopés-Bazo et al. 1999). In particular, questions about the main contributors to the regional dynamic process, whether economies have moved up or down the income ranking and/or whether a strong persistence dominates the observed distribution, are all interesting questions in the European Union framework, since convergence is simultaneously a necessity for the Union to prosper and an expected outcome.

The absence of convergence in GDP per capita is attributed by (Lopés-Bazo et al. 1999) to the inability of the poor regions to make significant moves up the ranking, as well as to the persistence of spatial clusters of low values in the traditional periphery; these can be seen as evidence of the persistence of locational

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disadvantages within these economies, even in a world in which activity is less dependent on specific geographical locations.

This inability of movement and persistence in spatial clusters can be analyzed with the Moran Scatterplot, that, in sum, indicates the relative position of a region relatively to the sample mean and to its neighbours mean for each of the years under analysis. In the present work, we follow the methodology used in Rey (2001) and Ertur and LeGallo (2003), in order to identify those regions which have changed quadrant within the period under analysis. However, the authors acknowledge in this study that there is a serious drawback with this methodology, namely that movements within quadrant, which may be of statistical and economic relevance are overlooked. Hence, an alternative method which measures the magnitude of the movement for each region between time periods and also the direction of this movement is introduced.

Other than studying regional dynamics in terms of regional income per capita, this study will compare economic aggregate data with socially perceived well-being variables. The introduction of psychological variables in the traditional neo-classical growth framework is based on the assumption that social indicators contribute, in the long-run, to the stability or dynamics of local economic systems. Well-being influences day-to-day life; moreover, it is a strong determinant of labour factor productivity.

A distinction will be made between *stable* and *instant* measures of well-being. While the first group attempts to capture long-run attitudes, the latter attempts to capture instant well-being, which can be seen as a proxy for instability and dynamism in a social system.

While perceptions of one's well-being is dependent on mostly latent psychological variables, the aggregation of these perceptions on a regional level can capture the effect of environmental factors in one's day-to-day life. On the other hand, depending on the level of aggregation, these effects may be lost if the regional aggregation is too high, hence the intra-regional realities too heterogeneous. This problem of *ecological fallacy* may in fact hamper the validity of some of the conclusion from this type of work (Robinson 1998, p.90).

In the present work, we use a dataset for 150 NUTS2 European regions from the Cambridge Econometrics database (1991-2002) and from the European Social Survey (version 3 - 2003). The first source provided harmonised economic indicators, while the latter provided social indicators based on individual questionnaires. The combination of both data sources implied the reduction of the

size of the dataset due mainly to distinct regional classification schemes<sup>1</sup>.

The rest of the paper is organised as follows: in the next section, the methodology used will be discussed. In section three, results the dynamic analysis of movements within and between quadrants of the Moran Scatter plot will be discussed. Also, similar exploratory spatial data analysis techniques will be used to analyse social perception variables. Section four concludes.

## 2 Methodology

Mixing social perception and economic variables should be done with care. Also, in the case of regional analysis, the use of data aggregated at the NUTS 2 level implies working with central tendencies for regions which are, within themselves, very diverse. Hence, it is very difficult to distinguish behaviours due to environmental variables, such as the level of urbanisation. Whenever possible, apart from central tendencies, measures of dispersion within regions should be analysed as these can give an idea of intra-regional (in)coherence in terms of behaviour.

Before mixing datasets, economic and social behaviour information will be dealt separately. Particular attention will be given to the spatial distribution of the phenomena being studied, since contagious behaviour is understood as central to the study of any phenomenon with a geographical character. Whenever possible, the influence of one agent's behaviour (individual, community, region) on its neighbour should be taken into account. Otherwise, the researcher's work is hampered from the study of the very nature of the data available to him.

The instability in the spatial distribution of a given economic variable may be studied using a Moran Scatterplot (Anselin1996). It represents, on the horizontal axis, the standardized value of the variable ( $z_t$ ) and in the vertical axis, its spatial lag ( $Wz_t$ ), which corresponds to the spatially weighted average of each region's neighbours. The four quadrants of the scatterplot represent four distinct types of association of each region with its neighbours: (1) HH, a region with a high value (i.e. above the mean) is surrounded by regions which, on average, behave similarly in relation to the mean; (2) LH, a region with a below the mean value is surrounded by regions with an above the mean behaviour; LL, both variables (the original and the spatial lag) are below the mean; (4) HL, a region with a value above the mean is surrounded by region with the opposite behaviour. Quadrants one and three contribute to a positive association (spatial autocorrelation), whilst

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<sup>1</sup>This explains, for example, the exclusion of all Italian and Greek regions, not contemplated in version 3 of the ESS.

regions in quadrantes two and four contribute to a negative spatial autocorrelation.

The evolution over the 12 years of the sample of the spatial distribution of regional real GDP per capita was performed, as suggested by Rey (2001). Using the logarithm of this variable, and its respective spatial lag, it was possible to compare Moran scatterplots for different years. Rey (2001) proposes that each region is classified according to its quadrant, which is also dependent on the location of its neighbours, and also to the shift in quadrant location between periods.

This classification schema includes four groups: the first includes the relative shift of one region:  $HH \rightarrow LH$ ,  $HL \rightarrow LL$ ,  $LH \rightarrow HH$ ,  $LL \rightarrow HL$ . The second includes relative shifts of the neighbour:  $HH \rightarrow HL$ ,  $HL \rightarrow HH$ ,  $LH \rightarrow LL$ ,  $LL \rightarrow LH$ . The third group includes shifts both of the region and its neighbours:  $HH \rightarrow LL$ ,  $HL \rightarrow LH$ ,  $LH \rightarrow HL$ ,  $LL \rightarrow HH$ . Finally, the fourth group includes null movements between quadrants.

Apart from identifying shifts between quadrants in the Moran Scatterplot, it is possible to measure the magnitude of the movement of the coordinates which correspond to each region, between time periods. This may be interpreted as a measure of regional (in)stability. This measure can be easily obtained by calculating the euclidean distance between pairs of coordinates. Other than this, the same clasification scheme which was introduced by Rey (2001) may be applied to classify the direction of the movement. It is also possible to measure the angle of such movements. It is thought that these provides valuable information in order to understand the dynamics within regional groups, classified according to their real income level per capita.

The object of this particular study is to cross regional mean per capita income with subjective measure of well-being and health. Five categorical variables from the 2003 version of the European Social Survey were chosen: “how happy are you?” (HAPPY), “subjective general health” (HEALTH), “enjoy life, how often last week” (ENJLF), “felt sad, how often last week” (FLTSD) and “felt calm and peaceful, how often last week” (FLTPCFL). Following the distinction made before in respect to social perception variables, the first two, HAPPY and HEALTH are understood as stable measures of well-being whilst the latter three are seen as instant measure of well-being.

Although the original data is categorical, central tendency and dispersion for each region was calculated, transforming that same data into continuous variables (although mean values are constrained by the answering schema). As was done with per capita income, the spatial distribution of these variables will be analysed, trying to identify spatial dependence and/or heterogeneity in the data.

After the analysis of each group of variables, economic and social perception independently, different econometric specifications of the growth model will be estimated, in order to try to understand the effect of social factors in long-term growth. Spatial versions of the same models will be estimated in order to test whether the spatial distribution of the phenomena studied is in effect important as an explanation of long-term growth in European regions.

## 3 Results

### 3.1 Choice of Spatial Weights Matrix

The study of spatial structure associated with any variable is strongly dependent on the form chosen of the spatial weights matrix  $W$ , where each  $w_{ij}$  element represents the proximity between each pair of spatial units. This is a theme of paramount importance, always discussed with more or less emphasis in all econometric studies where the variable *space* is made endogenous (see for example Baumont et al. 1999, Aragon et al. 2003, Ertur et al. 2003).

Probably the two most common forms of imposing a proximity relationship between regions are through a contiguity matrix  $W^f$  and through a nearest neighbors matrix  $W^n$ . In terms of contiguity matrices, it is common to choose a binary specification, where  $w_{ij} = 1$  when  $i$  and  $j$  are contiguous or zero otherwise (values in the main diagonal are set to zero).

In the present study, it was chosen a nearest neighbours matrix, but where each element  $w_{ij}$  is equal to the relative distance between the spatial units' centroids. Otherwise, values are equal to zero. Formally:

$$W^k = \begin{cases} w_{ij} = 0 & \text{if } i = j \\ w_{ij} = d_{ij} & \text{if } j \in k \\ w_{ij} = 0 & \text{if } j \ni k \end{cases}, \quad (1)$$

where  $k$  is the set of  $i$ 's nearest neighbours and  $d_{ij}$  is the relative distance between units  $i$  and  $j$ .

In the present study, the nature of the spatial structure was performed using distinct nearest neighbours matrix with different number of neighbours (6, 10, 15 and 20)<sup>2</sup>. The Moran's I statistic was used to test the performance of each matrix specification in capturing the spatial structure of the data. Seven variables were

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<sup>2</sup>The choice of 6, rather than less as the smallest number of neighbours is due to the fact that the mean number of contiguous polygons for the given dataset is 6

used, the log of real GDP per capital in the base year (lGDP91), real GDP growth rate (rGDP) and the five variables taken from the European Social Survey.

Variable / Number of neighbours	6	10	15	20
lGDP91	0.5025	0.4465	0.3971	0.3585
rGDP	0.3729	0	0	0
happy	0.5061	0.4252	0.3717	0.3130
health	0.5306	0.4391	0.3614	0.2806
enjlif	0.3885	0.3196	0.2720	0.2295
fltsd	0.5945	0.5406	0.4925	0.4450
fltpcfl	0.3607	0.1968	0.2505	0.1968

Table 1: Moran’s I statistic for different weights matrices

Table 1 shows a strong presence of spatial autocorrelation of the data in most variables<sup>3</sup>. Also, for most variables, the 6 neighbours specification is that which better captures the spatial structure in the data. This specification will be used hence forward.

### 3.2 Aggregate spatial autocorrelation

When comparing the 1991 and the 2002 Moran scatterplots (Figures 1 and 2), it is possible to observe a strong tendency for positive spatial autocorrelation in the data. This pattern is true for both years and is summarised by the value of the Moran’s I statistic around 0.5 (significant at the 99% level). The dotted lines, in both graphs, represent the central tendency in the data.

The strong positive spatial autocorrelation in the datasets is reflected in the fact that, for both years, 84% of the data is located in the HH and LL quadrants. It is interesting to note that there is a strong cluster of regions from Central/Eastern Europe whose values of both the original and the lagged variables are well below average. From the 16% of “atypical” regions<sup>4</sup>, located in the HL and the LH quadrants, the only aspect to note is that most of these include regions are located between the cluster mentioned above and the rest of the dataset, which is in accordance to what would be expected.

The analysis performed so far is only related to comparisons between the first and the last year of the sample. In order to analyse those movements which occurred throughout the time span of the sample, 12 years, it is possible to perform a temporal evolution of the spatial patterns observed through the Moran

<sup>3</sup>All values are significant at the 99% level using the permutations criteria (Anselin, 1988).

<sup>4</sup>atypical in the sense that they do not follow the general tendency.

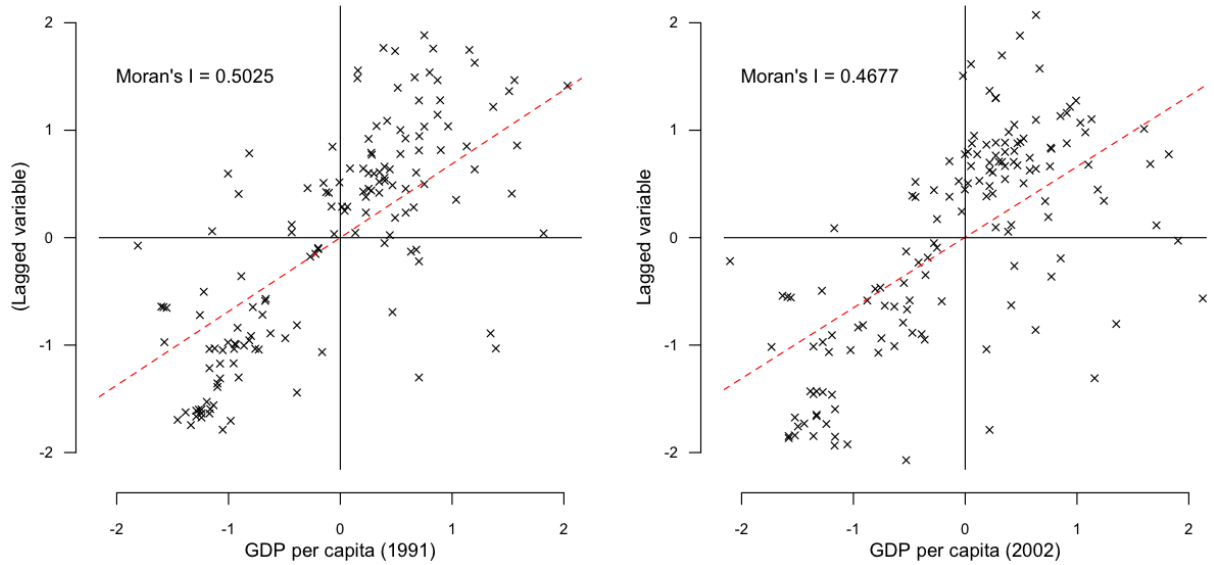


Figure 1: Moran Scatterplot (Logarithm of real GDP per capita - 1991 and 2002)

scatterplot, as suggested in ?. The author proposes the classification of each region in four distinct groups: The first group includes movements of the region:  $HH \rightarrow LH$ ,  $HL \rightarrow LL$ ,  $LH \rightarrow HH$ ,  $LL \rightarrow HL$ . The second deals with movements in the neighbours' mean:  $HH \rightarrow HL$ ,  $HL \rightarrow HH$ ,  $LH \rightarrow LL$ ,  $LL \rightarrow LH$ . The third group is related to shifts of both the region and its neighbours:  $HH \rightarrow LL$ ,  $HL \rightarrow LH$ ,  $LH \rightarrow HL$ ,  $LL \rightarrow HH$ . Finally, the fourth group is related to those regions whose quadrant position in the scatterplot remained the same.

The higher the number of regions belonging to the fourth group, the higher the stability of the whole sample (Ertur and Le Gallo 2003, Rey 2001). In the present study, 89% of the regions belong to group 4 which, as just mentioned, represents a high degree of stability. This stability in the spatial pattern may indicate the existence of spatial heterogeneity, since both the regions and their neighbours' position in relation to the European mean remained constant. Furthermore, this immobility reflects a tendency towards *positive* spatial agglomerations, since from the group of regions belonging to group four, 49% belong to the HH quadrant and 39% to the LL quadrant.

From the 150 regions that are included in the dataset, only 16 changed quadrant in the Moran scatterplot. However, the lack of movement between quadrants hides movements within quadrants throughout the period under analysis. As mentioned above, in order to achieve a better understanding of the dynamics in the regional distribution of per capita GDP, the distances moved between years in the Moran scatterplot were measured. As an illustrative example, from the 16 regions



with the highest movement within Moran's graph, only seven belong to the group of 16 which changed quadrant. Moreover, some of this later group hardly moved at all, this being justified by the fact that their location is very near the dataset's mean.

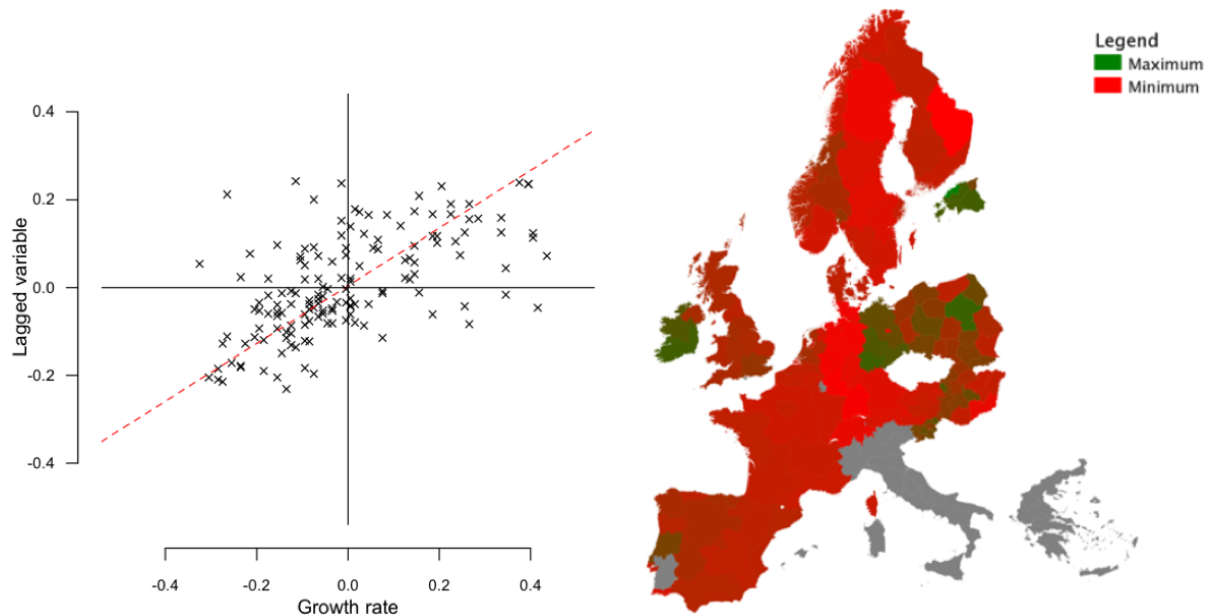


Figure 2: Growth rate (Real GDP per capita - 1991 and 2002) - Moran scatterplot and spatial distribution

Within the Neoclassical growth paradigm, it is central to analyse changes over time of GDP. The dataset used has a 12 year span, from 1991 to 2002. Figure 2 presents the Moran scatterplot (and the spatial distribution) of the GDP growth rate (between the first and the last time period). There is a solid positive trend in the series, indicating strong positive autocorrelation in the data. The map shows that growth has occurred particularly in some of the fringes, indicating some degree of convergence.

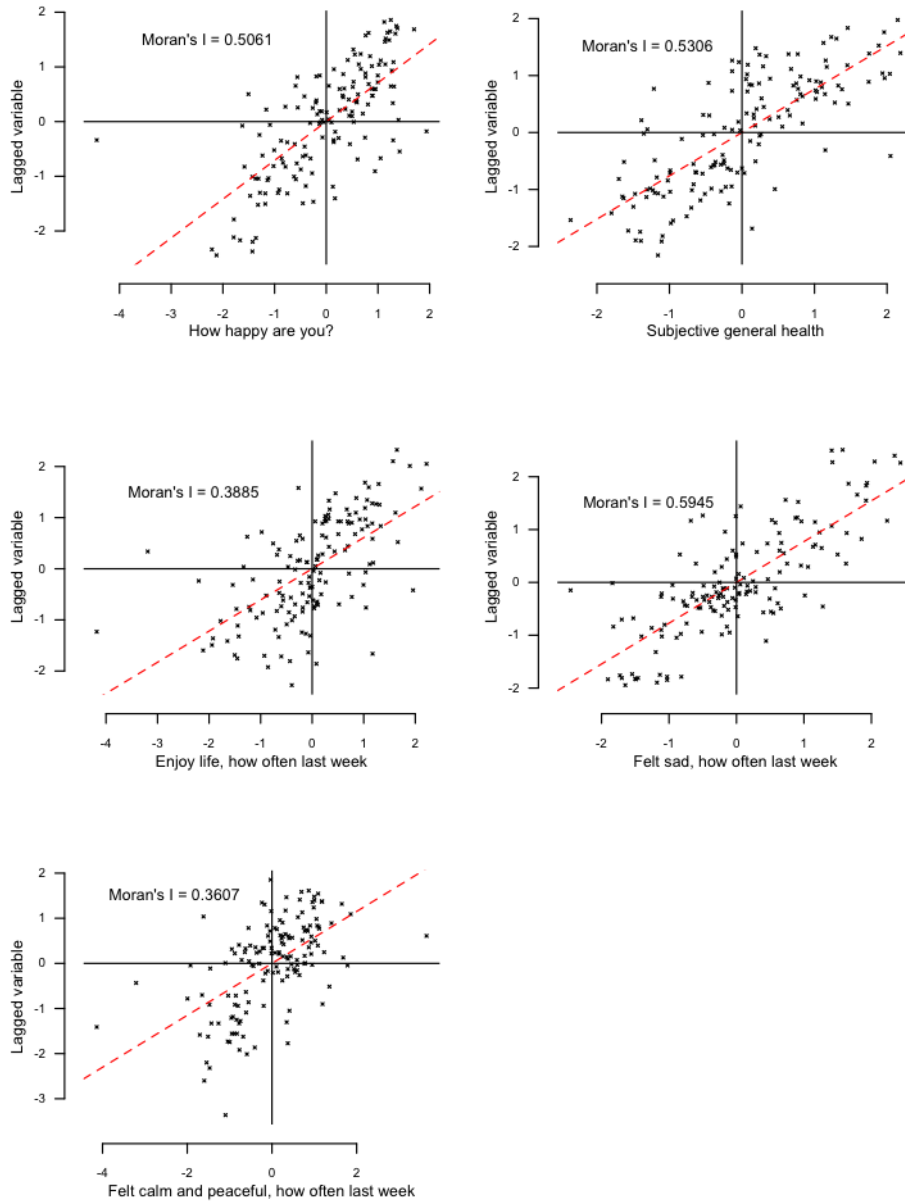


Figure 3: Growth rate (subjective well-being variables) - Moran scatter plot

Still within the exploratory exercise, it is important to check whether there is some spatial trend in the social perception variables. Figure 3 indicates that for the two stable measures of well-being (*HAPPY* and *HEALTH*), there is a strong positive trend of spatial autocorrelation. In relation to the three instant measures, all statistics are significant, although for two of them (*ENJLF* and *FLTPCFL*), autocorrelation exists, but it is weaker.

Finally, linear correlations between variables from the European Social Survey were calculated<sup>5</sup>. Table 1 shows that there is an inverse relation between subjective

<sup>5</sup>Non-linear correlations were also calculated (Spearman's rank correlation); however, the

	happy	health	enjl	fltsd	fltpcfl
happy	-				
health	-0.72	-			
enjl	0.63	-0.60	-		
fltsd	-0.74	0.64	-0.47	-	
fltpcfl	0.23	-0.16	0.15	-0.36	-

Table 2: Subjective well-being variables (correlation matrix)

health and happiness. It is beyond the scope of this paper to explore why this is so; however, one clue may lie in cultural characteristics which would emphasise the importance of environmental variables, a fact which is hard to explain at this level of aggregation. Subjective health is in fact the one variable whose behaviour is not in line with what would be expected.

### 3.3 Econometric specifications

In order to infer whether this is a significant dependent relation between the growth rate of real GDP per capita and social perception variables, four functional relationships were estimated:  $\Delta Y = f(Y)$ ,  $\Delta Y = f(Y, HA, HE)$ ,  $\Delta Y = f(Y, EN, FS, FP)$ ,  $\Delta Y = f(Y, HA, HE, EN, FS, FP)$ <sup>6</sup>.

In order to account for spatial dependence in the real GDP growth rate, two linear specifications were estimated for each model, one including the lagged dependent variable on the right side of the equation (spatial lag model - SAR), the other including the spatial structure of the data in the error term (Spatial error model - SEM). Equation 1 and 2 exemplify the types of spatial stochastic processes being estimated.

$$y_r = \rho W y_r + \beta X_r + \mu_r \quad (2)$$

$$\begin{aligned} y_r &= \beta X + \epsilon_r \\ \epsilon_r &= \lambda W \epsilon_r + \mu_r, \end{aligned} \quad (3)$$

where  $\rho$  and  $\lambda$  represent respectively the spatial autocorrelation coefficients,  $W$  the weights matrix,  $W y_r$  and  $W \epsilon_r$  represent the lagged dependent variable (SAR

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results are almost the same.

<sup>6</sup> $Y$  and  $\Delta Y$  represent respectively the logarithm of Real GDP per capita and its growth rate,  $HA, HE, EN, FS, FP$  represent the variables: “how happy are you?” (HAPPY), “subjective general health” (HEALTH), “enjoy life, how often last week” (ENJLF), “felt sad, how often last week” (FLTSD) and “felt calm and peaceful, how often last week” (FLTPCFL).

model) and the lagged error term (SEM model), and  $X$  is a matrix of dependent variables. All models were estimated using maximum likelihood.

	$\Delta Y = f(Y)$		$\Delta Y = f(Y, HA, HE)$	
	SAR	SEM	SAR	SEM
Constant	0.204 (<0.0001)	0.2929 (0)	0.1792 (0.625)	0.2392 (0.5641)
Y	-0.0018 (0.0001)	-0.0026 (0)	-0.0017 (0.0017)	-0.0023 (0.0002)
HA			-0.0053 (0.8685)	-0.0072 (0.8438)
HE			0.0218 (0.7668)	0.0374 (0.6528)
$\rho$	0.371 (0.0005)		0.3753 (0.0004)	
$\lambda$		0.3225 (0.0048)		0.3356 (0.003)

Table 3: Estimation results (1)

The results from the econometric estimations are presented in tables 3 and 4 (probabilities are presented in brackets). The first aspect to note is that in both spatial specifications (SAR and SEM models), the autoregressive coefficients ( $\rho$  and  $\lambda$ ) are significant. This indicates that growth rates in real GDP, for the sample used, depends on the behaviour of neighbouring regions. This is true both in relation to the lagged dependent and other variables not used in the model (this later effect captured by the estimated  $\lambda$  coefficient). Also important is that the convergence parameter is significant for all models and negative, indicating convergence for the time period and the regions analysed.

	$\Delta Y = f(Y, EN, FS, FP)$		$\Delta Y = f(Y, HA, HE, EN, FS, FP)$	
	SAR	SEM	SAR	SEM
Constant	-0.886 (0.016)	-1.2728 (0.0023)	0.6734 (0.4042)	-1.3011 (0.0295)
Y	-0.0019 (0.0004)	-0.0022 (0.0004)	-0.0018 (0.0095)	-0.0021 (0.001)
HA			-0.1215 (0.0843)	-0.0215 (0.5969)
HE			0.2371 (0.1113)	0.0759 (0.3633)
EN	0.1705 (0.0137)	0.2076 (0.008)	0.3488 (0.0348)	0.2565 (0.0031)
FS	0.1821 (0.0543)	0.3187 (0.0038)	-0.4536 (0.0264)	0.2389 (0.0608)
FP	0.1193 (0.0682)	0.1647 (0.0243)	-0.1476 (0.1992)	0.1592 (0.0286)
$\rho$	0.3576 (0.0007)		0.3174 (0.0038)	
$\lambda$		0.3919 (0.0002)		0.3854 (0.0003)

Table 4: Estimation results (2)

In relation to the stable and instant measures of well-being, the first point to note is that both stable measures ( $HA$  and  $HE$ ) are not significant. On the other hand,  $EN$  and  $FS$  are both significant, and both coefficients are positive.

The signal of the coefficients is not what would be expected at first, since the two variables reflect opposite states of mind. However, more than the signal of the coefficients, the main conclusion is that it is, on average and for the sample used, in those regions where respondents reflect greater volatility that real GDP per capita has grown more. This is an important result, which reflect the greater degree of change and instability which is present in those regions undergoing greater structural changes.

## 4 Conclusions

Regional system are dynamic entities whose elements (regions) constantly shift positions when comparing levels of economic development. When the variable used is real GDP per capita, it is expected, using a Neo-classic perspective, that dynamism leads in the long-run to stability, to a steady-state, which is a consequence of a convergence trajectory. This hypothesis was tested for a sample of 150 EU regions for the period between 1991 and 2002, using a methodology introduced in Rey (2001) and used in Ertur and LeGallo (2003) for a sample of European regions. This allowed the analysis of individual regions' dynamics. However, since this methodology only identifies movements between quadrants in the Moran scatterplot, it was thought as important to measure movements within quadrants, as this would indicate the level of stability within quadrants. One hypothesis which somehow confirms the Neo-classic reasoning is that instability occurs mainly in groups of regions located in the LL quadrant. Yet, direction also needs to be measured in order to confirm, or not, this hypothesis.

This paper, apart from further exploring the convergence hypothesis within European regions, also added to the original specification a group of social behaviour indicators, in order to test to what extent perceived well-being reflects itself in the growth trajectory of regions. It is acknowledged that the level of data spatial aggregation used is far from ideal since heterogeneity within spatial units is expected to be of great importance. This is particularly so since local environmental phenomena is likely to contribute to the observed spatial patterns in terms of social behaviour.

The results show first that there is a strong presence of spatial contagious behaviour in most variables. This justifies the use of spatial econometrics specifications in the estimations. Also, it is shown that dynamism in terms of GDP per capita is dependent on instant measures of perceived well-being, reflecting stronger social unease in the communities undergoing greater change.

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