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Was Poland the next Spain? Parallel analysis of regional convergence patterns after accession to the European Union

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Keywords: *Poland vs Spain; parallel regional convergence; convergence of clubs; distribution dynamics; spatial model*

Abstract

Research background: Poland and Spain share many common features resulting both from similarities of historical experience, and also cultural, political, socio-demographic factors. Both countries have a similar area, population and GDP structure. They also share historical experience related to political and economic transformation after a long period of non-democratic, centralized governments. Therefore, the experience of Spanish membership in the EU is often considered as a model for Poland.

Purpose of the article: The purpose of this research is to perform a comparative empirical analysis of income convergence processes in Poland and Spain on a regional level. We aim to verify if and how these processes are related to one another (show similar paths). Special attention is paid to the periods after accession of these countries to the EU. Convergence patterns in both countries are compared with several tools.

Methods: Spatial econometric model for absolute beta convergence, sigma convergence indicators and the analysis of distribution dynamics — transition matrices and kernel density estimation.

Findings & Value added: The impact on EU accession on income convergence in Spain was positive both at the national and regional level. Regional convergence processes sped-up and interregional disparities decreased. The poorest subregions had relatively high probability to increase their income and catch-up with initially more developed regions. In the first decade after accession to the EU Poland has also achieved a significant improvement of income indicators at the national level. However, empirical analyses of GDP per capita

distribution and its dynamics at the regional level in Poland show that the above mentioned progress does not spread out proportionally on all regions. Neither beta nor sigma convergence is observed. Instead, relatively fastest growth of initially richest regions (mostly large cities) introduces convergence of clubs leading to polarization. EU accession has accelerated divergence processes in Poland.

Introduction

Poland and Spain share many common features resulting both from similarities of historical experience, and also cultural, political, socio-demographic factors. Both countries have a similar area, population and GDP structure. They also share historical experience related to political and economic transformation after a long period of non-democratic, centralized governments. Also specific geographical location distinguishes Poland and Spain from other EU members. Both countries are a kind of a bridge linking the EU with North Africa or Eastern Europe. In addition, it is worth noting that the Spanish economy in the 1990s experienced similar difficulties as the Polish economy during transformation period, i.e. high structural unemployment rates and low investment levels. In the context of these analogies, the Spanish experience in the period during EU accession and in subsequent years is often seen as a model for Poland.

For both countries, joining the EU was seen from a common perspective as a chance for a civilizational jump and catching-up to the level of development of European countries. In the moment of accession, most EU members significantly outstripped Poland and Spain in terms of the level development.

In view of Spanish and Polish membership in the EU, it is important to check to what extent the internal disparities between regions of the two countries in terms of *per capita* income are sustainable, and if they have decreased over time since joining the EU. This is an interesting research question in the context of cohesion policy aimed at eliminating disparities in the level of development of Member States' regions.

The subject of research in this article will be the phenomenon of convergence of income (GDP *per capita*) in Poland and Spain at the regional level in the first decade after the accession to EU. The main purpose of this research is to perform a comparative empirical analysis of regional income convergence processes in Poland and Spain after joining the EU and to verify if these processes show similar paths, or in other words, if they are parallel.

In general terms, convergence means a process in which disparities of some phenomenon measured across different units decrease over time. In

economics and regional science it is usually applied to income. There are several types of convergence. Beta convergence involves verification of the relationship between the average yearly growth rate over some period and the initial income. Sigma convergence analyses if the dispersion of *per capita* income among regions decreases with time (analysis of standard deviation or other dispersion measures) — see e.g. Barro, Sala-i-Martin (2004).

The hypothesis about beta convergence is derived from neoclassical growth models assuming decreasing marginal productivity of capital (Solow, 1956; Mankiw *et al.*, 1992) and is verified in two forms, as absolute or conditional convergence. Absolute convergence assumes that regions become similar to one another independently of their initial conditions. Poorer regions grow faster than the richer. Conditional convergence assumes that regions converge to one another only if they are similar in terms of some structural characteristics. The process of increasing disparities (opposite to convergence) is called divergence. However, these approaches tell nothing about the mobility within the distribution. This can be modelled with the use of transition matrices or kernel density estimates as proposed by Quah (1996a, 1996b) or Durlauf and Quah (1999). These alternative methods also allow to verify the existence of so called convergence of clubs, observed in subgroups of regions similar in terms of initial level of income. This convergence pattern is commonly observed in empirical research for regions of EU. Its presence leads to polarization.

The remaining part of the article is structured as follows. The next section explains research methodology. Then we refer to some previous empirical findings concerning convergence patterns in Poland and Spain. In the empirical part, we provide the description of the data and apply different methods to analyse regional convergence in Poland and Spain. The last part summarizes the main findings and conclusions. All calculations and figures were prepared with R environment (R Core Team, 2016).

Research methodology

Sigma and beta convergence

The traditional approach of beta and sigma convergence analysis uses relatively simple statistical tools (see, for example, Sala-i-Martin, 1996). Sigma convergence is tested by calculating a selected measure of dispersion of *per capita* income across countries or regions and comparing its values in sub-

sequent periods of time. If dispersion is decreasing, one concludes about sigma-convergence. Increasing dispersion indicates sigma-divergence.

The verification of beta convergence is applied by running a regression model:

$$\frac{1}{T} \log \left(\frac{y_{i,t+T}}{y_{i,t}} \right) = \alpha - \left(\frac{1 - e^{-\beta T}}{T} \right) \log(y_{i,t}) + \gamma X_{i,t} + u_{i,t,t+T} \quad (1)$$

where $y_{i,t}$ indicates *per capita* income of region i at time t , $X_{i,t}$ is a vector of exogenous structural variables that can influence *per capita* income, T refers to time interval (for yearly data $T=1$), and $u_{i,t,t+T}$ is an error term. If structural variables $X_{i,t}$ are omitted, one tests for absolute convergence hypothesis, while using additional control variables $X_{i,t}$ in the regression results in testing for conditional convergence.

The parameter β is estimated by nonlinear least squares (NLS). In such framework positive β means that poorer regions grow faster than richer ones (convergence) and the value of β is interpreted as convergence speed.

However, this simple approach ignores the fact that observations are located in space and their relative proximity might result in correlation of residuals for neighbouring regions. If such a correlation appears — the assumption about independence of model residuals is violated and in such case cross-sectional regression model might show incorrect conclusions about significance of parameters.

The spatial regression specification is characterized by the inclusion of a new component — spatially lagged variables on the right-hand side of the estimated equation. In one of the simplest forms there is only one spatially lagged variable included — the dependent variable (Spatial Lag Model). This new variable captures the spatial interaction effect as a weighted average of neighbouring observations. Most often it is applied in a linear form as:

$$y_i = \rho W y_i + X_i \beta + \varepsilon_i \quad (2)$$

where W is an $n \times n$ spatial weights matrix and ρ is the spatial autoregressive coefficient. The matrix W defines how pairs of units relate to one another. It depends on a definition of neighbourhood. The term $W y_i$ is referred to as a spatially lagged dependent variable or spatial lag. If one wants to control for spatial relationships resulting from non-observable factors, alternatively Spatial Error Model can be used. It uses spatially lagged error as an explanatory variable instead of spatial lag of the dependent. One can also add spatially lagged independent term $W X_i$ as explanatory variables — see

Herbst and Wójcik (2012) or Tortosa-Ausina *et al.* (2005) for sample applications of spatial models to regional convergence analysis. We wish to control for the potential spill-overs of (observable) growth rates, therefore Spatial Lag Model will be used in the empirical part.

Distribution dynamics

Alternative methodology is based on transition matrices and kernel density estimation. Both methods allow to analyze the whole distribution of income and its dynamics in time. One can also test for convergence of clubs and polarization (see e.g. Magrini, 1999).

In case of transition matrices initial distribution is divided into intervals. Based on that division, the transition matrix (M) is estimated. It shows how the distribution of relative GDP *per capita* (d) changes with time¹:

$$d_t = M \times d_{t-1} \quad (3)$$

Elements of transition matrix M are probabilities of mobility between different income classes. They show the percentage of regions which being initially in a particular income class, remain in the same group or move to other classes². In other words, each element p_{ij} of the transition matrix M shows the conditional probability of moving towards group j in time t_2 , being initially (at time t_1) in group i , according to the formula:

$$p_{ij} = P(X_{t_2} = j | X_{t_1} = i) \quad (4)$$

Transition matrix allows for estimation of the long-run evolution of income distribution³, which should be interpreted as a synthetic indicator of tendencies in the analyzed period. One concludes about convergence if estimated ergodic probabilities move towards the group including the average value of income. If probability is moved towards extreme groups, it indicates polarization and convergence of clubs. High probabilities on the diagonal reflect strong persistence of the distribution.

¹ This method can be compared to the first order autoregression in time series analysis. All formulas related to transition matrices and kernel density estimates shown as in Smełkowski and Wójcik (2012).

² Therefore, all values in transition matrix are nonnegative and sum up in each row to 1.

³ Transition matrix M raised to power s with $s \rightarrow \infty$ converges to an ergodic matrix (with rank equal to one), called also an ergodic vector.

The limitation of transition matrices is an arbitrary selection of interval boundaries — different divisions may lead to different results and conclusions. To avoid such risk, one can use conditional kernel density estimation, which can be considered as a continuous generalization of the transition matrix with infinite number of rows and columns. Let x denote initial income and y stand for final income. Then conditional distribution of y given x can be calculated by:

$$f(y|x) = \frac{f(x,y)}{f_x(x)} \quad (5)$$

where $f_x(x)$ is the marginal distribution of initial income and $f(y,x)$ is the joined distribution of y and x . Both the numerator and denominator of the equation (5) are replaced with nonparametric estimators. The denominator is estimated using univariate adaptive kernel density estimate:

$$\hat{f}_{xA}(x) = \frac{1}{n} \sum_{i=1}^n \frac{1}{h_x w_i} K\left(\frac{x-x_i}{h_x w_i}\right) \quad (6)$$

where n is number of observations, h_x is the optimal bandwidth for initial income, w_i is a weight of the observation i^4 and $K(\cdot)$ is a kernel function. Numerator of equation (5) is estimated according to the formula:

$$\hat{f}(x,y) = \frac{1}{n} \sum_{i=1}^n \frac{1}{h_y h_x w_i^2} K\left(\frac{y-y_i}{h_y w_i}\right) K\left(\frac{x-x_i}{h_x w_i}\right) \quad (7)$$

where h_y refers to the bandwidth for the final GDP *per capita*.

The estimation result is usually interpreted in a form of a contour plot (see: e.g. Smętkowski & Wójcik, 2012). The shape parallel to the axis of initial income indicates convergence, while the shape parallel to the axis of final income means divergence. Concentration of the plot along the diagonal shows persistence of distribution. Several peaks of the distribution, especially on extreme ends of the figure, show tendency to polarization and convergence of clubs. The figure below the diagonal (closer to the axis of initial income) indicates higher initial income — therefore becoming relatively poorer and *vice versa*.

⁴ In the simplest case all weights=1. In adaptive kernel density estimate weights are differentiated across observations with respect to their local dispersion. This results in a density estimator more precisely reflecting distribution of the data.

Data description and research hypotheses

The research is based on the data for subregions (NUTS3). In 2016 Poland reshaped its subregions and now it consists of 72 such units. The empirical analysis for Poland is based on data provided by the Central Statistical Office (GUS). On the level of 72 subregions the data is currently available for the period 2000–2014. In order to obtain comparable data over the whole period, without the need for a regional GDP deflators, GDP *per capita* data for each subregion was reflected in relation to the average GDP *per capita* on the country level.

Data for Spain was obtained from the Spanish National Institute of Statistics (INE). Due to the direct unavailability of GDP *per capita* data for the period 1980–1999, GDP data on the subregional level were divided by population for these regions. Population data by subregions were only available back to 1990. Therefore, for the years 1980–1989 the 1990 population was assumed for simplicity. The data for Spain for different periods were expressed in different currencies and in current prices. To obtain fully comparable data, again all GDP *per capita* numbers were converted into values relative to country average for a particular year.

Administratively, Spain is divided into 59 NUTS3 units. In the analysis, the units belonging to Canarias were treated together as a single region, similarly to the Balearic Islands. Finally, 51 Spanish subregions were considered in the analysis.

The time horizon for the analysis is 1980–2014 for Spain and 2000–2014 for Poland, with particular emphasis on the first decade after the EU accession of each country (2004–2014 for Poland and 1986–1996 for Spain).

Results

The presence of both beta and sigma regional convergence of labour productivity in Spain has been confirmed by Villaverde (2005), who applied a classical approach and spatial methods to analysis covering the period 1985–2002. The occurrence of convergence was accompanied by an increase in the concentration of GDP and employment in the most developed regions.

Similar conclusions were drawn by Mas *et al.* (2010). They analysed 17 regions of Spain in 1985–2007 in terms of productivity growth and concluded the existence of beta and sigma convergence. Apart from income, they also applied convergence tests for different phenomena. It appeared

that the most intensive convergence process took place in ICT capital endowments, followed by the educational levels of the workers and by the rest of capital (non ICT).

The influence of Spanish accession to the EU on the processes of regional convergence was examined by Mela-Marquez and Yrigoyen (2004). The analysis of the Spanish regions in the period 1986–1998 suggested positive impact of accession — beta and sigma convergence was observed. Although generally long-term convergence of income was observed, some regions experienced divergence. Some of the richest regions of the country developed significantly faster than others, which made it difficult to catch up.

There are some previous examples of comparative regional convergence processes in Poland and Spain. Caselli *et al.* (2004) attempted to answer the question of whether Poland could follow Spain with the analogous path of development after EU accession. Spain managed to achieve an above-average increase in productivity as compared to France (considered by the authors as the benchmark of EU average). This was largely obtained by the shift of employment from the agricultural sector to the sector of advanced technologies and services. When joining the EU, Poland had a similar level of productivity as observed in the southern European countries during their accession to the EU. The authors note that gaps in aggregate productivity of the industrial sector are much larger in Poland than they were in Spain, which might imply different patterns of convergence in Poland and that convergence in Poland may be slower than in Spain.

At the beginning, we verify the existence of sigma convergence in both countries with the use of coefficient of variation (CV). Figure 1 shows its values for relative GDP *per capita* among Polish subregions between 2000 and 2014. The light-grey shaded area indicates the first decade after Polish accession to the EU (2004–2014). A solid line shows the CV for all regions, and other dashed lines the CVs for regions from particular quartile groups (assignment based on the distribution in 2004). One can see that before joining the EU, the dispersion of income *per capita* was stable ($CV \approx 37.5$ –38) and between 2004 and 2010 it increased to 42 and remained stable until 2014.

In the first years after the EU accession income disparities in Poland were regularly increasing, with the only exception being 2008. The largest and relatively stable disparities were observed for the top quartile group (4) — the CV for the 25% richest regions changed from 31.3 in 2000, 29.7 in 2004 to 33.5 in 2014. The remaining groups of regions were much less diversified (CV below 10). However, since 2008 disparities across regions from two lowest quartile groups have significantly increased. One can

therefore conclude that Polish subregions faced sigma-divergence process which was strengthened by the EU accession.

Figure 2 depicts sigma convergence analysis for relative GDP *per capita* across Spanish subregions between 1980 and 2014. Similarly, the light-grey shaded area indicates the first decade after Spanish accession to the EU (1986–1996), the solid line shows the CV for all regions, and various dashed lines the CVs for regions from quartile groups (assignment based on the distribution in 1986). The conclusions from this figure are different than for Poland. Before joining the EU, the dispersion of income *per capita* among Spanish regions was also stable, but at a much lower level than for Poland (CV $\approx$ 24.5–25.5). Between 1986 and 1996 it decreased to 21.3, and later fluctuated between 20 and 22.5 until 2014. Therefore, in the first decade after accession to EU income disparities in Spain clearly decreased. Another distinctive feature for Spain is that the levels of disparities in four quartile groups were relatively small and quite stable over the whole long period (only the richest regions faced increase in disparities over the last 20 years).

Therefore sigma convergence patterns for Polish (divergence) and Spanish (convergence) regions were not parallel.

As the next step, we verify the existence of absolute beta convergence — both graphically and by applying a spatial autoregressive model. However, starting from this analysis on for each country we take into account only the first 10 years after its EU accession. Figure 3. depicts the relationship between the average yearly growth of relative GDP *per capita* in the period 2004–2014⁵ and initial relative GDP *per capita* (2004) for Polish regions.

One can clearly see a positive slope of the relationship, which indicates that the average growth was generally faster for initially richer regions (beta divergence). To verify whether this relationship is statistically significant, we run a spatial autoregression model in which the average yearly growth was the dependent variable, and the only independent variable (apart from a spatial lag) was initial income⁶. The results of this regression are presented in Table 1. The spatial component requires the definition of neighbourhood. We assumed k-nearest neighbours and to check robustness of results applied several values (3, 5, 10)⁷.

⁵ Average growth of relative GDP *per capita* is calculated as the difference between relative GDP *per capita* in 2014 and 2004 divided by the number of years (10).

⁶ The model was estimated in a simplified linear version of beta convergence equation as we only want to assess the direction of relationship and its statistical significance.

⁷ For Poland we also tested neighbors with common border and within the distance of 100, 150 and 200 km. The results were in line with those presented in Table 1. We could not

Independently of the definition of neighbourhood initial income is significantly and positively related with the average growth of relative income. This suggests that in the first decade after joining EU Polish subregions faced beta-divergence.

Similar analysis was applied on Spanish regions. Figure 4. depicts the relationship between the average yearly growth of relative GDP *per capita* in the period 1986–1996 and initial relative GDP *per capita* (1986).

Again, the conclusion is different for Spain than from Poland — one can observe a negative slope of the relationship, which indicates that the average growth was generally faster for initially poorer regions (beta convergence). The results of a spatial autoregression are presented in Table 2. It indicates that initial income is significantly and negatively related with the average growth of relative income. This leads to the conclusion that Spanish regions faced beta-convergence process.

Therefore, beta convergence patterns for Polish (divergence) and Spanish (convergence) subregions were also not parallel.

Let us turn to the methodology proposed by Quah (1996a, 1996b). In the transition matrices we divide regions into five quintile groups (classes) with respect to the initial distribution of relative GDP *per capita*. So, initially, all groups of regions are equal-sized. Table 3 depicts the transition probabilities calculated for yearly transitions between 2004 and 2014 (values equal to 0 are not shown). Column headers show class boundaries.

One can observe a strong persistence of the distribution. On average, 91.1% of regions remain in its initial class from year to year (high values on the matrix diagonal). The persistence is the strongest in extreme groups, especially for the richest regions (98.6%). There is very little chance to get relatively richer for the poorest group of subregions (4.2%). The probability of becoming relatively poorer is always higher than for getting richer. Group 4, including the average value (100%), has the strongest imbalance between the probability of becoming richer (0.7%) and poorer (8.4%). This suggests strong tendencies to polarization, confirmed by the ergodic vector. Most of the probability mass is concentrated in the two lowest groups (most in the poorest — 59.2%, 25.2% in group 2), with relative GDP *per capita* below 76.26%.

Table 4. shows transition matrix calculated in a similar way for Spanish regions. The borders of groups were based on the quintiles of relative *per capita* income distribution in 1986. One can also observe relatively strong persistence of the distribution. However, it is not as strong as Poland — on

use alternative definitions for Spanish regions, as some of them are islands without common border with others, located far from the main continent (empty neighbor sets are not allowed in spatial models).

average 83.5% of regions remain in its initial class from year to year and all diagonal probabilities for Spain are lower than for Poland. The chance to get relatively richer for the poorest group of Spanish regions is equal to 11.8%, and the probability of getting relatively richer for group 2 is higher (17.6%) than of becoming poorer (11.8%). Tendencies to polarization (ergodic vector) are still moderately high. Most of the probability mass is concentrated in the two poorest groups, but now “only” 32.7% in the poorest and 27.2% in group 2.

One can therefore conclude that the analysis of mobility within the distribution of *per capita* income based on transition matrices has revealed somewhat different results for Polish and Spanish regions. Both show tendencies for polarization, but much weaker in Spain. The poorest Spanish regions had much higher chance to catch-up after Spain joined the UE than the poorest Polish regions after 2004.

Finally, to verify the above findings one should also look at the estimated conditional kernel density. The results for Poland are presented in Figure 5.

The figure as a whole is positioned on the diagonal, and does not move towards the horizontal axis. This leads to the conclusion that convergence was not observed. There are several distinct peaks of the distribution — for the initial income level 250%–300% of the average (representing Warsaw), for values around 200% (remaining large cities and regions endowed with natural resources), and the remaining part of a plot. Two top peaks and a part of a density function in the bottom left corner (for poorest regions) seem to be parallel to the horizontal axis. This suggests convergence of clubs for the richest and the poorest regions separately. The rest of the distribution is positioned along the diagonal, which indicates its high persistence. The part of the figure for initial incomes around 100% and between 150%–175% is positioned slightly below the diagonal. This suggests that regions with GDP *per capita* from these intervals were becoming relatively poorer, which is in line with previous findings in the transition matrix.

Figure 6. shows kernel density estimation results for Spanish subregions between 1986 and 1996, and one can observe a different picture.

The distribution has much lower range than for Poland. This is also influenced by the fact that none of Spanish subregions is a separate large city (8 such regions in Poland). Therefore, there are no separate peaks of the distribution. The upper-right part of the shape is positioned rather below the diagonal and the lower-left end above. This means that the richest Spanish subregions were becoming relatively poorer and the poorest regions became relatively richer in the first decade after EU accession.

Therefore, independently of the applied methodology, the convergence patterns observed for Spanish and Polish subregions in the first decade after UE accession were not the same — they were not parallel. In Spain one generally observed tendencies for convergence, while Polish regions faced divergence, which was even accelerated by the accession.

Conclusions

The aim of the study was to compare the processes of regional convergence of income *per capita* in Poland and Spain in the first decade after their accession to the European Union. The analysis was performed on the level of subregions (NUTS3) and used a variety of research tools to verify hypotheses of various potential convergence patterns.

Poland's accession to the European Union did not have a positive impact on the process of convergence of regional income, and has accelerated the divergence process. In the period after Poland's accession to the EU neither beta nor sigma convergence was observed. The fastest growing regions were Warsaw, other large cities and the regions abounding in natural resources. In general, subregions in the surveyed period were more often becoming poorer than richer.

Spain was subject to a much smaller dispersion in relative GDP *per capita*. In contrast to Poland, the occurrence of both beta and sigma convergence was observed. Spain's accession to the European Union has accelerated regional convergence processes in this country, and offset income between sub-regions. The poorest regions were more likely to increase their relative income and move to higher group (catch-up with the initially more developed subregions). Faster development of the richest regions led to income polarization both in Poland in Spain, but it was significantly weaker in the case of Spain.

Based on the analysis, one can conclude about the existence and persistence of the problem of regional disparities in *per capita* income. Contrary to the aims and assumptions of cohesion policy, the gap between the poorest and richest subregions is not diminishing or even increasing over time. In the period after the accession of both countries to the European Union, the largest cities and regions with the highest initial income levels are still growing the fastest. Hence, it is still a question of how to effectively use the funds for cohesion policy and to guide the development of the poorest regions so that they can best benefit from the neighborhoods of the richest regions. The catching up process was hampered by the extremely rapid development of some subregions.

The research in this article was limited to comparison of the convergence patterns in both countries, without a detailed look on the sources of convergence/divergence processes. As far as Spain is concerned, the most important source of regional convergence in this country after the EU accession was convergence of the total factor productivity levels across regions, driven by the migratory flows of employment between regions. This changed the sectoral structure of employment in regions – agriculture rapidly lost its weight in regional GDP of initially poorest regions (see: de la Fuente, 2000). Employment structure across the Polish regions is much more rigid, although also changing after the EU accession. Employment flows between regions are limited due to relatively shallow residential rental market. Therefore, based on the Spanish experience policy recommendations for Poland include: creating strong incentives to move from employment in agriculture to sectors with higher value added and active support for the development of residential rental market.

Further research might be directed on identifying and quantifying the sources of divergence of Polish subregions.

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Annex

Table 1. Analysis of beta convergence for Polish subregions: average yearly growth of relative GDP *per capita* in 2004–2014 vs. initial income (2004)

variable	knn = 3		knn = 5		knn = 10	
intercept	-0.6757	**	-0.6347	**	-0.6309	**
initial income (2004)	0.0064	**	0.0062	**	0.0063	**
spatial AR (ρ)	0.3524	**	0.5144	***	0.4937	**

Source: own calculations based on Polish CSO data.

Table 2. Analysis of beta convergence for Spanish subregions: average yearly growth of relative GDP *per capita* in 1986–1996 vs. initial income (1986)

variable	knn3		knn5		knn10	
intercept	2.0106	***	2.0540	***	1.9957	***
initial income (1986)	-0.0240	***	-0.0247	***	-0.0242	***
spatial AR (ρ)	-0.4471	**	-0.6156	**	-0.7838	*

Source: own calculations based on Spanish INE data.

Table 3. Transition matrix for Polish subregions (2004–2014, yearly transitions)

	group 1	group 2	group 3	group 4	group 5
	<=67.18	(67.18, 76.26]	(76.26, 84]	(84, 108.24]	>108.24
group 1 (144)	95.8%	4.2%			
group 2 (144)	7.6%	86.8%	5.6%		
group 3 (145)		9.0%	83.4%	7.6%	
group 4 (143)			8.4%	90.9%	0.7%
group 5 (144)				1.4%	98.6%
ergodic	59.2%	25.2%	9.9%	5.4%	0.3%

Source: own calculations based on Polish CSO data.

Table 4. Transition matrix for Spanish subregions (1986–1996, yearly transitions)

	group 1 <=77.78	group 2 (77.78, 84.76]	group 3 (84.76, 98.2]	group 4 (98.2, 116.52]	group 5 >116.52
group 1 (102)	88.2%	11.8%			
group 2 (102)	11.8%	70.6%	17.6%		
group 3 (103)	1.0%	14.6%	79.6%	4.9%	
group 4 (101)			8.9%	86.1%	5.0%
group 5 (102)				6.9%	93.1%
ergodic	32.7%	27.2%	27.3%	9.6%	3.6%

Source: own calculations based on Spanish INE data.

Figure 1. Analysis of sigma convergence for Poland: CV of relative GDP *per capita* (2000–2014, all subregions and different quartile groups)

Note: labels on the right refer to the quartile group number – division based on relative GDP *per capita* in 2004; shaded area is the first decade after Polish EU accession.

Source: own calculations based on Polish CSO data.

Figure 2. Analysis of sigma convergence for Spain: CV of relative GDP *per capita* (1980–2014, all subregions and different quartile groups)

Note: labels on the right refer to the quartile group number – division based on relative GDP *per capita* in 1986; shaded area is the first decade after Spanish EU accession.

Source: own calculations based on Spanish INE data.

Figure 3. Analysis of beta convergence for Polish subregions: average yearly growth of relative GDP *per capita* in 2004–2014 vs. initial income (2004)

Source: own calculations based on Polish CSO data.

Figure 4. Analysis of beta convergence for Spanish subregions: average yearly growth of relative GDP *per capita* in 1986-1996 vs. initial income (1986)

Source: own calculations based on Spanish INE data.

Figure 5. Conditional kernel density estimate for Polish subregions (2004–2014, yearly transitions)

Source: own calculations based on Polish CSO data.

Figure 6. Conditional kernel density estimate for Spanish subregions (1986–1996, yearly transitions)

Source: own calculations based on Spanish INE data.