

# Great Recession and club convergence in Europe: a cross-country cross-region panel analysis (2000-2015)

Fabio Mazzola<sup>a</sup> and Pietro Pizzuto<sup>b</sup>

<sup>a</sup> *Department of Economics, Business and Statistics (SEAS), University of Palermo, Palermo, Italy.*

e-mail: [fabio.mazzola@unipa.it](mailto:fabio.mazzola@unipa.it)

<sup>b</sup> *Department of Economics, Business and Statistics (SEAS), University of Palermo, Palermo, Italy;*

ORCID iD: 0000-0001-5055-8916

e-mail: [pietro.pizzuto02@unipa.it](mailto:pietro.pizzuto02@unipa.it)

*Corresponding author: Pietro Pizzuto* (Email: [pietro.pizzuto02@unipa.it](mailto:pietro.pizzuto02@unipa.it))

Running title: **Great Recession and club convergence in Europe**

## ETHICAL STATEMENTS:

**Conflict of Interest:** The authors declare that they have no conflict of interest.

**This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.**

An updated version of this article has been published in *Growth and Change*:

Mazzola F., Pizzuto, P. (2020) Great Recession and club convergence in Europe: A cross-country cross-region panel analysis (2000–2015). *Growth and Change*, 51(2), 676-711  
<https://doi.org/10.1111/grow.12369>

# **Great Recession and club convergence in Europe: a cross-country cross-region panel analysis (2000-2015)**

## **Abstract**

The paper aims at investigating the impact of the Great Recession on per-capita GDP convergence process across European regions and countries. By using the time-varying factor model developed by Phillips and Sul for the period 2000-2015 and two different merging procedures to identify clubs, we provide evidence of the diverging impact of the Great Recession ‘between’ the higher and the lower convergence clubs at both regional and country levels as well as of the strengthening of the convergence process ‘within’ most clubs. In addition, we add further evidence to the common belief of a ‘multi-speed’ Europe by contrasting Eastern European countries’ and regions’ behaviour *vis-à-vis* original European members’ one, and by identifying the factors that affect club membership and resilience to the recent economic downturn. We find that the membership to the higher clubs and resilience to the Great Recession are positively affected by the presence of several local specific factors and macroeconomic characteristics.

Keywords: Convergence clubs, Economic crises, Great Recession, Resilience, Log-t test

JEL classification: R11, O47, C23

## 1. Introduction

From the beginning, the European Union aimed at promoting integration and cohesion in order to reduce regional and territorial disparities (European Commission 2017). Indeed, an increasing amount of funds has been allocated by the European Commission to less developed regions and the process of progressive integration has required greater cohesion efforts among the member countries.

A large and growing amount of research has investigated the effect of the integration process from different points of view. The results are diversified mainly because of the different methodologies adopted and the different periods analysed. In particular, during the last years much debate has concerned the role of the recent crisis in affecting the results. In fact, it seems that the process of progressive integration has been somewhat jeopardised by the Great Recession which has affected countries and regions in different ways, stimulating, also, manifold decisions by policymakers.

Within this framework, this paper aims at investigating the impact of the Great Recession on per capita GDP convergence process among European regions and countries in the period 2000-2015. To reach this goal, we apply the time-varying factor model developed by Phillips and Sul (2007; 2009) which allows for individual and transitional heterogeneity.

The contribution of this paper is fourfold. First, it tries to investigate the effect of the Great Recession by analysing an extended sample of 268 regions (and 28 countries). By using the Phillips and Sul (PS henceforth) procedure, we assess the impact of the recent crisis on the convergence process both *between* and *within* the clubs. In this sense, we try to generalize and confront our results with the few evidence concerning the impact of the Great Recession on the convergence process which is currently restricted to single countries (see, for Spain, Montañés et al. 2018). Second, since the geographical level of analysis may lead to different results we apply the abovementioned procedure simultaneously to the regional and the country levels for the same set of countries, making direct comparison between the two levels. Third, we supplement the merging algorithm for club formation developed by PS with the more recent one by von Lyncker and Thoennessen (2017) and test the two procedures with respect to a broader sample of regions than in previous studies. Indeed, the underlying hypotheses of the two merging algorithms may lead to remarkably different (final) club composition that may affect

the club characterization, therefore yielding different conclusions (especially when comparing units with different structural characteristics such as EU-15 vs EU-13 regions). Fourth, we identify a number of local and macroeconomic factors that may play a role both in fostering growth and in affecting resilience to shocks.

Our findings suggest that the hypothesis of absolute convergence among all the European regions or countries is rejected, leading us to accept the hypothesis of club convergence. Furthermore, we find strong evidence of divergence starting from the Great Recession *between* the higher and the lower regional convergence clubs, and a slowdown in country club convergence. Conversely, the crisis seems to have strengthened the relative convergence *within* almost all clubs at both geographical levels. Our conclusions do not change if we exploit the full potential of the PS methodology by applying the *club merging* algorithm (also in its modified version developed by von Lyncker and Thoennessen (VLT henceforth)). We find that the membership to the higher clubs is positively affected by traditional engines of growth (i.e. investments in R&D, human capital and agglomeration economies), local specific factors (i.e. regional specialization, infrastructure endowment and migration) and macroeconomic characteristics (i.e. rule of law and financial openness).

The remainder of the paper is organized as follows. The next section provides a review of the existing literature on convergence (especially club convergence) whereas section 3 describes the data and presents some descriptive statistics. The methodology used is presented in section 4, whilst section 5 discusses the results for the club convergence hypothesis and for the impact analysis of the Great Recession on the convergence process. Section 6 analyses several local and macroeconomic factors that play a role in fostering growth and in affecting resilience to shocks. Finally, section 7 concludes by discussing some interpretations and policy implications.

## 2. Literature Review

Since the neoclassical contributions of Solow (1956) and Swan (1956) the concept of economic convergence has been extensively investigated. Studies have produced rather mixed results at the regional level, concerning both *sigma* and *beta* convergence<sup>1</sup>.

In this context, Sala-i-Martin (1996) analysed the growth of 90 European regions for the

period 1950-1990 and found absolute convergence at the annual speed of 1.5%. Similar conclusions are, among others, those of Tondl (1997), who found absolute convergence between 122 regions at a speed of 2% for the period 1975-1994, and Geppert and Stephan (2008) who detected a speed of convergence of 2.4% for 108 regions in the period 1980-2000. Slightly different are the results of Armstrong (1995) who identified a lower speed of convergence (1%) for 85 regions (1960-1990).

Some other studies claim the emergence of divergence as a consequence of the '70s oil crisis (Fingleton 1997). Others have found mixed results, such as a convergence pattern at the country level but a divergence pattern at the regional level (Giannetti 2002). Also, diversified results were found according to the period analysed (Ezcurra et al. 2007).

In addition to the traditional concepts of *beta* and *sigma* convergence, an increasing amount of literature has recently emerged on the concept of 'club convergence'. This notion was originally introduced by Baumol (1986) to describe convergence among a subset of national economies and it has quickly spread at the regional level. As discussed in Bartkowska and Riedl (2012), a line of research on growth theories (Azariadis and Drazen 1990; Galor 1996), demonstrates that economies with structural similarities may converge to different steady states if they differ in terms of initial conditions. Hence, the club convergence hypothesis, allowing for multiple steady-states, implies that economies that are similar in terms of structural characteristics converge to the same steady-state only if their initial conditions are also similar.

In Table 1 we summarize the most relevant studies dealing with club convergence at the European level.

[insert Table 1 near here]

Convergence clubs have also emerged by adopting the Phillips and Sul (2007, 2009) methodology (Table 2), both at the country (Apergis et al. 2010; Fritsche and Kuzin 2011; Monfort et al. 2013; Borsi and Metiu 2015) and at the regional and provincial level (Bartkowska and Riedl 2012; von Lyncker and Thoennessen 2017; Montañés et al. 2018). However, none of these studies analyses simultaneously the national and regional club convergence on the same panel of countries. More important, only one of them (Montañés et al. 2018) considers in the analysis the Great Recession period but in a single country framework (Spain).

[insert Table 2 near here]

The relationship between crises and convergence has received relatively scarce attention in the literature inside the European context. Exceptions are the work by Halmai and Vásáry (2012) who found divergence in looking at the potential growth rate of European countries and the contributions by Marelli and Signorelli (2015) and Dijkstra et al. (2015) who extend the analysis to employment conditions finding in both cases traces of a divergent impact of the last crisis. Looking at the Euro Area members, Estrada Galí and López-Salido (2013) noticed an increase in the dispersion of the major macroeconomic indicators in the first years following the Great Recession.

As expected, this issue has recently gained importance in the wake of the recent global crisis. Understanding how and why the various economies react to major recessionary shocks can be crucial to analyze the issue of regional (country) long-run growth patterns and, thus, the existence, persistence and evolution of regional (country) imbalances (Martin 2012). In fact, regional (country) convergence may be affected by economic shocks if different economies have a different degree of resilience to a common shock or/and a different speed of adjustment.

A growing amount of the empirical literature has focused on specific determinants of regional and country resilience. However, many studies have demonstrated the heterogeneous effects of shocks across economies and over time often focusing on single country framework. Differently, Brakman et al. (2015) found that the degree and nature of regional urbanisation are relevant for the resilience of European regions. Crescenzi, Luca and Milio (2016) and Mazzola et al. (2018) identified a number of regional and local factors that may have affected regional (or provincial) resilience. Martin et al. (2016), found in the sectoral composition the source of the different behaviours. Conversely, Lane and Milesi-Ferretti (2011) and Rose and Spiegel (2011) focused on several macroeconomic factors and financial conditions that have shaped countries responsiveness to the Great Recession.

### **3. Data and descriptive statistics**

To study economic convergence at the European level, we use data from the Eurostat REGIO database. This dataset covers an unbalanced panel of 268 regions and 28 countries for

the period 2000-2015, namely all the members of the European Union including United Kingdom<sup>2</sup>. Since we are interested in understanding both the presence of convergence among European economies and the effect of the Great Recession, we refer to the Gross Domestic Product per inhabitant (per-capita GDP) at current market prices in Purchasing Power Standard as variable of interest.

Using *sigma* convergence both in its unweighted and population weighted versions (Figure 1), it appears that in the fifteen years under analysis there has been a process of convergence, both at country and regional levels, which suddenly stops after the Great Recession.

[insert Figure 1 near here]

A different picture emerges if we take into consideration (unconditional) *beta* convergence. Figure 2 displays the log per-capita GDP in 2000 against its growth rate during the period 2000-2015. However, by inspecting the different points, it seems that there are different regimes of growth, both between and within countries. Therefore, the investigation of overall convergence across all European economies appears not sufficient.

[insert Figure 2 near here]

In Figure 3, we distinguish the unconditional *beta* convergence patterns between the old and the new members of the European Union by obtaining opposite results. Namely, contrary to the new member countries, EU 15 members seem to be characterized by a divergence rather than by a convergence pattern.

[insert Figure 3 near here]

In addition, heterogeneity in dispersion within countries seems also high. Table A1 in the Appendix shows some descriptive statistics for all European members over the period 2000-2015. The country differences in the coefficients of variation of regional per-capita GDP levels and regional growth rates are clear indications of internal heterogeneity in behaviours. This suggests the existence of a ‘multi-speed’ Europe that will be investigated later.

#### 4. Methodology

To investigate for the existence of a convergence pattern, we follow the methodology developed by Phillips and Sul (2007; 2009). Unlike conventional panel data decomposition, they use the following dynamic factor formulation of the variable of interest,  $\log y_{it} = b_{it}\mu_t$ , where  $y_{it}$  represents the per-capita GDP of each economy and  $b_{it}$  indicates the transition path of the economy to the common steady-state growth path determined by  $\mu_t$ .

In order to test if different economies converge, a key role is played by the estimation of  $b_{it}$ , since the authors suggest to verify whether  $b_{it}$  converges towards  $b$ . According to PS, the estimation of this parameter is not possible without imposing additional structural restrictions and assumptions. However, as a viable way to model this element, they propose the construction of the following relative transition component:

$$h_{it} = \frac{\log y_{it}}{N^{-1} \sum_{i=1}^N \log y_{it}} = \frac{b_{it}}{N^{-1} \sum_{i=1}^N b_{it}} \quad (1)$$

that can be directly computed from the data.

In such a way it is possible to remove the common steady-state trend  $\mu_t$ , tracing an individual trajectory for each economy  $i$  in relation to the panel average. This allows to test whether heterogeneous time-varying idiosyncratic components converge over time to a steady state after controlling for a common growth component in the economies under scrutiny. In other words, the relative transition path  $h_{it}$  describes the relative individual behaviour as well as the relative departures of economy  $i$  from the common growth path  $\mu_t$ .

In presence of convergence, when there is a common limit in the transition path of each economy, the coefficient  $h_{it}$  should converge towards unity ( $h_{it} \rightarrow 1$ ) for all  $i$ , as  $t \rightarrow \infty$ . At the same time, the cross-sectional variation  $H_{it}$  (computed as the quadratic distance measure for the panel from the common limit) should converge to zero:

$$H_t = N^{-1} \sum_{i=1}^N (h_{it} - 1)^2 \rightarrow 0 \quad \text{as } t \rightarrow \infty \quad (2)$$



To test for the presence of convergence among different economies, PS suggest to estimate the following equation by ordinary least squares methodology:

$$\log \frac{H_1}{H_t} - 2 \log(\log t) = a + \beta \log t + u_t, \quad (3)$$

$$\text{for } t = [rT], [rT] + 1, \dots, T \quad (4)$$

where  $H_t = N^{-1} \sum_{i=1}^N (h_{it} - 1)^2$  and  $H_1/H_t$  is the cross-sectional variance ratio;  $\beta$  is the speed of convergence parameter of  $b_{it}$ ;  $-2 \log(\log t)$  is a penalization function that improves the performance of the test mainly under the alternative;  $r$  assumes a positive value in order to discard the first block of observation from the estimation, and  $[rT]$  is the integer part of  $rT$ . The null hypothesis of convergence is tested through a one-sided  $t$ -test robust to heteroskedasticity and autocorrelation (HAC) and specifically it is rejected at the 5% level if  $t_{\hat{\beta}} < -1.65$ .

This procedure, generally called ‘log  $t$ -test’, has power against cases of club convergence and it is one of the most important features of the PS approach. Indeed, if the full panel of economies analysed does not converge to a common steady state, the methodology allows to investigate for the presence of groups of economies that converge to different equilibria, and at the same time, it permits individual economies to diverge. Specifically, if the log  $t$ -test is rejected for the whole sample, the authors suggest to repeat the test procedures according to a clustering mechanism concerning of four steps: 1) cross section last observation ordering; 2) core group formation of size  $k^*$  obtained running the log  $t$  regression satisfying the condition  $k^* = \arg \max_k \{t_k\}$  subject to  $\min\{t_k\} > -1.65$ ; 3) club formation achieved adding (one by one) each unit  $i$  not belonging to the core group that satisfies the condition  $\{t_{(k+i)}\} > c^{*4}$ ; 4) recursion and stopping rule: if there are units for which the previous condition fails, gather all these units in one group and run the log- $t$  test to see if the condition  $\{t_k\} > -1.65$  holds. If the condition is satisfied, conclude that there are two convergence clubs. Otherwise, step 1 to 3 should be repeated, until no  $k$  in step 2 satisfies the condition  $\{t_k\} > -1.65$  and the remaining regions diverge.

The PS framework has additional advantages over other existing methodologies. First, this approach is based on a general nonlinear time-varying factor model that incorporates the possibility of transitional heterogeneity or even transitional divergence. This means that under

the hypothesis of convergence, different transitional paths are possible. Under such (possible) heterogeneity, standard unit root and cointegration tests tend to be not suitable for examining convergence and, as demonstrated in Phillips and Sul (2007), even if two series are not cointegrated, it is still possible to find convergence between them. Thus, this approach allows to detect convergence even in the cases of transitional divergence, where other methods (i.e. cointegration tests for long-run analysis and stationary time series tests) may fail. Second, as highlighted by Panopoulou & Pantelidis (2009) the PS methodology can be interpreted as an asymptotic cointegration test that does not suffer from the small sample problems of standard unit root and cointegration tests. Third, it is robust to heterogeneity and the stationarity properties of the series since the common growth component  $\mu_t$  may follow either a trend-stationary process or a non-stationary stochastic trend with drift. A specific assumption regarding the behaviour of  $\mu_t$  is not necessary. Fourth, unlike other approaches in which economies are grouped *a priori*, the methodology enables the endogenous determination of convergence clubs if the log  $t$ -test is rejected for the whole sample. Finally, due to its general specification, it allows to determine not only the presence but also the type of convergence among groups of economies. Specifically, looking at the magnitude of the parameter  $\beta$  in equation (3) we can detect the presence of convergence in level per capita incomes if  $\beta \geq 2$ . Otherwise, if  $2 > \beta \geq 0$  there will be only relative convergence, that is convergence in growth rates.

Due to the fact that, in presence of transition across clubs (i.e. part of one club tend to move towards another club) or highly conservative values of some parameters (i.e.  $c^*$ ), there could be an over determination of the groups, the authors proposed a ‘club merging algorithm’ (Phillips and Sul 2009) that is adopted in this paper. As an improvement, we also apply a different club merging algorithm developed by von Lyncker and Thoennessen (2017). They introduce two innovations to the merging procedure used by PS. First, they add a further condition to the club clustering algorithm to avoid mistakes in merging procedures in the case of transition across clubs. Second, they propose an algorithm for diverging regions claiming that initially divergent economies might not necessarily be still diverging if the club merging algorithm has formed new clubs. The details of these two procedures are provided in the Table A2 in the Appendix<sup>5</sup>.

## 5. Club convergence analysis for EU countries

### 5.1. Regional level

When we apply the log  $t$ -test to the overall sample of NUTS 2 regions belonging to Europe-28 countries, the hypothesis of absolute convergence among all the regions is rejected at the 1% significance level<sup>6</sup>. After the rejection of the null hypothesis for the whole sample, we follow the recursive algorithm proposed by PS to verify the presence of convergence clubs.

Table 3 shows that the application of the PS algorithm yields ten convergence clubs for which all  $t$ -stats are greater than  $-1.65$ . For all these clubs the hypothesis of absolute convergence among regions belonging to each group is rejected. In fact, for clubs with a positive  $\beta$ , the value is below the minimum threshold to detect absolute convergence ( $\beta = 2$ ). In these cases, the  $\beta$  displays only relative convergence, i.e. convergence in growth rates but not in levels. Conversely, clubs 2 and 10 form weak convergence clubs with diverging behaviour (negative  $\beta$ ). Thus, since the hypothesis of club convergence is accepted, it means that the detected groups of regions converge to different steady-states.

[insert Table 3 near here]

To prevent an over determination of the groups we apply both the club merging algorithm proposed by PS and the algorithm developed by VLT (see Table A2). The application of the merging algorithms reduces the number of detected clubs to four and five, respectively. In particular, it seems that, in this case, the VLT merging algorithm works better than the PS one which detects less stable (weaker) convergence clubs (the beta coefficient is negative for clubs from 2 to 4). Conversely, using the VLT algorithm we find five convergence clubs with more homogenous patterns, which is a sign of greater stability (Table 3). A picture of the club membership according to each step is shown in Figure 4.

[insert Figure 4 near here]

Using the VLT classification, we also test for the possibility of transition between the detected clubs, that is the possibility of sequential club convergence where part of one group may tend to move towards another group. As in Phillips and Sul (2009), we perform this analysis running the log t-test regression using data that includes a fraction (50%) of the lowest (in terms of final income) members in the upper club together with a fraction (50%) of the highest (in terms of final income) members in the lower club. Interestingly, we find evidence of transitioning across the bottom club clusters (positive and significant values of the parameter  $\beta$ ), but no evidence of transitioning across the top clubs<sup>7</sup>. This means that some regions within clubs 3-5 may exhibit a tendency to be in transition towards a higher or lower club, leaving open the possibility of joining the new club in the future. However, transition towards top regions seem to be precluded to intermediate regions.

Looking at the composition of each club, our results provide a more detailed picture of the club convergence patterns within the European context with respect to that outlined by European Commission (2017) in which regions (and countries) are grouped *a priori* according to the level of development (proxied by the distance of GDP per head from the EU average).

Particularly, we find that in all specifications, the top two clubs include almost all German regions, several regions of Belgium, Austria and Sweden and the metropolitan areas both of Western and Eastern countries. Conversely, the lower level clubs mainly include the southern Italian regions, the Greek regions, some of the regions of Bulgaria, Romania and Hungary. Similarly to other studies (i.e. Bartkowska and Riedl 2012; von Lyncker and Thoennessen 2017) we find that the first club is typically composed of regions including cities and metropolitan areas, while the intermediate ones pertain to northern and central European advanced regions, and the lower clubs pertain to the peripheral regions of western European members. The larger sample used in our study allows to add further interesting insights to previous research. Indeed, the metropolitan areas of some Eastern countries belong to the highest club as the metropolitan areas of the original European members. Second, the Eastern regions do not necessarily belong to the lower clubs. In fact, we find that most of the regions of Slovakia, Slovenia, Poland and Czech Republic belong to the intermediate clubs. Third, by analysing the growth dynamics within the lower clubs we detect a catching up process (in growth rates) between the Hungarian and Bulgarian regions and the Greek, southern Italian and southern Spanish ones<sup>8</sup>.

Furthermore, regions in top clubs tend to show, on average, higher levels of per-capita GDP, better institutional features, as well as greater fixed and human capital endowments with respect to regions belonging to bottom clubs. Top regions tend to show also higher labour force migration inflows due to their attractiveness, while lagging regions clustering in the bottom club tend to show migration outflows and higher reliance on the manufacturing sector.

## 5.2. *Country level*

In order to make a more accurate statement concerning the homogeneity or heterogeneity of European economies we also performed the analysis at the country level. As said, several papers investigated convergence at the country level and have discussed the role of the new member countries (i.e. Giannetti 2002; Ezcurra et al. 2007).

By applying the log  $t$ -test to the 28 European countries, the hypothesis of absolute convergence is rejected at the 1% significance level<sup>9</sup>. As a consequence, we use the recursive PS algorithm to verify the presence of convergence clubs at the country level.

[insert Table 4 near here]

From Table 4, we clearly identify four different groups that converge towards four different steady-states. Again, we find only relative convergence among the countries within the same club ( $2 > \beta \geq 0$ ).

[insert Figure 5 near here]

As shown in Table 4 and in Figure 5, the first club is mainly composed of the richest countries of Europe, with small pace of convergence in growth rates. The remaining groups are more heterogeneous and include the Mediterranean countries as well as the Eastern countries clustered in different growth paths. In these cases, the magnitude of the speed of convergence is higher than in the previous group, highlighting a diversified catching up process within these clubs. Some developing Eastern European countries (Slovakia, Estonia, Romania, Bulgaria) grew more than the most Mediterranean countries.

Also, in this case we apply the two club merging algorithms discussed above, obtaining the following results (Table 5).

[insert Table 5 near here]

Both procedures reduce the number of the groups to two, by merging the three lowest clubs. The second (merged) group becomes a weaker convergence club because it displays a smaller beta coefficient with respect to clubs 2 to 4 in Table 5. Less developed countries of former clubs 2 to 4 display greater growth rates than European core countries, but on average, smaller in the two lowest clubs (Bulgaria, Croatia, Hungary) than in the highest (Romania, Poland, Estonia, Slovakia)<sup>10</sup>.

As in the case of regions, our results provide a more comprehensive picture of the club convergence patterns with respect to other studies (i.e. European Commission 2017) grouping countries *a priori* according to the level of development. Moreover, our findings advocate the relevance of carrying out simultaneous analyses at different geographical levels, since regions of the bottom club countries may follow very diversified growth patterns and may partly belong to higher level intermediate regional clubs.

### ***5.3. The effect of the Great Recession***

Once we have defined the club membership, we focus on the main question of this paper: in which way has the last crisis modified the convergence process among European regions and countries?

To address this point, we look at the transition paths of each economy as defined in section 4. In particular, the coefficient  $h_{it}$  embodies the economic growth relative to the average performance in a subgroup of economies (in our cases all European regions or countries). This process enables us to identify the relative changes that occur within these subgroups measuring these transitions against the corresponding common growth trend. By this way we are able to assess the path of each economy over time relative to a useful benchmark.

Figure 6 describes the relative transition paths of the regional groups detected through the application of the PS basic clustering procedure and those obtained using the two merging procedures.

[insert Figure 6 near here]

In particular, the lines representing each club are traced using the cross sectional means of the relative transitional coefficients for each year. Due to the fact that in presence of convergence among clubs these lines should converge towards 1, it appears immediately a clear divergent impact of the crisis among the groups under consideration. In particular, it seems that the crisis has affected more the regions belonging to the lower convergence clubs rather than the richer ones. Further evidence of this intuition is shown in Table 6.

[insert Table 6 near here]

In the baseline case, the table shows that the first six clubs have not been affected by (or have completely recovered from) the recent crisis. In fact, the average per-capita GDP for these clubs in 2015 is well above the corresponding value in 2008. For club 6 the 2015 value is slightly above the 2008 value, suggesting weak recovery and internal heterogeneous behaviours. Finally, for the three lowest clubs (from 8 to 10) it is clearly observable that the fall in per-capita GDP was not recovered yet until 2015. In some cases, the divergence pattern started one or two years before the crisis, but it is also evident that the crisis has accelerated this process.

These findings are confirmed when we follow the clubs' membership as obtained by applying the merging procedures described in previous sections. With both methodologies, the lower groups clearly show a lower per-capita GDP in 2015 respect to 2008. Contrary to what happened in the 2000-2008 period, the difference in the degree of recovery between the first two and the following clubs strongly confirms the divergent impact of the crisis in both cases.

Moving to the country level, the distance between the richest and the poorest clubs was narrowing before the crisis in the baseline while, after the Great Recession, the pace of convergence among steady states has suddenly slowed down, except for the members of club 2. The results obtained considering the merging algorithms do not change our findings. Figure 7

and Table 7 confirm the well-known ‘core-periphery’ pattern advocated by Krugman (1991) and, among others, by Baldwin and Forslid (2000). In this case, our results detect a sort of catching up pattern within the ‘Periphery’ (greater growth rates in Eastern countries than in Mediterranean ones, even in the crisis period), but, on average, no trace of convergence between ‘Core’ and ‘Periphery’ after the recession. This means that a share of the gains in per-capita GDP convergence has been lost over the past years because of the Great Recession.

[insert Figure 7 near here]

[insert Table 7 near here]

Our results at both geographical levels are different from those obtained by Montañés et al. (2018) who adopt a similar approach. They found a pro-cyclical behaviour of GDP disparities among Spanish provinces during the Great Recession. This may be due to two reasons. First, our analysis considers a wider spectrum of countries. Second, the different behaviour at a finer geographical level may be explained also by the fact that during the crisis, the surrounding areas of capital regions have performed better than both rural and higher-level urban areas in some countries (Garcilazo and Oliveira Martins 2015; Brakman et al. 2015).

Besides the between-clubs effect, the Great Crisis may have also affected the magnitude of convergence within each club. To investigate this point, we estimate an augmented version of the log  $t$  regression model in order to understand whether and how the speed of convergence has changed before and after the crisis, namely:

$$\log \frac{H_1}{H_t} - 2 \log(\log t) = a_1 D_1 + a_2 D_2 + \beta_1 D_1 \log t + \beta_2 D_2 \log t + u_t \quad (5)$$

with:

$$D_1 = 1 \text{ if } t \leq 2008, \text{ otherwise } D_1 = 0$$

$$D_2 = 1 \text{ if } t > 2008, \text{ otherwise } D_2 = 0$$

To identify temporal marginal effects on the intercept and slope we use dummy variables reporting the results in Table 8. When analysing all the units, our findings suggest the absence



of convergence in both periods (pre- and post-crisis) at both geographical levels (regional and country) and a deterioration in the temporal evolution of the speed of convergence.

A worsening of the temporal evolution of the speed of convergence is also detected in the top clubs at the regional level. On the contrary, within the medium-low clubs the process of relative catching up seems to have been strengthened by the crisis. Here, the estimates suggest to not reject the null hypothesis of convergence especially in the post-crisis period, though the process we observe is somewhat weak. The same behaviour is detected at the country level, where the crisis seems to have reinforced the process of convergence within each club.

Thus, it seems that the Great Recession had two different effects. On the one hand, it has increased the disparities among the clubs causing divergence ‘between’ groups of similar countries and regions, while on the other hand, it has reinforced the process of convergence ‘within’ each club (except for the top clubs at the regional level). In particular, in the enlarged Europe the catching up process of the lagging regions of the Eastern countries with respect to the peripheral ones of the Mediterranean countries continues even after the crisis period due to the sluggish recovery of the Western regions and the higher growth rates of Eastern regions<sup>11</sup>.

[insert Table 8 near here]

## **6. Factors explaining club membership and resilience to the Great Recession**

The existence of several clubs both at the regional and country levels, as well as the contrasting behaviours between and within clubs in the aftermath of the crisis, raises questions about the factors that may influence both the club membership and the resilience to shocks of such economies.

On the one hand, traditional growth theories identify several variables that may affect the growth path of economies. For example, the neoclassical growth theory considers saving rates, population dynamics and physical capital accumulation as main engines of growth. In addition, the endogenous growth theory highlights the role of human capital and technological endowment as key factors that foster growth. On the other hand, an increasing number of contributions on regional and local development has identified auxiliary factors that may reinforce regional economic growth. We refer mainly to infrastructure endowment (Calderón and Servén 2004), institutions quality (Rodríguez-Pose and Garcilazo, 2015, Ketterer and

Rodríguez-Pose 2018, Rodríguez-Pose and Ketterer 2019) and agglomeration (Duranton and Puga 2014; Brakman et al. 2015). Conversely, at the country level, increasing efforts have been made to understand, whether foreign trade and financial openness stimulate growth or make countries more vulnerable (Cerra et al. 2013; Lane and Milesi-Feretti 2011), and whether high government debt and poor institutions may act as constraints to country development (Eberhardt and Presbitero 2015; Acemoglu and Robinson 2010; Haggard and Tiede 2011).

In line with this theoretical background we consider several indicators that may explain club membership and heterogeneity in resilience. Table A4 in the Appendix provides the definition and the corresponding sources of the variables adopted. A descriptive analysis of these variables at the regional level reveals significant differences between the clubs (Table 9). Top clubs perform better in almost all the dimensions analysed. The higher is the club to which the region belong to, the better are the scores in the indicators analysed. Regions clustered in higher clubs tend to show, on average, higher population density, lower shares in the manufacturing sector, higher human and physical (infrastructures) capital endowments, higher share of technology investments and better institutional quality.

[insert Table 9 near here]

To formally test whether these factors are relevant in clubs' formation and the resilience to the shock, we estimate several ordered probit models where the dependent variable is the club to which a region (country) belongs that is classified as an ordinal variable, with  $y=0$  in the case of the lowest club and higher values corresponding to higher clubs (i.e. opposite order with respect to club classification).

Particularly, to evaluate the relevance of these factors over the whole period, we use the VLT club membership as indicated in Table 3, whilst to investigate possible differences in the periods before and after the crisis, we use the VLT club membership obtained re-estimating separately the clustering algorithm for the two periods.

Table 10 shows the results for the whole period (columns 1-3), and for the two subperiods (columns 4-8). Looking at the whole period, in line with endogenous growth theories (i.e. Lucas 1988; Romer 1990), we detect a strong positive effect of human capital on

economic growth. Higher levels of education rise the probability of belonging to higher convergence clubs, namely those with higher per-capita GDP.

A positive effect is also found for investments in R&D and population density<sup>12</sup>. As found by several studies (i.e. Dijkstra et al. 2011; Capello and Lenzi 2013) the capability to innovate is an essential determinant of the global competitiveness and tend to be crucial in advanced economies. At the same time, as population density increases, the probability of belonging to the highest clubs increases as well. Indeed, agglomeration and growth have been seen as mutually self-reinforcing processes (Duranton and Puga 2014).

On the contrary, our results show that regions with a higher share of manufacturing are likely to belong to lower convergence clubs. As known, there are considerable differences in the patterns of regional specialization across Europe and leading regions tend to be less specialized in low-tech manufacturing (Brakman et al. 2015).

Infrastructure density has a significant and positive effect, indicating that regions with higher infrastructure endowment are likely to converge to higher steady-states. In fact, better infrastructures allow to reduce barriers and, though this may expose regions to worldwide competition, they promote a faster diffusion of knowledge through the improved accessibility and provide incentives for firms' settlement (Calderón and Servén 2004; Annoni and Dijkstra 2017).<sup>13</sup>

Larger net migration rates imply higher probability of belonging to top clubs for two main reasons. First, since richest regions tend to have better institutions and more efficient labour markets, migrants tend to be more easily integrated in the productive process. Second, top regions usually include capital cities where large firms locate their headquarters. This induces migration of more skilled and educated workers which acts as a further stimulus to growth.

When we look at the results for the two subperiods, previous findings on the role of agglomeration economies, investments in R&D and manufacturing share are confirmed. Interestingly, higher human capital endowment appears crucial especially in the after-crisis scenario highlighting the importance of this factor in supporting the resilience to the Great Recession. Also, workers' mobility is found to be critical in periods of distress since it is one of the mechanisms of shock absorption. Higher workers' mobility appears to strengthen the resistance of economies and to increase the speed of recovery. Finally, though the quality of

government is not statistically significant in affecting club membership in the whole period, it appears to be strongly and positively associated with resilience when considering the two subperiods separately.<sup>14</sup>

[insert Table 10 near here]

Since the results of the previous exercises may be affected by endogeneity problems and convergence clubs are formed in a way that is related to the level (and growth) of the per-capita GDP, we follow existing literature (i.e. Choi and Wang 2015; Fufa and Kim 2018) in estimating dynamic panel system GMM-models (Blundell and Bond 1998) to address this issue and check for the robustness of our findings. Results displayed in table A6 in the Appendix confirm our previous conclusions. Particularly, in the full sample almost all variables (except for migration) are statistically significant in explaining per-capita GDP growth. Before the crisis, human capital and non-industrial specialisation (a proxy for diversity) acted as primary drivers of growth. Instead, after the outbreak of the crisis, the positive effect of human capital is complemented by the increasing role of agglomeration economies. When including quality of government in the estimations, the results highlight the importance of this distinctive characteristic in all the specifications. Regressions by clubs confirm the results (table A7), since human capital, diversity and investments in R&D appear to be particularly relevant in the growth process of intermediate clubs<sup>15</sup>.

We replicated the exercises at the country level including some macroeconomic variables instead of the regional ones (Table A8)<sup>16</sup>. Although results should be interpreted with caution due to the limited sample, the key variables previously identified (i.e. population density, human capital and investments in R&D) are still significant and with the expected sign. In addition, the rule of law (our proxy of good governance) and financial openness exert a statistically significant positive effect in affecting the probability to converge to a higher steady-state. Results for the two sub-periods (here not shown for brevity) confirm these findings, emphasising the role of such macroeconomic and structural characteristics in fostering growth and favouring better resilience to shocks.

Rule of law, that is a multidimensional concept encompassing a variety of components, from property rights, to government accountability and control of corruption, is usually linked

to better economic performances (Haggard and Tiede 2011). Our results are also consistent with Lane and Milesi-Feretti (2011) who found that there is no evidence that financial openness is associated with lower growth during the crisis. On the other hand, although with the expected sign, the coefficients for government debt (as a share to GDP) and trade openness are not statistically significant in explaining club membership. In the first case, results may be driven by non-linearities in debt–growth relationship (Eberhardt and Presbitero 2015). In the second, they can be related to the ambiguous effect of trade openness on growth since more opened countries are capable to take advantages in high growth periods but at the same time are less sheltered from the risk of external negative shocks.

## **7. Conclusions and policy implications**

The persistence of disparities in Europe has raised questions about the sustainability of the current growth patterns and the effectiveness of the policies aiming at reducing territorial differences. The processes of European integration and reducing disparities may have been truly jeopardised by the Great Recession, as perceived by many analysts just after the outbreak of the crisis.

In this paper we try to answer to these questions, by analysing the broad sample of EU-28 countries and regions simultaneously and by making direct comparison between their different behaviours. In addition, we adopt the club convergence framework trying to generalize the impact of the Great Recession on the convergence process at the European level since most of the literature restrict the analysis to single countries.

Our results confirm the existence of a “multi-speed” Europe, and the larger sample used in our analysis allow us to add interesting insights concerning the behaviours of Eastern economies (i.e. differentiated patterns of the regions with respect to those of the countries to which they belong to). Moreover, our findings suggest a clear and strong divergent impact of the Great Recession on the convergence process *between* the European regions in spite of a (somewhat weak) consolidation of the convergence *within* each club.

Such divergent pattern may have been amplified by the globalization process. In fact, the opening of regional economies has determined a much greater local exposure to external shocks. As discussed in Capello and Fratesi (2013), the increasing integration process may have resulted

in a worsening of regional disparities due to a fiercer competition. In this context, the specific characteristics of the regions assume greater importance. In fact, the heterogeneous impact of the crisis is related to different endowments in specific local assets, both material and immaterial. The regional clubs are mainly determined by specific variables such as investments in R&D, human capital, population density, regional specialization and infrastructure endowment. Therefore, less advanced regions which tend to have a lower endowment in economic, environmental and institutional variables become more and more vulnerable to global external shocks.

Also the increase in personal income inequality in the last three decades, may be an additional possible source of regional divergence. In fact, income and wealth inequality has increased widely during the crisis at a global scale and the concentration at the top of the distribution determines a reduction (or a slower growth) of aggregate demand especially for the weakest economies.

An additional cause may be related to the distortion in the use of regional policy. As it is well-known, the main goal of the Structural Funds is to promote economic and social cohesion in order to reduce disparities within the European Union. Numerous papers have been published to discuss their role in enhancing growth, but few researches have been conducted to investigate their possible role in making regions more able to response to crises. As discussed in Rodriguez-Pose and Fratesi (2004), European regional support has grown in parallel with European integration, but it is not clear if it has worked properly (Boldrin and Canova 2001). It is possible that the effectiveness of regional policy has lowered during the crisis although a rigorous counterfactual analysis is needed to assess whether the performances would have been better or worse without the cohesion policy.

The detection of a divergent impact of the Great Recession at the country level is something new. Indeed, national disparities were narrowing before 2008. This was mainly due to the decrease in between-countries disparities, in spite of a slow (but constant) increase in within-countries differences. Instead, our results suggest that two different processes seem to be in place: a slowdown in convergence among clubs after the crisis and a ‘multi-speed’ catching up pattern within the ‘Periphery’ especially considering the crisis period (greater growth rates in Eastern countries rather than in the Mediterranean ones).

At the national level, the macroeconomic conditions may have played a key role. In particular, high levels of debt and deficit as a share to GDP mixed with the introduction of austerity package may have strengthened the disparities. Fiscal consolidations may have significant distributional effects (Ball et al. 2013; Agnello et al. 2016), raising personal inequality and territorial disparities, at the same time decreasing wage income shares and increasing long-term unemployment. In addition, ‘quantitative easing’ policies without fiscal stimulus may have determined a ‘liquidity trap’, since the reduction in interest rates has not been able to raise the demand for goods, consumption and investments. In this context, there is room for a coordination of industrial policy with fiscal and monetary policies.

As a consequence of the above discussed points, policy interventions should be specifically tailored to the conditions of different regional (and national) economic and institutional environments. This requires an in-depth understanding of local conditions and an assessment of the local effectiveness of the different policy instruments both in expansionary periods and in downturns.

## References

- Acemoglu, D., & Robinson, J. (2010). The role of institutions in growth and development. In *Leadership and growth*, edited by Spence, M., & Brady, D., 135-164. Washington D.C.: The World Bank.
- Agnello, L., Fazio G., R., & Sousa, M. (2016). National fiscal consolidations and regional inequality in Europe. *Cambridge Journal of Regions, Economy and Society* 9 (1): 59-80. <https://doi.org/10.1093/cjres/rsv033>
- Annoni, P., & Dijkstra, L. (2017). Measuring and monitoring regional competitiveness in the European Union. In Huggins R. and Thompson (Eds.) *Handbook of regions and competitiveness, contemporary theories and perspectives on economic development*. Edward Elgar Publishing Limited, UK, 49-79.
- Apergis, N., Panopoulou, E., & Tsoumas C. (2010). Old wine in a new bottle: growth convergence dynamics in the EU. *Atlantic Economic Journal* 38 (2): 169-181. <https://doi.org/10.1007/s11293-010-9219-1>
- Armstrong, H. (1995). Convergence among Regions of the European Union. *Papers in Regional Science* 74 (2): 143-152. <https://doi.org/10.1111/j.1435-5597.1995.tb00633.x>
- Artelaris, P., Kallioras, D., & Petrakos, G. (2010). Regional inequalities and convergence clubs in the European Union new member-states. *Eastern Journal of European Studies* 1 (1): 113-133.
- Azariadis, C., & Drazen, A. (1990). Threshold externalities in economic development. *The Quarterly Journal of Economics*, 501-526. <https://doi.org/10.2307/2937797>
- Baldwin, R. E., & Forslid, R. (2000). The core-periphery model and endogenous growth: stabilizing and destabilizing integration. *Economica* 67 (267): 307-324. <https://doi.org/10.1111/1468-0335.00211>
- Ball, L., Furceri, D., Leigh, D., & Loungani, P. (2013). The distributional effects of fiscal consolidation. *Working Paper No. WP/13/151, International Monetary Fund, Washington D.C.*
- Bartkowska, M., & Riedl, A. (2012). Regional convergence clubs in Europe: Identification and conditioning factors. *Economic Modelling* 29 (1): 22-31. <https://doi.org/10.1016/j.econmod.2011.01.013>
- Battisti, M., & De Vaio, G. (2008). A spatially filtered mixture of  $\beta$ -convergence regressions for EU regions, 1980–2002. *Empirical Economics* 34 (1): 105-121. <https://doi.org/10.1007/s00181-007-0168-8>
- Baumol, W. (1986). Productivity Growth, Convergence and Welfare: What the Long Run Data Show?. *American Economic Review* 76 (5): 1072-1085.
- Blundell, R., & Bond, S. (1998). Initial conditions and moment restrictions in dynamic panel data models. *Journal of Econometrics*, 87 (1): 115-143. [https://doi.org/10.1016/S0304-4076\(98\)00009-8](https://doi.org/10.1016/S0304-4076(98)00009-8)



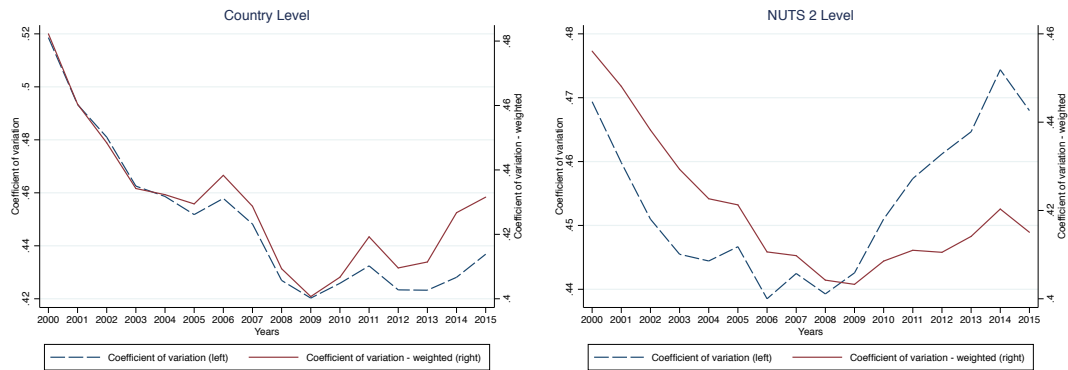
- Boldrin, M., & Canova, F. (2001). Inequality and convergence in Europe's regions: reconsidering European regional policies. *Economic Policy* 16 (32): 205-253. <https://doi.org/10.1111/1468-0327.00074>
- Borsi, M. T., & Metiu, N. (2015). The evolution of economic convergence in the European Union. *Empirical Economics* 48 (2): 657-681. <https://doi.org/10.1007/s00181-014-0801-2>
- Brakman, S., Garretsen, H., & van Marrewijk, C. (2015). Regional resilience across Europe: on urbanisation and the initial impact of the Great Recession. *Cambridge Journal of Regions, Economy and Society*, 8 (2): 225-240. <https://doi.org/10.1093/cjres/rsv005>
- Calderón, C., & Servén, L. (2004). The effects of infrastructure development on growth and income distribution. Washington D.C.: World Bank Publications.
- Canova, F. (2004). Testing for convergence clubs in income per capita: a predictive density approach. *International Economic Review* 45 (1): 49-77. <https://doi.org/10.1111/j.1468-2354.2004.00117.x>
- Capello, R., & Fratesi, U. (2013). Globalization and endogenous regional growth. In *Geography, Institutions and Regional Economic Performance*, edited by Crescenzi, R., Percoco, M., 15-37. Springer Berlin Heidelberg.
- Capello, R., & Lenzi, C., (2013). Territorial Patterns of Innovation and Economic Growth in European Regions. *Growth and change*, 44 (2): 195-227. <https://doi.org/10.1111/grow.12009>
- Cerra, V., Panizza, U., & Saxena S.C., (2013). International evidence on recovery from recessions. *Contemporary Economic Policy*, 31 (2): 424-439. <https://doi.org/10.1111/j.1465-7287.2012.00313.x>
- Choi, C. Y., & Wang, X. (2015). Discontinuity of Output Convergence within the United States: Why Has the Course Changed?. *Economic Inquiry*, 53(1), 49-71. <https://doi.org/10.1111/ecin.12129>
- Corrado, L., Martin R., & Weeks M., (2005). Identifying and interpreting regional convergence clusters across Europe. *The Economic Journal* 115 (502): C133-C160. <https://doi.org/10.1111/j.0013-0133.2005.00984.x>
- Crescenzi, R., Luca, D., & S. Milio. (2016). The geography of the economic crisis in Europe: national macroeconomic conditions, regional structural factors and short-term economic performance. *Cambridge Journal of Regions, Economy and Society*, 9 (1): 13-32. <https://doi.org/10.1093/cjres/rsv031>
- De Siano, R., & D'Uva, M.. (2006). Club convergence in European regions. *Applied Economics Letters* 13 (9): 569-574. <https://doi.org/10.1080/13504850600733473>
- Dijkstra, L., Annoni, P., & Kozovska, K. (2011). A new regional competitiveness index: theory, methods and findings. *European Union Regional Policy Working Papers*, 2, 2011.
- Dijkstra, L., Garcilazo, E., & McCann, P. (2015). The effects of the global financial crisis on European regions and cities. *Journal of Economic Geography* 15 (5): 935-949. <https://doi.org/10.1093/jeg/lbv032>
- Duranton, G., & Puga, D.. (2014). The growth of cities. In *Handbook of Economic Growth*, Durlauf S.N. and Aghion P., Vol. 2, 781-853. Amsterdam: North-Holland.

- Eberhardt, M., & Presbitero, A.F. (2015). Public debt and growth: Heterogeneity and non-linearity. *Journal of International Economics* 97 (1): 45-58. <https://doi.org/10.1016/j.jinteco.2015.04.005>
- Estrada, Á., Galí, J., & López-Salido, D. (2013). Patterns of convergence and divergence in the euro area. *IMF Economic Review* 61 (4): 601-630. <https://doi.org/10.1057/imfer.2013.22>
- European Commission. (2017). *My Region, My Europe, Our Future*. Seventh report on economic, social and territorial cohesion. Luxembourg: Publications Office of the European Union.
- Ezcurra, R., Pascual, P., & Rapún, M. (2007). Spatial disparities in the European Union: an analysis of regional polarization. *The Annals of Regional Science* 41 (2): 401-429. <https://doi.org/10.1007/s00168-006-0111-5>
- Fingleton, B., (1997). Specification and Testing of Markov Chain Models: An Application to Convergence in the European Union. *Oxford Bulletin of Economics and Statistics* 59 (3): 385-403. <https://doi.org/10.1111/1468-0084.00072>
- Fischer, M.M., & LeSage, J.P. (2015). A Bayesian space-time approach to identifying and interpreting regional convergence clubs in Europe. *Papers in Regional Science* 94 (4): 677-702. <https://doi.org/10.1111/pirs.12104>
- Fischer, M.M., & Stirböck, C. (2006). Pan-European regional income growth and club-convergence. *The Annals of Regional Science* 40 (4): 693-721. <https://doi.org/10.1007/s00168-005-0042-6>
- Fritsche, U., & Kuzin, V. (2011). Analysing convergence in Europe using the non-linear single factor model. *Empirical Economics* 41 (2): 343-369. <https://doi.org/10.1007/s00181-010-0385-4>
- Fufa, T., & Kim, J. (2018). Financial development, economic growth and convergence clubs. *Applied Economics*, 1-17. <https://doi.org/10.1080/00036846.2018.1489521>
- Galor, O. (1996). Convergence? Inferences from theoretical models. *The Economic Journal* 106: 1056-1069. <https://doi.org/10.2307/2235378>
- Garcilazo E., & Oliveira Martins, J. (2015). The contribution of regions to aggregate growth in the OECD. *Economic Geography* 91 (2): 205-221. <https://doi.org/10.1111/ecge.12087>
- Geppert, K., & Stephan, A. (2008). Regional disparities in the European Union: Convergence and agglomeration. *Papers in Regional Science* 87 (2): 193-217. <https://doi.org/10.1111/j.1435-5957.2007.00161.x>
- Giannetti, M. (2002). The Effects of Integration on Regional Disparities: Convergence, Divergence or Both?. *European Economic Review* 46: 539-567. [https://doi.org/10.1016/S0014-2921\(01\)00166-0](https://doi.org/10.1016/S0014-2921(01)00166-0)
- Haggard, S., & Tiede, L. (2011). The rule of law and economic growth: where are we?. *World Development* 39 (5): 673-685. <https://doi.org/10.1016/j.worlddev.2010.10.007>
- Halmi, P., & Vásáry, V. (2012). Convergence crisis: economic crisis and convergence in the European Union. *International Economics and Economic Policy* 9 (3-4): 297-322. <https://doi.org/10.1007/s10368-012-0218-3>

- Ketterer, T. D., & Rodríguez-Pose, A. (2018). Institutions vs. 'first-nature' geography: What drives economic growth in Europe's regions?. *Papers in Regional Science*, 97: S25-S62. <https://doi.org/10.1111/pirs.12237>
- Krugman, P., (1991). Increasing Returns and Economic Geography. *Journal of Political Economy* 99: 183-199. <https://doi.org/10.1086/261763>
- Lane, P.R., & Milesi-Ferretti, G.M. (2007). The external wealth of nations mark II: Revised and extended estimates of foreign assets and liabilities, 1970–2004. *Journal of international Economics*, 73 (2): 223-250. <https://doi.org/10.1016/j.jinteco.2007.02.003>
- Lane, P. R., & Milesi-Ferretti, G.M. (2011). The cross-country incidence of the global crisis. *IMF Economic Review* 59 (1): 77-110. <https://doi.org/10.1057/imfer.2010.12>
- Le Gallo, J., & Dall'Erba, S. (2003). Spatial econometric analysis of the evolution of the European regional convergence process, 1980-1999. *Urban/Regional EconWPA*, May 2005.
- Marelli, E., & Signorelli, M.. (2015). Convergence, crisis and unemployment in Europe: the need for innovative policies. *Croatian Economic Survey* 17 (2): 5-56. <https://doi.org/10.15179/ces.17.2.1>
- Martin, R. (2012). Regional economic resilience, hysteresis and recessionary shocks, *Journal of Economic Geography*, 12, 1–32. <https://doi.org/10.1093/jeg/lbr019>
- Martin R, Sunley P, Gardiner P, Tyler P (2016) How Regions React to Recessions: Resilience and the Role of Economic Structure. *Regional Studies*, 50: 561–585. <https://doi.org/10.1080/00343404.2015.1136410>
- Mazzola, F., Lo Cascio, I., Epifanio, R., & Di Giacomo, G. (2018). Territorial Capital and Growth over the Great Recession: a Local Analysis for Italy. *The Annals Of Regional Science* 60 (2): 411-441. <https://doi.org/10.1007/s00168-017-0853-2>
- Monfort, M., Cuestas, J.C., & Ordóñez, J. (2013). Real convergence in Europe: A cluster analysis. *Economic Modelling* 33: 689-694. <https://doi.org/10.1016/j.econmod.2013.05.015>
- Montañés, A., Olmos L., & Reyes, M. (2018). Has the Great Recession affected the convergence process? The case of Spanish provinces. *Economic Modelling* 68: 360-371. <https://doi.org/10.1016/j.econmod.2017.08.006>
- Mora, T., Vayá, E., & Suriñach, J.. (2005). Specialisation and growth: the detection of European regional convergence clubs. *Economics Letters* 86 (2): 181-185. <https://doi.org/10.1016/j.econlet.2004.07.010>
- Panopoulou, E., & Pantelidis, T. (2009). Club convergence in carbon dioxide emissions. *Environmental and Resource Economics*, 44(1), 47-70. <https://doi.org/10.1007/s10640-008-9260-6>
- Phillips, P.C., & Sul, D. (2007). Transition modeling and econometric convergence tests. *Econometrica* 75 (6): 1771-1855. <https://doi.org/10.1111/j.1468-0262.2007.00811.x>
- Phillips, P.C., & Sul, D. (2009). Economic transition and growth. *Journal of Applied Econometrics* 24 (7): 1153-1185. <https://doi.org/10.1002/jae.1080>
- Quah, D. T. (1996). Regional convergence clusters across Europe. *European economic review* 40 (3): 951-958. [https://doi.org/10.1016/0014-2921\(95\)00105-0](https://doi.org/10.1016/0014-2921(95)00105-0)

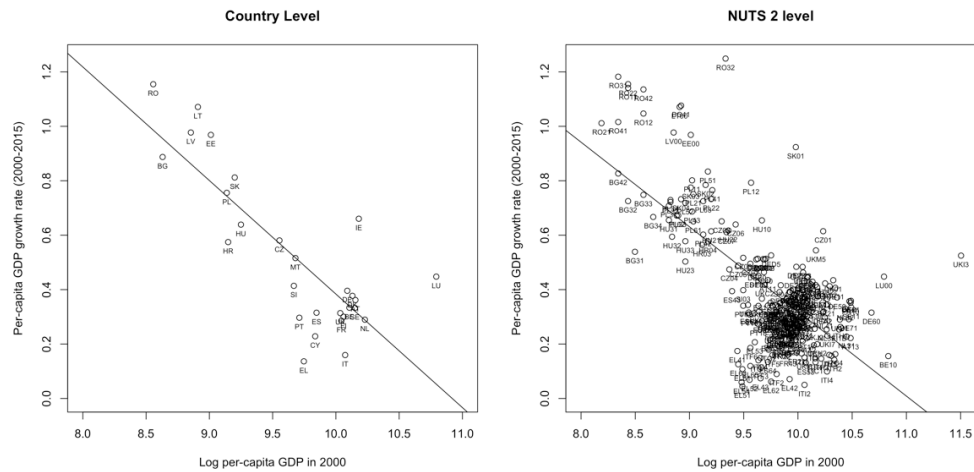
- Rodríguez-Pose, A., & Fratesi U. (2004). Between development and social policies: the impact of European Structural Funds in Objective 1 regions. *Regional Studies* 38: 97–113. <https://doi.org/10.1080/00343400310001632226>
- Rodríguez-Pose, A., & Garcilazo, E. (2015). Quality of government and the returns of investment: Examining the impact of cohesion expenditure in European regions. *Regional Studies*, 49(8), 1274-1290. <https://doi.org/10.1080/00343404.2015.1007933>
- Rodríguez-Pose, A., & Ketterer, T. (2019). Institutional change and the development of lagging regions in Europe. *Regional Studies*, 1-13. <https://doi.org/10.1080/00343404.2019.1608356>
- Rose, A. K., & Spiegel, M. M. (2011). Cross-country causes and consequences of the crisis: An update. *European Economic Review*, 55, 309–324. <https://doi.org/10.1016/j.euroecorev.2010.12.006>
- Sala-i-Martin, X. (1996). Regional cohesion: evidence and theories of regional growth and convergence. *European Economic Review* 40 (6): 1325-1352. [https://doi.org/10.1016/0014-2921\(95\)00029-1](https://doi.org/10.1016/0014-2921(95)00029-1)
- Sichera, R., Pizzuto, P. (2019) ConvergenceClubs: A Package for Performing the Phillips and Sul's Club Convergence Clustering Procedure. *The R Journal*. <https://doi.org/10.32614/RJ-2019-021>
- Solow, R.M. (1956). A contribution to the theory of economic growth. *The Quarterly Journal of Economics* 70 (1): 65-94. <https://doi.org/10.2307/1884513>
- Swan, T.W. (1956). Economic growth and capital accumulation. *Economic record* 32 (2): 334-361. <https://doi.org/10.1111/j.1475-4932.1956.tb00434.x>
- Tondl, G. (1997). Regional Convergence in Europe during the Past 40 Years. *Working Paper No. 53, European University Institute (EUI)*.
- von Lyncker, K., & Thoennessen, R. (2017). Regional club convergence in the EU: evidence from a panel data analysis. *Empirical Economics* 52 (2): 525-553. <https://doi.org/10.1007/s00181-016-1096-2>

**Fig. 1** *Sigma* convergence

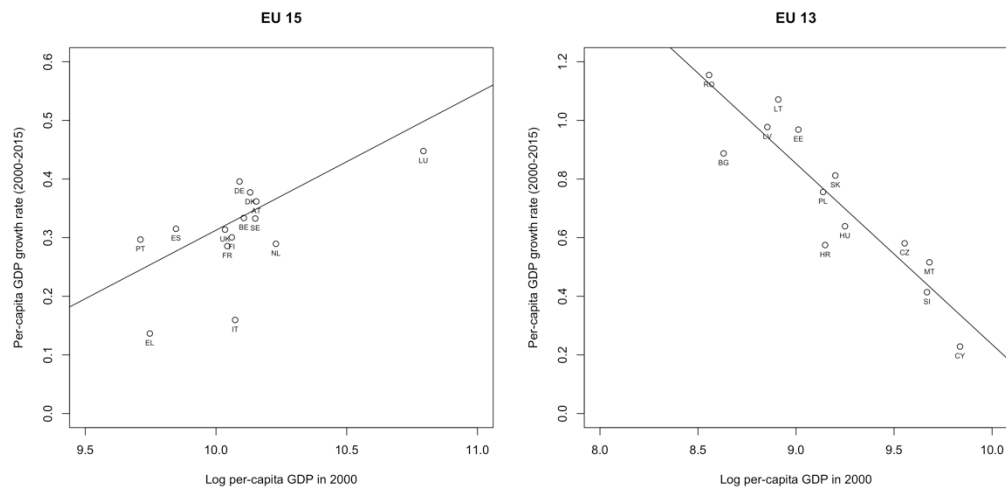


Note: Coefficient of variation of per capita GDP – unweighted and weighted for the population

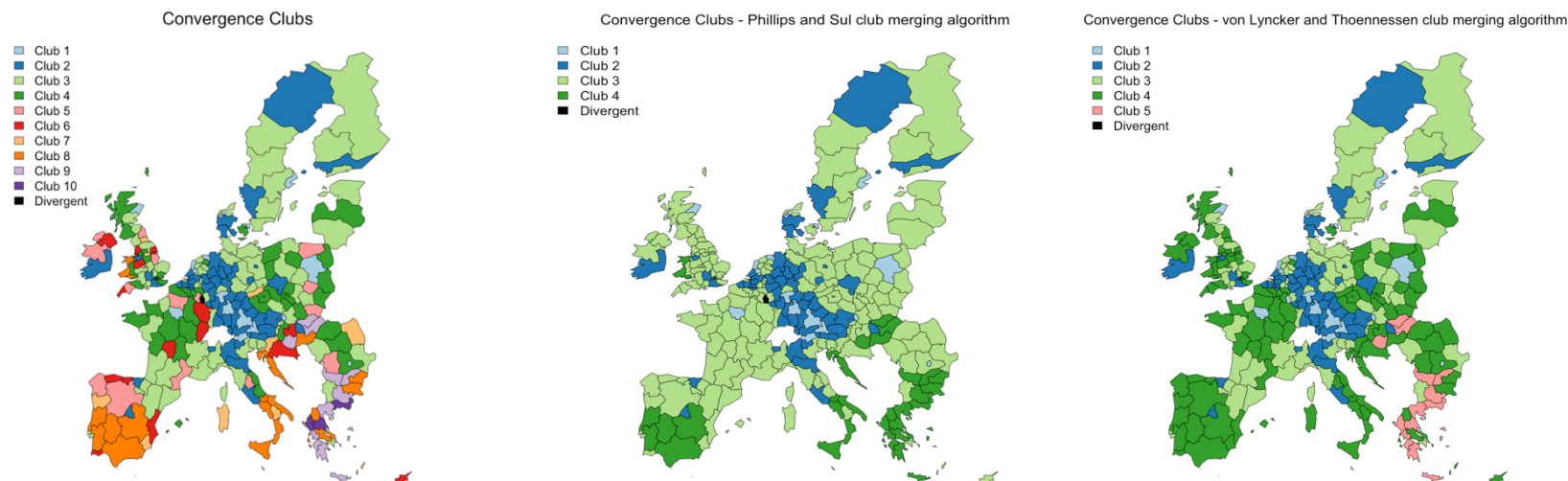
**Fig. 2** *Beta* convergence (unconditional)



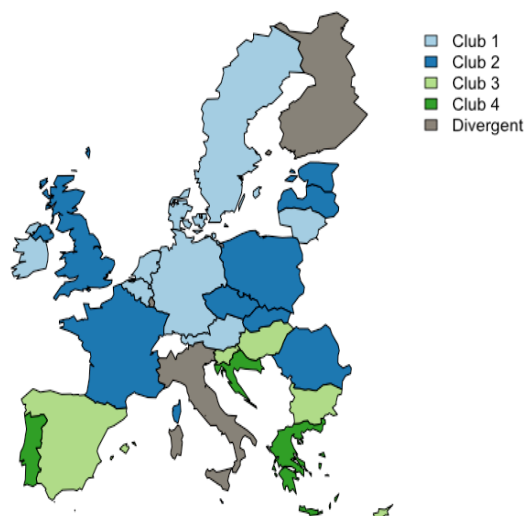
**Fig. 3** *Beta* convergence: EU 15 vs EU 13



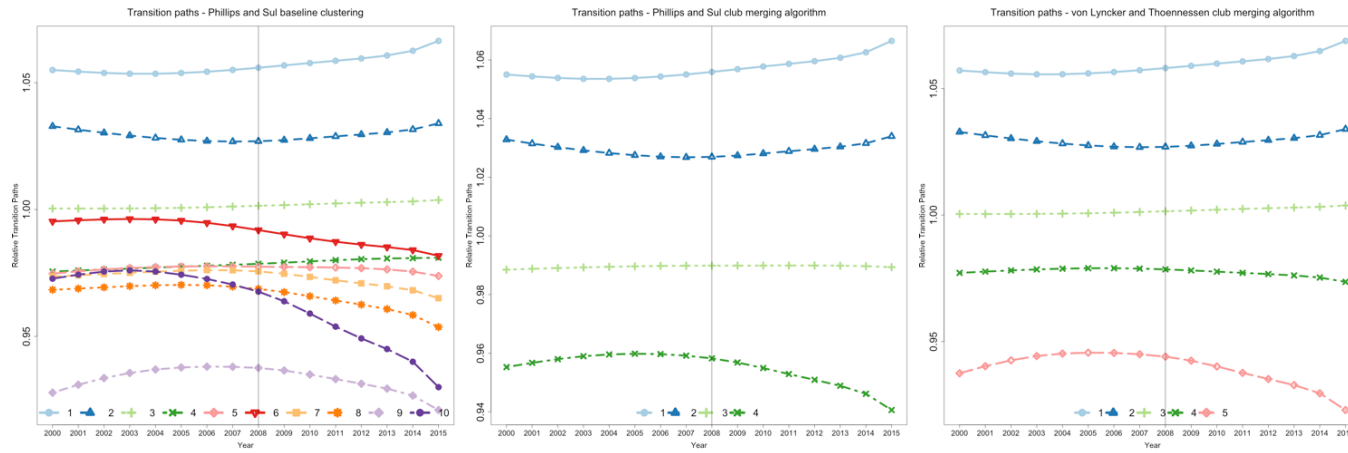
**Fig. 4** Convergence clubs in Europe – NUTS 2 level (268 regions)



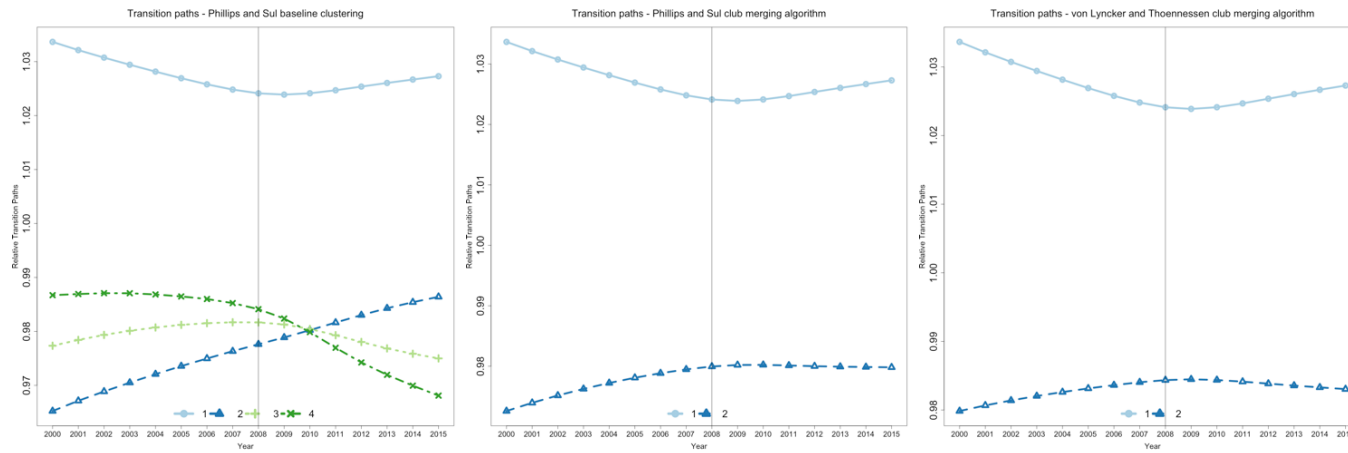
**Fig. 5** Convergence clubs in Europe – Country level (28 Members)



**Fig. 6** Relative transition curves across clubs – Regional level



**Fig. 7** Relative transition curves across clubs – Country level



## TABLES

**Table 1** Club convergence literature on European regions and countries

Authors	Period	Spatial level	Sample size	Method	Results
Quah (1996)	1980-1989	Nuts-2 (Selected regions of BE, DE, ES, IT, NL, UK)	78	Markov chain model with probability transitions	Four convergence clubs (mixed membership)
Le Gallo and Dall'Erba (2003)	1980-1999	Nuts-2 (EU-12)	145	Spatial convergence clubs approach	Two convergence clubs: Core vs Periphery
Canova (2004)	1980-1992	Nuts-2 (EU-12)	144	Predictive density approach	Four groups (mixed membership)
Corrado, Martin and Weeks (2005)	1975-1999	Nuts-1 (EU-15 + NO)	77	Multivariate test for stationarity	Mixed results depending on the sector analyzed
Mora, Vayá, and Suriñach (2005)	1985-2000	Nuts-1 and 2 (EU-12)	108	Ex-ante identification according to the level of specialization	Two regimes: high and low specialization
De Siano and D'Uva (2006)	1981-2000	Nuts-1 and 2 (BE, DE, FR, IT, ES, PT, EL, UK)	123	Classification and Regression Tree Analysis (CART)	Four groups (mixed membership)
Fischer and Stirböck (2006)	1995-2000	Nuts-2 (EU-25)	256	Getis and Ord's local clustering technique	Two regimes: Core vs Periphery
Battisti and De Vaio (2008)	1980-2002	Nuts-2 (EU-15)	191	Spatially filtered mixture regression approach	Four convergence clubs: Core vs Periphery
Artelaris, Kallioras, and Petrakos (2010)	1990-2005	Nuts-2 and 3 (BG, CZ, EE, HU, LT, LV, PL, RO, SK, SL)	190	Non linear econometric approach	Several groups in the EU new member States
Fisher and Le Sage (2015)	1995-2005	Nuts-2 (EU-15)	216	Bayesian space-time approach	Two groups (mixed membership)

**Table 2** Club convergence studies on European regions and countries using the PS methodology

Authors	Period	Spatial level	Sample size	Results
Apergis, Panopoulou, and Tsoumas (2010)	1980-2004	Country (EU-14)	14	One convergence club and several divergent countries
Fritsche and Kuzin (2011)	1960-2006	Country (12 Euro-Area Members + DK, NO, UK)	15	Three convergence clubs (mixed membership)
Bartkowska and Riedl (2012)	1990-2002	Nuts-2 (EU-15 + NO, CH)	206	Six convergence clubs: Core vs Periphery
Monfort, Cuestas, and Ordonez (2013)	1980-2009	Country (EU-14 + 10 Eastern Countries)	24	Polarized Europe: Core (EU-14 Members) vs Periphery (Eastern countries)
Borsi and Metiu (2015)	1995-2010	Country (EU-27)	27	Four convergence clubs: North vs South Europe
Von Lyncker and Thoennessen (2017)	1980-2011	Nuts 2 (EU-15)	194	Four convergence clubs: Core vs Periphery
Montañés, Olmos, and Reyes (2018)	1980-2014	Nuts 3 (Spanish Provinces)	50	Two clubs for GDP (reduction in disparities after the Great Recession)



**Table 3** Convergence clubs at the regional level

	Club	n° Regions	$\beta$	se	t-stat	
Baseline	1	21	0.253	0.052	4.886	
	2	56	-0.077	0.078	-0.979	
	3	69	0.274	0.075	3.661	
	4	44	0.161	0.058	2.800	
	5	15	0.129	0.066	1.937	
	6	17	0.086	0.093	0.921	
	7	11	0.141	0.073	1.940	
	8	19	0.193	0.106	1.818	
	9	11	0.325	0.164	1.982	
	10	3	-0.180	0.421	-0.427	
PS club merging	Club	n° Regions	$\beta$	se	t-stat	Merging
	1	21	0.253	0.052	4.886	1
	2	56	-0.077	0.078	-0.979	2
	3	156	-0.046	0.051	-0.901	3-7
	4	33	-0.020	0.096	-0.210	8-10
VLT club merging	Club	n° Regions	$\beta$	se	t-stat	Merging
	1	22	-0.020	0.053	-0.369	1 + LU00
	2	56	-0.077	0.078	-0.979	2
	3	69	0.274	0.075	3.661	3
	4	106	0.023	0.060	0.391	4-8
	5	14	0.395	0.169	2.337	9-10

Note: Inner London (UKI3) and Luxembourg (LU00) are divergent regions for PS baseline clustering algorithm. For PS merging algorithm Inner London (UKI3) and Luxembourg (LU00) are divergent regions. For VLT, Inner London (UKI3) is divergent region.

**Table 4** PS club clustering algorithm – Country level

Club	Members	n° Countries	$\beta$	se	t-stat
1	Ireland (IE), Netherlands (NL), Austria (AT), Germany (DE), Denmark (DK), Sweden (SE), Lithuania (LT), Belgium (BE)	8	0.034	0.069	0.485
2	United Kingdom (UK), France (FR), Malta (MT), Czech Republic (CZ), Slovakia (SK), Estonia (EE), Poland (PL), Latvia (LV), Romania (RO)	9	0.272	0.031	8.792
3	Spain (ES), Slovenia (SI), Cyprus (CY), Hungary (HU), Bulgaria (BG)	5	0.130	0.102	1.276
4	Portugal (PT), Greece (EL), Croatia (HR)	3	0.531	0.122	4.367

Note: Luxembourg (LU), Finland (FI) and Italy (IT), are divergent countries.

**Table 5** Convergence clubs obtained by adopting the club merging methodologies – Country Level

	Club	Members	n° Countries	$\beta$	se	t-stat
PS	1	IE, NL, AT, DE, DK, SE, BE, LT	8	0.034	0.069	0.485
	2	UK, FR, MT, CZ, SK, EE, PL, LV, RO, ES, SI, CY, HU, BG, PT, EL, HR	17	0.172	0.054	3.163
	Club	Members	n° Countries	$\beta$	se	t-stat
VLT	1	IE, NL, AT, DE, DK, SE, BE, LT	8	0.034	0.069	0.485
	2	UK, FR, MT, CZ, SK, EE, PL, LV, RO, ES, SI, CY, HU, BG, PT, EL, HR, FI, IT	19	0.109	0.050	2.155

Note: For PS, Luxembourg (LU), Finland (FI) and Italy (IT), are divergent countries; for vLT, Luxembourg (LU), is divergent country.

**Table 6** Average per-capita GDP (in Euro) and growth rates for different periods – Regional level

	Club	2008	2015	$\Delta\%$ 2008/00	$\Delta\%$ 2015/08
Baseline	1	42,257	47,271	34.3	11.9
	2	31,113	35,149	27.2	13.0
	3	24,701	26,974	31.8	9.2
	4	19,820	22,282	30.2	12.4
	5	19,673	20,966	31.5	6.6
	6	21,929	22,424	29.6	2.3
	7	19,455	19,491	33.8	0.2
	8	17,837	17,416	31.4	-2.4
	9	13,864	13,009	46.2	-6.2
	10	17,467	14,133	32.7	-19.1
PS	Club	2008	2015	$\Delta\%$ 2008/00	$\Delta\%$ 2015/08
	1	42,257	47,271	34.3	11.9
	2	31,113	35,149	27.2	13.0
	3	22,169	24,049	31.2	8.5
	4	16,479	15,648	35.5	-5.0
VLT	Club	2008	2015	$\Delta\%$ 2008/00	$\Delta\%$ 2015/08
	1	43,409	48,586	34.6	11.9
	2	31,113	35,149	27.2	13.0
	3	24,701	26,974	31.8	9.2
	4	19,744	20,957	30.8	6.1
	5	14,636	13,250	42.5	-9.5

**Table 7** Average per-capita GDP (in Euro) and growth rates for different periods – Country level

	Club	2008	2015	$\Delta\%$ 2008/00	$\Delta\%$ 2015/08
Baseline	1	30,800	36,113	32.1	17.3
	2	19,800	23,622	54.3	19.3
	3	20,980	21,320	51.2	1.6
	4	20,633	19,500	44.0	-5.5
PS	Club	2008	2015	$\Delta\%$ 2008/00	$\Delta\%$ 2015/08
	1	30,800	36,113	32.1	17.3
	2	20,294	22,218	51.4	9.5
VLT	Club	2008	2015	$\Delta\%$ 2008/00	$\Delta\%$ 2015/08
	1	30,800	36,113	32.1	17.3
	2	21,284	23,005	47.1	8.1

**Table 8** The effect of the Great Recession within clubs

Club merging algorithm			$\beta$ pre-crisis	t-value	$\beta$ post-crisis	t-value
EU-28 NUTS 2	overall		-0.667 <sup>d</sup>	-7.916	-1.084 <sup>d</sup>	-11.457
	PS	club 1	0.224 <sup>c</sup>	2.275	-0.138 <sup>c</sup>	-1.252
		club 2	-0.402 <sup>d</sup>	-3.126	-0.195 <sup>c</sup>	-1.349
		club 3	-0.231 <sup>d</sup>	-2.742	-0.204 <sup>d</sup>	-2.155
		club 4	-0.574 <sup>d</sup>	-12.338	0.409 <sup>c</sup>	7.836
			$\beta$ pre-crisis	t-value	$\beta$ post-crisis	t-value
	VLT	club 1	-0.014 <sup>c</sup>	-0.134	-0.425 <sup>d</sup>	-3.749
		club 2	-0.402 <sup>d</sup>	-3.126	-0.195 <sup>c</sup>	-1.348
		club 3	-0.133 <sup>d</sup>	-1.922	0.411 <sup>c</sup>	5.299
		club 4	-0.190 <sup>d</sup>	-1.923	-0.159 <sup>c</sup>	-1.437
		club 5	-0.591 <sup>d</sup>	-8.183	1.460 <sup>c</sup>	18.019
			$\beta$ pre-crisis	t-value	$\beta$ post-crisis	t-value
EU-28 COUNTRY	overall		-0.458 <sup>d</sup>	-15.34	-0.477 <sup>d</sup>	-14.228
	PS	club 1	-0.276 <sup>d</sup>	-3.407	0.332 <sup>c</sup>	3.653
		club 2	-0.098 <sup>c</sup>	-1.584	0.246 <sup>c</sup>	3.547
			$\beta$ pre-crisis	t-value	$\beta$ post-crisis	t-value
	VLT	club 1	-0.276 <sup>d</sup>	-3.407	0.332 <sup>c</sup>	3.653
		club 2	-0.152 <sup>d</sup>	-3.729	0.260 <sup>c</sup>	5.697

Note: *c* denotes the presence of convergence within the club (t-value > -1.65); *d* denotes the presence of divergence within the club (t-value ≤ -1.65).

**Table 9** Descriptive statistics on the explanatory variables

	Population Density	Human Capital (%)	Investments in R&D (%)	Manufacturing share (%)	Net Migration rate (%)	Infrastructure density	European QoG Index (EQI)
Club 1	15.61	79.57	2.29	0.83	4.92	2.15	0.28
Club 2	4.16	77.57	2.25	1.30	3.97	1.89	0.57
Club 3	2.00	74.46	1.63	2.77	2.86	1.44	0.04
Club 4	3.64	66.04	0.83	3.82	2.38	1.22	-0.41
Club 5	0.63	62.22	0.56	9.33	-0.97	0.64	-1.21
Total	4.51	71.55	1.44	3.06	2.87	1.46	-0.12

Note: Data are values or averages in the period of data availability for each club based on VLT classification. Total values refer to the whole sample (including the diverging region (Inner London - UKI3)).

**Table 10** Ordered probit models – Regional Level

	Full sample			Before Crisis		After Crisis		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Population Density	0.033*** (0.008)	0.010 (0.008)	0.189*** (0.050)	0.001*** (0.000)	0.001*** (0.000)	0.001*** (0.000)	0.001 (0.000)	0.001 (0.000)
Human Capital	2.362*** (0.509)	2.963*** (0.593)	2.610*** (0.771)	0.002 (0.005)	0.005 (0.007)	0.013*** (0.005)	0.016*** (0.005)	0.014** (0.006)
Investments in R&D	48.903*** (6.417)	24.752*** (7.228)	29.627** (14.571)	0.464*** (0.081)	0.334* (0.195)	0.559*** (0.065)	0.404*** (0.069)	0.319** (0.148)
Manufacturing share		-16.437*** (3.569)	-14.551*** (4.772)		-14.109*** (3.423)		-30.335*** (4.080)	-32.228*** (5.191)
Net Migration rate		6.782*** (2.241)	7.680*** (2.880)		-0.013 (0.020)		0.024** (0.012)	0.028** (0.014)
Infrastructure density		0.284*** (0.094)	-0.014 (0.166)					0.001 (0.002)
Quality of Government			0.166 (0.128)		0.558*** (0.149)			0.652*** (0.118)
Observations	267	267	154	166	110	235	235	144
LR	119.90	181.13	113.51	63.54	92.72	108.41	175.83	165.26
<i>Prob&gt;chi2</i>	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Pseudo R <sup>2</sup>	0.160	0.242	0.278	0.092	0.204	0.099	0.155	0.246

*Note:* Standard errors in parentheses. \*\*\* p<0.01, \*\* p<0.05, \* p<0.1. The table shows the results obtained using the VLT merging algorithm. Results are robust to other specifications (i.e. baseline clustering and PS merging procedure). Note that for the subperiods the number of clubs identified is 9 before the crisis and 14 after the crisis. Despite the different number of clubs, results are qualitatively unchanged respect to what shown in previous sections. They are not shown for brevity and are available from the authors upon request. Data for explanatory variables are values or averages in the period of data availability.

## APPENDIX

**Table A1** Descriptive statistics on per-capita GDP (2000-2015)

Country	Average national per-capita GDP (in Euro)	Average national Growth Rates	CV of regional per-capita GDP	CV of regional Growth Rates
AT	30174	0.251%	0.200	1.085
BE	28266	0.212%	0.368	1.005
BG	8928	0.567%	0.363	0.795
CY	23313	0.153%	-	-
CZ	19991	0.382%	0.441	0.621
DE	28431	0.265%	0.247	0.761
DK	28273	0.240%	0.211	0.780
EE	15556	0.681%	-	-
EL	18194	0.065%	0.203	1.227
ES	22964	0.204%	0.203	0.605
FI	29235	0.194%	0.228	3.410
FR	23825	0.165%	0.193	4.005
HR	13938	0.404%	0.033	0.380
HU	13551	0.427%	0.400	0.517
IE	30117	0.210%	0.357	0.651
IT	25692	0.101%	0.259	2.105
LT	14419	0.757%	-	-
LU	61913	0.271%	-	-
LV	12988	0.698%	-	-
MT	20175	0.344%	-	-
NL	30532	0.194%	0.222	3.143
PL	12865	0.512%	0.232	1.794
PT	19675	0.195%	0.242	0.611
RO	11266	0.820%	0.504	0.606
SE	29134	0.203%	0.194	1.298
SI	20856	0.275%	0.266	0.310
SK	19814	0.554%	0.644	0.409
UK	27159	0.206%	0.641	1.416

*Note:* see table 5 for list of countries. All values are averages of the 2000-2015 period.

**Table A2** Comparison between Phillips and Sul (PS) and von Lyncker and Thoennessen (VLT) merging procedures

<b>Description of the club merging procedure according to Phillips and Sul (2009)</b>
Take the first two groups detected in the basic clustering mechanism and run the log- $t$ test. If $\{t_k\} > -1.65$ , these groups together form a new convergence club. Then, repeat the test adding the next group and continue until the basic condition $\{t_k\} > -1.65$ holds. If convergence hypothesis is rejected, conclude that all previous groups converge, except the last one. Hence, start again the test merging algorithm beginning from the group for which the hypothesis of convergence did not hold.
<b>Description of the club merging procedure according to von Lyncker and Thoennessen (2017)</b>
Take all the groups detected in the basic clustering mechanism ( $P$ ) and run the log $t$ -test for adjacent groups, obtaining a $(M \times 1)$ vector of convergence test statistics $t$ (where $M = P - 1$ and $m = 1, \dots, M$ ). Then merge for adjacent groups starting from the first, under the conditions $t(m) > -1.65$ and $t(m) > t(m + 1)$ . If both conditions hold, the two clubs determining $t(m)$ are merged and the algorithm starts again from step 1, otherwise it continues for all following pairs. For the last element of vector $M$ (the value of the last two clubs) the only condition required for merging is $t(m = M) > -1.65$ .
<b>Description of the algorithm for diverging regions according to von Lyncker and Thoennessen (2017)</b>
Run a log $t$ -test for each diverging unit and each club, creating a matrix of $t$ -values with dimension $d \times p$ , where each row $d$ represents a divergent unit and each column $p$ a convergence club. Then, the unit with the highest $t$ -value $> e^*$ should be taken and added to the respective club (the authors suggest to use $e^* = t = -1.65$ ). The algorithm stops when no $t$ -value $> e^*$ is found, and as a consequence all remaining units are considered divergent.

**Table A3** Club membership NUTS 2 level EU 28

**Basic algorithm**

<b>Club 1</b> AT13 AT32 BE10 CZ01 DE11 DE21 DE50 DE60 DE71 DK01 FR10 ITH1 NL11 NL31 NL32 PL12 RO32 SE11 SK01 UKI4 UKM5	<b>Club 2</b> AT12 AT21 AT22 AT31 AT33 AT34 BE21 BE23 BE24 BE25 BE31 DE12 DE13 DE14 DE22 DE23 DE24 DE25 DE26 DE27 DE30 DE73 DE91 DE92 DE94 DEA1 DEA2 DEA3 DEA4 DEA5 DEB1 DEB3 DEC0 DED5 DK03 DK04 ES21 ES30 FI1B FI20 HU10 IE02 ITC2 ITC4 ITH2 ITH5 ITI4 NL33 NL41 PL51 SE23 SE33 UKD6 UKI7 UKJ1 UKJ2	<b>Club 3</b> AT11 BE22 BG41 CZ06 DE40 DE72 DE80 DE93 DEB2 DED2 DED4 DEE0 DEF0 DEG0 DK05 EE00 EL30 ES22 ES23 ES24 ES51 FI19 FI1C FI1D FR23 FR42 FR51 FR61 FR62 FR71 FR82 FR83 ITC1 ITC3 ITH3 ITH4 ITI1 LT00 MT00 NL12 NL21 NL22 NL23 NL34 NL42 PL11 PL21 PL22 PL41 PL63 PT17 RO22 RO42 SE12 SE21 SE22 SE31 SE32 SI04 SK02 UKD1 UKE2 UKF2 UKG1 UKH1 UKH2 UKJ3 UKK1 UKM2
<b>Club 4</b> BE32 BE33 BE35 CZ02 CZ03 CZ05 CZ07 CZ08 DK02 ES53 FR21 FR24 FR25 FR26 FR30 FR52 FR53 FR72 HU22 ITF1 ITI3 LV00 NL13 PL31 PL32 PL34 PL42 PL43 PL52 PL61 RO11 RO12 RO31 SK03 UKD3 UKE4 UKF1 UKH3 UKI6 UKJ4 UKK2 UKL2 UKM3 UKM6	<b>Club 5</b> BE34 ES11 ES41 FR22 FR81 IE01 ITI2 PL33 PL62 RO41 SK04 UKC2 UKF3 UKG3 UKK4	<b>Club 6</b> CY00 ES12 ES13 ES52 FR41 FR43 FR63 HR04 HU21 PT15 UKD4 UKD7 UKE1 UKG2 UKI5 UKK3 UKN0
<b>Club 7</b> CZ04 EL42 ES62 ES63 ITF5 ITG2 PT11 RO21 SI03 UKC1 UKE3	<b>Club 8</b> BG33 BG34 EL53 EL62 EL64 ES42 ES43 ES61 ES64 HR03 HU33 ITF2 ITF3 ITF4 ITF6 ITG1 PT16 PT18 UKL1	<b>Club 9</b> BG31 BG32 BG42 EL41 EL43 EL52 EL63 EL65 HU23 HU31 HU32
<b>Club 10</b> EL51 EL54 EL61		

**Divergent:** UKI3 LU00

*Note:* see Table S1 in the supplemental material for list of regions.



**Table A4** Variables description

	<b>Variables</b>	<b>Definition</b>	<b>Period</b>	<b>Source</b>
Country and regional level	Population density	Average population per square kilometre	2000-2015	Eurostat
	Human capital	Percentage of people aged 25-64 with Upper secondary, post-secondary non-tertiary and tertiary education (ISCED levels 3-8)	2000-2015	Eurostat
	Investments in R&D	Intramural R&D expenditure (GERD) as a share to GDP	2000-2015	Eurostat
Regional level	Manufacturing share	Share of GVA accounted for by manufacturing sector	2000-2015	Eurostat
	Migration	Crude rate of net migration plus statistical adjustment	2000-2015	Eurostat
	Infrastructure Density	Combined index: Average of the lengths of motorways and railways divided by population and the area.	2007	Eurostat
	Accessibility by air	Total number of air transport passengers in thousand standardized by regional population size	2000-2015	Eurostat
	Quality of government	European Regional Quality of Government Index (EQI) based on different indicators (corruption, regulatory quality and impartiality)	2000-2015	Charron et al (2014) and WDI database – World Bank
Country level	Government Debt	Debt/GDP ratio	2000-2015	Eurostat
	Trade openness	(Imports + Exports)/GDP	2000-2015	Eurostat
	Rule of law	Index of rule of law based on different World Bank indicators	2000-2015	World Bank
	Financial openness	Sum of external asset and liabilities over GDP (in log)	2000-2011	Lane and Milesi-Ferretti (2007)

Note: To compute the time-varying version of the European QoG Index (EQI) we followed the approach by Charron et al (2014) using data from the WDI database of the World Bank.

**Table A5** Ordered probit models - Robustness check – Regional Level

	Full sample		Before Crisis		After Crisis	
	(1)	(2)	(3)	(4)	(5)	(6)
Population Density	0.009 (0.014)	0.210*** (0.054)	0.000 (0.000)	0.001* (0.001)	-0.000 (0.000)	0.001*** (0.000)
Human Capital	3.645*** (0.714)	4.247*** (1.026)	0.020** (0.009)	0.008 (0.018)	0.023*** (0.007)	0.021*** (0.008)
Investments in R&D	28.950*** (7.971)	26.722* (16.007)	0.225 (0.138)	0.323 (0.329)	0.348*** (0.078)	0.316* (0.163)
Manufacturing share	-10.668** (4.509)	-6.568 (6.207)	-10.809** (5.088)	-14.673** (6.980)	-23.677*** (5.839)	-23.361*** (7.612)
Net Migration rate	5.447** (2.632)	9.409** (3.765)	0.054* (0.028)	-0.005 (0.038)	0.009 (0.015)	0.021 (0.018)
Accessibility by air	0.030 (0.023)	0.004 (0.035)	0.031 (0.028)	0.038 (0.037)	0.049** (0.022)	0.012 (0.030)
Quality of Government		0.105 (0.143)		1.279*** (0.337)		0.637*** (0.133)
Observations	201	119	83	52	169	95
LR	98.89	73.24	45.94	46.77	92.34	86.79
<i>Prob&gt;chi2</i>	0.000	0.000	0.000	0.000	0.000	0.000
Pseudo R <sup>2</sup>	0.186	0.251	0.139	0.232	0.116	0.195

Note: See Table 10

**Table A6** System-GMM models – Regional level

	(1) Full sample	(2) Before crisis	(3) After Crisis	(4) Full sample	(5) Before crisis	(6) After Crisis
Per-Capita GDP (t-1)	1.348*** (0.106)	0.119 (0.531)	1.293*** (0.135)	1.277*** (0.153)	0.503 (0.397)	1.433*** (0.181)
Population Density	0.005** (0.002)	-0.022 (0.019)	0.003** (0.002)	0.026 (0.020)	-0.062 (0.099)	0.010 (0.018)
Human Capital	0.682*** (0.089)	3.545** (1.722)	0.551*** (0.101)	0.720*** (0.161)	2.335* (1.264)	0.544*** (0.106)
Investments in R&D	2.574** (1.114)	2.238 (3.668)	2.633 (1.612)	2.795** (1.145)	-1.382 (2.952)	2.885* (1.741)
Manufacturing share	-3.044*** (0.800)	-1.958*** (0.586)	-1.702 (1.223)	-1.534*** (0.516)	-2.186*** (0.731)	-0.398 (1.034)
Net Migration rate	0.040 (0.084)	0.398 (0.252)	-0.050 (0.068)	-0.233** (0.117)	0.619*** (0.176)	-0.199 (0.151)
Quality of Government				7.362*** (2.515)	11.771** (4.957)	9.930*** (3.545)
Constant	-0.016*** (0.004)	0.009 (0.026)	-0.016*** (0.006)	-0.012** (0.005)	-0.004 (0.023)	-0.008 (0.006)
Observations	2,446	894	1,552	1,551	603	948
Number of units	268	253	268	149	149	149
Hansen test	19.32	9.58	27.62	45.74	11.20	36.85
P-value Hansen test	0.081	0.214	0.010	0.000	0.191	0.000
AR(2) p-value	0.179	0.690	0.906	0.398	0.917	0.355

*Note:* We estimate a System-GMM model (Blundell and Bond, 1988). The regression equation is:  $\Delta y_{it} = \sum_{j=1}^p \alpha_j y_{i,t-j} + W_{it}\gamma + v_i + \epsilon_{it}$ , where  $y_{it}$  is the (log of) per-capita GDP and  $W_{it}$  is a vector of explanatory variables that are treated as endogenous (in our case all). Variables are demeaned in order to remove unobserved fixed effects. All regressions include different lags of the (log of) per-capita GDP in order to control for serial correlation which are not reported for brevity. The infrastructure density combined index is not included in the GMM analysis due to data constraints. Robust standard errors in parentheses. \*\*\* p<0.01, \*\* p<0.05, \* p<0.1.

**Table A7** System-GMM models – Regional Clubs

	(1) Club 1	(2) Club 2	(3) Club 3	(4) Club 4	(5) Club 5
Per-Capita GDP (t-1)	0.999 (0.891)	2.146*** (0.452)	1.398*** (0.264)	1.153*** (0.118)	1.400*** (0.344)
Population Density	0.002 (0.008)	-0.002 (0.021)	0.028 (0.052)	0.001 (0.002)	-1.996* (1.122)
Human Capital	0.076 (0.358)	0.739*** (0.265)	0.742*** (0.126)	0.688*** (0.128)	-0.058 (0.404)
Investments in R&D	0.693 (6.350)	7.141* (3.790)	3.829*** (1.251)	3.162 (2.336)	-4.655 (14.131)
Manufacturing share	-5.296 (4.289)	-13.173* (7.994)	-3.260*** (1.199)	-2.211*** (0.771)	0.882 (1.082)
Net Migration rate	0.258 (0.303)	-0.030 (0.159)	-0.124 (0.166)	0.226** (0.093)	-0.105 (0.664)
Constant	0.009 (0.042)	-0.039* (0.022)	-0.017*** (0.006)	-0.006 (0.005)	-0.008 (0.014)
Observations	186	414	633	1,106	104
Number of units	22	56	69	106	14
Hansen test	16.44	15.92	11.34	38.90	8.536
P-value Hansen test	0.172	0.195	0.500	0.001	0.742
AR(2) p-value	0.905	0.429	0.452	0.497	0.682

Note: see Table A5.

**Table A8** Ordered probit models – Country Level

	(1)	(2)	(3)	(4)	(5)
Population Density	0.325** (0.128)	0.290** (0.134)	0.317** (0.137)	0.312** (0.128)	0.316** (0.141)
Human Capital	5.957*** (2.223)	7.702*** (2.541)	8.048*** (2.750)	4.908** (2.502)	5.750** (2.615)
Investments in R&D	115.578*** (38.335)	35.127 (58.822)	90.461** (40.571)	126.648*** (41.545)	115.947*** (0.383)
Rule of Law		1.421* (0.819)			
Financial openness			0.713* (0.407)		
Government Debt				-1.038 (1.236)	
Trade openness					0.105 (0.718)
Observations	25	25	25	25	25
LR	20.89	23.98	24.12	21.61	20.91
<i>Prob&gt;chi2</i>	0.000	0.000	0.000	0.000	0.000
Pseudo R <sup>2</sup>	0.319	0.367	0.369	0.330	0.320

Note: Standard errors in parentheses. \*\*\* p<0.01, \*\* p<0.05, \* p<0.1 Data for explanatory variables in models 1-5 are average values in the period of data availability.

## Supplemental material

**Table S1** List of regions by NUTS2 codes

AT11	Burgenland (AT)	DED2	Dresden	FR81	Languedoc-Roussillon (NUTS 2013)	PT11	Norte
AT12	Niederösterreich	DED4	Chemnitz	FR82	Provence-Alpes-Côte d'Azur (NUTS 2013)	PT15	Algarve
AT13	Wien	DED5	Leipzig	FR83	Corse (NUTS 2013)	PT16	Centro (PT)
AT21	Kärnten	DEE0	Sachsen-Anhalt	HR03	Jadranska Hrvatska	PT17	Área Metropolitana de Lisboa
AT22	Steiermark	DEF0	Schleswig-Holstein	HR04	Kontinentalna Hrvatska	PT18	Alentejo
AT31	Oberösterreich	DEG0	Thüringen	HU10	Közép-Magyarország (NUTS 2013)	RO11	Nord-Vest
AT32	Salzburg	DK01	Hovedstaden	HU21	Közép-Dunántúl	RO12	Centru
AT33	Tirol	DK02	Sjælland	HU22	Nyugat-Dunántúl	RO21	Nord-Est
AT34	Vorarlberg	DK03	Syddanmark	HU23	Dél-Dunántúl	RO22	Sud-Est
BE10	Région de Bruxelles-Capitale	DK04	Midtjylland	HU31	Észak-Magyarország	RO31	Sud - Muntenia
BE21	Prov. Antwerpen	DK05	Nordjylland	HU32	Észak-Alföld	RO32	Bucuresti - Ilfov
BE22	Prov. Limburg (BE)	EE00	Eesti	HU33	Dél-Alföld	RO41	Sud-Vest Oltenia
BE23	Prov. Oost-Vlaanderen	EL30	Attiki	IE01	Border, Midland and Western (NUTS 2013)	RO42	Vest
BE24	Prov. Vlaams-Brabant	EL41	Voreio Aigaio	IE02	Southern and Eastern (NUTS 2013)	SE11	Stockholm
BE25	Prov. West-Vlaanderen	EL42	Notio Aigaio	ITC1	Piemonte	SE12	Östra Mellansverige
BE31	Prov. Brabant Wallon	EL43	Kriti	ITC2	Valle d'Aosta/Vallée d'Aoste	SE21	Småland med öarna
BE32	Prov. Hainaut	EL51	Anatoliki Makedonia, Thraki	ITC3	Liguria	SE22	Sydsverige
BE33	Prov. Liège	EL52	Kentriki Makedonia	ITC4	Lombardia	SE23	Västsverige
BE34	Prov. Luxembourg (BE)	EL53	Dytiki Makedonia	ITF1	Abruzzo	SE31	Norra Mellansverige
BE35	Prov. Namur	EL54	Ipeiros	ITF2	Molise	SE32	Mellersta Norrland
BG31	Severozapaden	EL61	Thessalia	ITF3	Campania	SE33	Övre Norrland
BG32	Severen tsentralen	EL62	Ionía Nisia	ITF4	Puglia	SI03	Vzhodna Slovenija
BG33	Severoiztochen	EL63	Dytiki Ellada	ITF5	Basilicata	SI04	Zahodna Slovenija
BG34	Yugoiztochen	EL64	Stereá Ellada	ITF6	Calabria	SK01	Bratislavský kraj
BG41	Yugozapaden	EL65	Peloponnisos	ITG1	Sicilia	SK02	Západné Slovensko
BG42	Yuzhen tsentralen	ES11	Galicia	ITG2	Sardegna	SK03	Stredné Slovensko
CY00	Kypros	ES12	Principado de Asturias	ITH1	Provincia Autonoma di Bolzano/Bozen	SK04	Východné Slovensko
CZ01	Praha	ES13	Cantabria	ITH2	Provincia Autonoma di Trento	UKC1	Tees Valley and Durham
CZ02	Střední Čechy	ES21	País Vasco	ITH3	Veneto	UKC2	Northumberland and Tyne and Wear
CZ03	Jihozápad	ES22	Comunidad Foral de Navarra	ITH4	Friuli-Venezia Giulia	UKD1	Cumbria
CZ04	Severozápad	ES23	La Rioja	ITH5	Emilia-Romagna	UKD3	Greater Manchester
CZ05	Severovýchod	ES24	Aragón	ITI1	Toscana	UKD4	Lancashire
CZ06	Jihovýchod	ES30	Comunidad de Madrid	ITI2	Umbria	UKD6	Cheshire
CZ07	Střední Morava	ES41	Castilla y León	ITI3	Marche	UKD7	Merseyside
CZ08	Moravskoslezsko	ES42	Castilla-la Mancha	ITI4	Lazio	UKF1	East Yorkshire and Northern Lincolnshire
DE11	Stuttgart	ES43	Extremadura	LT00	Lietuva (NUTS 2013)	UKF2	North Yorkshire
DE12	Karlsruhe	ES51	Cataluña	LU00	Luxembourg	UKF3	South Yorkshire
DE13	Freiburg	ES52	Comunidad Valenciana	LV00	Latvija	UKF4	West Yorkshire
DE14	Tübingen	ES53	Illes Balears	MT00	Malta	UKF5	Derbyshire and Nottinghamshire
DE21	Oberbayern	ES61	Andalucía	NL11	Groningen	UKF6	Leicestershire, Rutland and Northamptonshire
DE22	Niederbayern	ES62	Región de Murcia	NL12	Friesland (NL)	UKF7	Lincolnshire
DE23	Oberpfalz	ES63	Ciudad Autónoma de Ceuta (ES)	NL13	Drenthe	UKG1	Herefordshire, Worcestershire and Warwickshire
DE24	Oberfranken	ES64	Ciudad Autónoma de Melilla (ES)	NL21	Overijssel	UKG2	Shropshire and Staffordshire

DE25	Mittelfranken	FI19	Länsi-Suomi	NL22	Gelderland	UKG3	West Midlands
DE26	Unterfranken	FI1B	Helsinki-Uusimaa	NL23	Flevoland	UKH1	East Anglia
DE27	Schwaben	FI1C	Etelä-Suomi	NL31	Utrecht	UKH2	Bedfordshire and Hertfordshire
DE30	Berlin	FI1D	Pohjois- ja Itä-Suomi	NL32	Noord-Holland	UKH3	Essex

**Table S1 (continued)** List of regions by NUTS2 codes

DE40	Brandenburg	FI20	Åland	NL33	Zuid-Holland	UKI3	Inner London - West
DE50	Bremen	FR10	Île de France	NL34	Zeeland	UKI4	Inner London - East
DE60	Hamburg	FR21	Champagne-Ardenne (NUTS 2013)	NL41	Noord-Brabant	UKI5	Outer London - East and North East
DE71	Darmstadt	FR22	Picardie (NUTS 2013)	NL42	Limburg (NL)	UKI6	Outer London - South
DE72	Gießen	FR23	Haute-Normandie (NUTS 2013)	PL11	Łódzkie (NUTS 2013)	UKI7	Outer London - West and North West
DE73	Kassel	FR24	Centre (FR) (NUTS 2013)	PL12	Mazowieckie (NUTS 2013)	UKJ1	Berkshire, Buckinghamshire and Oxfordshire
DE80	Mecklenburg-Vorpommern	FR25	Basse-Normandie (NUTS 2013)	PL21	Malopolskie	UKJ2	Surrey, East and West Sussex
DE91	Braunschweig	FR26	Bourgogne (NUTS 2013)	PL22	Slaskie	UKJ3	Hampshire and Isle of Wight
DE92	Hannover	FR30	Nord - Pas-de-Calais (NUTS 2013)	PL31	Lubelskie (NUTS 2013)	UKJ4	Kent
DE93	Lüneburg	FR41	Lorraine (NUTS 2013)	PL32	Podkarpackie (NUTS 2013)	UKK1	Gloucestershire, Wiltshire and Bristol/Bath area
DE94	Weser-Ems	FR42	Alsace (NUTS 2013)	PL33	Swietokrzyskie (NUTS 2013)	UKK2	Dorset and Somerset
DEA1	Düsseldorf	FR43	Franche-Comté (NUTS 2013)	PL34	Podlaskie (NUTS 2013)	UKK3	Cornwall and Isles of Scilly
DEA2	Köln	FR51	Pays de la Loire (NUTS 2013)	PL41	Wielkopolskie	UKK4	Devon
DEA3	Münster	FR52	Bretagne (NUTS 2013)	PL42	Zachodniopomorskie	UKL1	West Wales and The Valleys
DEA4	Detmold	FR53	Poitou-Charentes (NUTS 2013)	PL43	Lubuskie	UKL2	East Wales
DEA5	Arnsberg	FR61	Aquitaine (NUTS 2013)	PL51	Dolnoslaskie	UKM2	Eastern Scotland (NUTS 2013)
DEB1	Koblenz	FR62	Midi-Pyrénées (NUTS 2013)	PL52	Opolskie	UKM3	South Western Scotland (NUTS 2013)
DEB2	Trier	FR63	Limousin (NUTS 2013)	PL61	Kujawsko-Pomorskie	UKM5	North Eastern Scotland
DEB3	Rheinhessen-Pfalz	FR71	Rhône-Alpes (NUTS 2013)	PL62	Warminsko-Mazurskie	UKM6	Highlands and Islands
DEC0	Saarland	FR72	Auvergne (NUTS 2013)	PL63	Pomorskie	UKN0	Northern Ireland (UK)

<sup>1</sup> For *sigma*, conditional and unconditional *beta* convergence see, for example, Sala-i-Martin (1996).

<sup>2</sup> Data constraints at the regional level prevented us to use a larger time sample since comparable data for the broad sample of regions belonging to EU-28 starts in 2000.

<sup>3</sup> To this regard, PS suggest to use  $r = [0.2, 0.3]$  for small sample size ( $T < 50$ ). This values are suggested as a result of Monte Carlo simulations. For more details, see Phillips and Sul (2007; 2009).

<sup>4</sup> PS suggest to set  $c^* = 0$ .

<sup>5</sup> For additional details see also Phillips and Sul (2009), von Lyncker and Thoennessen (2017) and Sichera and Pizzuto (2019).

<sup>6</sup> The t-value is -15.56. As suggested by Phillips and Sul (2007; 2009) log-*t* tests have been performed on time series filtered for business cycle fluctuations with the Hodrick-Prescott (HP) filter, choosing the value of 6.25 as a smoothing parameter, in accordance with the literature in this field (Borsi and Metiu 2015; von

---

Lyncker and Thoennessen 2017). At the same time, robustness checks with unfiltered series and different values of the critical value  $c^*$  have been performed and are available from the authors upon request. Also in these cases conclusions are very similar and broadly unchanged with respect to those reported in the paper.

<sup>7</sup> The beta values for this exercise are the following (t-stats in parentheses): Club 1 [lower 12] + Club 2 [upper 28] = -0.02 (-0.42); Club 2 [lower 28] + Club 3 [upper 33] = 0.10 (1.07); Club 3 [lower 36] + Club 4 [upper 52] = 0.53 (5.96); Club 4 [lower 54] + Club 5 [upper 7] = 0.42 (4.23).

<sup>8</sup> The composition of each club by NUTS 2 codes is shown in Table A3 in the Appendix whereas the complete list of regions is shown in the supplemental material.

<sup>9</sup> The t-value is -22.41.

<sup>10</sup> In this case, the VLT algorithm has the advantage to include Italy and Finland in the bottom club thus reducing the case of divergence to one.

<sup>11</sup> We performed a sensitivity analysis considering only regions and countries belonging to the Euro Area. Conclusions obtained in this and previous sections are confirmed and appear not to be driven by the inclusion (exclusion) of the Eastern European countries and regions. Results are available from the authors upon request.

<sup>12</sup> Using the gross fixed capital formation instead of investments in R&D we obtain very similar results to those presented in the paper.

<sup>13</sup> Robustness checks performed using a measure of accessibility by air at the NUTS 2 level instead of the index of infrastructure density (Table A5), suggest very similar and broadly unchanged overall results with respect to previous findings, although this measure appears to contribute in explaining club membership only after the Great Recession.

<sup>14</sup> Results for quality of government should be interpreted with some caution since data are not available at the regional level for a number of countries (i.e. Belgium, Germany, Greece, Sweden, United Kingdom). They are provided at NUTS 1 level instead of NUTS 2 level.

<sup>15</sup> We do not include Quality of Government in this exercise due to data constraints. Estimations for top and bottom clubs may suffer from the reduced number of observations.

<sup>16</sup> We performed only probit models, due to the limitation of the sample at the country level.