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Heterogeneity of Regional Growth in the European Union

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Abstract

This paper uses model-based recursive partitioning to study economic growth in the 255 European Union NUTS2 regions over the period 1995–2005. The starting point of the analysis is a human-capital augmented Solow-type growth equation similar in spirit to Mankiw *et al.* (1992). Initial GDP and the share of highly educated in the working age population are found to be important for explaining economic growth, whereas the investment share in physical capital is only significant for coastal regions in the PIIGS countries. Recursive partitioning leads to a regression tree with four terminal nodes with partitioning according to (i) capital regions, (ii) non-capital regions in or outside the so-called PIIGS countries and (iii) inside the respective PIIGS regions furthermore between coastal and non-coastal regions.

Keywords: convergence, growth regressions, recursive partitioning, regional data.
JEL classification: C31, C51, O18, O47.

1. Introduction

The econometric analysis of the determinants of economic growth and of potential convergence of output across countries or regions has been a major research topic in economics in the last decades. Early empirical contributions include Baumol (1986), Barro (1991) or Barro and Sala-i-Martin (1992). Since then in numerous studies – that employ a broad variety of methods – a large number of potential explanatory variables has been considered, for an overview see Durlauf *et al.* (2005).

Given the open-endedness of economic growth theories, in the words of Brock and Durlauf (2001), a key question is to determine, out of an often large set of candidate variables, the variables relevant for economic growth. To address this uncertainty many contributions have applied some form of model averaging, be it Bayesian (e.g., Fernandez *et al.* 2001) pseudo-Bayesian (e.g., Sala-i-Martin *et al.* 2004) or frequentist (e.g., Wagner and Hlouskova 2009; Hlouskova and Wagner 2010). The latter two papers combine model averaging techniques with principal components augmentation to achieve regularization and complexity reduction. Schneider and Wagner (2012) use the adaptive LASSO estimator, that simultaneously performs model selection and parameter estimation, to single out the determinants of economic growth in the regions of the European Union.

All the mentioned contributions assume, however, that the relationship between economic growth and the explanatory variables is identical for all considered countries or regions. This assumption is clearly restrictive since there is a large theoretical literature that implies that growth processes across countries or regions are not necessarily governed by a common linear relationship, compare Azariadis and Drazen (1990); Durlauf (1993) and Murphy *et al.* (1989). These models highlight different mechanisms that may lead to potential nonlinearities in growth processes, e.g., poverty traps or convergence clubs. Furthermore, the usually considered data sets that comprise very heterogeneous countries or regions make the assumption of a common growth process, even when controlling for a variety of variables, at least worth investigating.

The present paper assesses the homogeneity of the growth process by using model-based recursive partitioning to study the growth determinants for a data set covering the 255 NUTS2 regions of the European Union over the period 1995–2005 (see Section 2 for details on the data). Partitioning of growth regressions to uncover multiple regimes has been considered previously in Durlauf and Johnson (1995) using data similar to those of Barro (1991). They employ a recursive partitioning algorithm that combines the classic classification and regression tree (CART) approach of Breiman *et al.* (1984) with residual sums of squares from growth regressions. However, while that approach lacks a concept of (asymptotic) significance of the regimes found, we use a modern model-based extension of the classic recursive partitioning approaches suggested by Zeileis *et al.* (2008) based on formal (score-based) parameter stability tests. More specifically, in each step of the partitioning, a linear growth regression is first estimated and then the stability of its parameters is assessed along all partitioning variables using the supLM test of Andrews (1993) for numerical variables and a score-based χ^2 test for categorical variables (see Hjort and Koning 2002 and Zeileis 2005 for a unifying view on these parameter stability tests). Moreover we apply a Bonferroni-type correction to the parameter stability tests in order to correct for size distortions arising from multiple testing (over the different partitioning variables).

2. Data

The data used in this paper are (a subset of the variables) used in Schneider and Wagner (2012), see Table 1 for a list. The regional dataset covers the 255 NUTS2 regions in the 27 member countries of the European Union over the period 1995–2005. We use here only a subset of the variables available in this dataset, with the choice being driven by the following considerations. First, as the basis of our model-based recursive partitioning we take a simple, economically interpretable relationship. Secondly, as partitioning variables we consider variables according to which partitioning and heterogeneity appears to be a potential issue, given growth theory and the institutional and historical characteristics

Type	Name	Description
Dependent	ggdpcap	Average annual growth rate of real GDP per capita over the period 1995–2005
Regressor	gdpcap0	Real GDP per capita in logs in 1995
	shgfcf	Share of gross fixed capital formation in gross value added
	shsh	Share of highly educated in working age population
	shsm	Share of medium educated in working age population
Partitioning	accessrail	Measure for potential accessability by rail
	accessroad	Measure for potential accessability by road
	capital	Dummy variable for the 27 capital regions
	regborder	Dummy variable for the 136 border regions
	regcoast	Dummy variable for the 118 coastal regions
	regobj1	Dummy variable for the 104 Objective 1 regions eligible for EU structural funds
	cee	Dummy variable for the 53 regions in the Central and Eastern European countries
	piigs	Dummy variable for the 57 regions in Portugal, Ireland, Italy, Greece and Spain

Table 1: List of variables. For a more detailed description including the sources see Schneider and Wagner (2012). The variable gdpcap0 is used not only as regressor but also as partitioning variable.

present in the European Union. Third, the number of partitioning variables is limited by the need for having a sufficient set of observations in each (terminal) node. Fourth, we build on the analysis to a certain extent on the findings of Wagner and Hlouskova (2009) and Schneider and Wagner (2012).

The dependent variable is the average growth rate of real GDP per capita (ggdpcap) and the explanatory variables are initial real GDP per capita in logs (gdpcap0) to capture potential β-convergence, the investment share in GDP (shgfcf) to capture physical capital accumulation and the shares of high and of medium educated in the labor force (shsh and shsm) as measures of human capital. Thus, in effect we estimate a human capital augmented version of the Solow model, not dissimilar in spirit to the by now classical work of Mankiw *et al.* (1992). We employ the following partitioning variables:[1] First, we use the log of initial real GDP per capita as a partitioning variable as a simple device to check for the presence of convergence clubs. We use two measures for traffic accessibility of the region, one for accessibility via rail (accessrail) and one via the road network (accessroad). Clearly, integration in the European traffic networks is beneficial for trade and thus for

[1] The choice of partitioning variables is on the one hand inspired by the findings of Schneider and Wagner (2012) and on the other hand intended to capture some main factors that may be expected to segregate the growth performance. Altogether it has to be noted, however, that at the regional level the availability of core economic data is still relatively limited.

economic development and growth. While these three variables are numeric the other partitioning variables are dummy variables. The dummy variable for capital regions (capital) has been found significant in Schneider and Wagner (2012), in line with the large literature on core-periphery effects in new economic geography models (compare Fujita *et al.*, 1999). We also consider dummy variables for border regions (regborder) and coastal regions (regcoast). Both of these variables are again related to trade (and its impact on economic growth). Since the seminal study of McCallum (1995) that has studied the detrimental effect of national borders on trade in North America such border effects have been found important in many empirical trade studies. Matters are ex ante less clear with respect to coastal regions since these are faced on the one hand with a 'border' with the sea but are for exactly that reason on the other hand the locations of ports and are from this perspective expected to benefit from both EU imports and exports as well as from infrastructure investments. A key tool of EU policy is to foster regional development via its structural funds, with the prime recipients of such funds being the so-called Objective 1 regions (regobj1). We include the corresponding dummy variable to assess the potential effects of EU structural funds on the regional growth performance. Finally, we include two dummy variables corresponding to two different groups of countries. One is a CEE dummy for 10 Central and Eastern European countries (i.e. Bulgaria, Czech Republic, Estonia, Hungary, Lithuania, Latvia, Poland, Romania, Slovak Republic and Slovenia) and the other is for the so-called PIIGS countries (Portugal, Ireland, Italy, Greece and Spain). The former group comprises previously centrally planned economies that have joined the EU at the very end (May 1, 2004) or even after the sample period (January 1, 2007 in case of Bulgaria and Romania). Against this background (central planning legacy, recent EU membership) it sounds reasonable to at least check for whether the regions in these countries have experienced a different growth performance. The latter group comprises Southern or Western peripheral countries that are in crisis now. These are considered separately in order to see whether the growth performance in these regions has been different already prior to the crisis.

3. Results

The results of the parameter stability tests are displayed in Table 2. The results show that the regression tree is spanned (when the significance level is chosen to be 5%) with 3 partitioning variables (capital, piigs and regcoast) and 4 terminal nodes, see Figure 1 for a visualization. According to these results capital regions indeed exhibit a different growth performance, as is true also for the PIIGS regions as well as coastal regions within the PIIGS countries. Note, however, that in the first block-row of Table 2 also for 4 more variables the null hypothesis of parameter stability is rejected at the 5% level (with p-values higher than that of capital). These are initial GDP, the 2 accessibility measures and the CEE dummy. Thus, viewed in isolation there is indeed evidence for heterogeneity along these variables. Nevertheless, after partitioning according to capital, none of these variables reappears as a variable indicating associated heterogeneity. E.g. the finding with respect to the CEE

	gdpcap0 (num)	accessrail (num)	accessroad (num)	capital (bin)	regborder (bin)	regcoast (bin)	regobj1 (bin)	cee (bin)	piigs (bin)
1	25.467	27.513	29.840	73.495	3.968	13.507	7.189	23.381	10.358
	0.030	0.012	0.004	< 0.001	0.999	0.159	0.876	0.003	0.457
2	21.241	20.087	20.687	–	7.547	9.846	5.075	11.112	19.779
	0.141	0.211	0.171	–	0.802	0.485	0.985	0.332	0.011
3	22.311	22.640	19.480	–	9.248	7.945	6.531	8.247	–
	0.082	0.073	0.229	–	0.520	0.703	0.876	0.661	–
4	6.608	10.155	10.150	–	8.556	17.039	3.076	–	–
	1.000	0.965	0.965	–	0.561	0.027	0.999	–	–
5	–	–	–	–	–	–	–	–	–
	–	–	–	–	–	–	–	–	–
6	7.392	6.452	8.781	–	5.836	–	3.280	–	–
	0.994	0.999	0.963	–	0.857	–	0.995	–	–
7	6.962	3.789	3.425	–	2.040	4.065	4.766	9.389	7.937
	0.991	1.000	1.000	–	1.000	0.998	0.991	0.548	0.752

Table 2: Parameter stability tests (test statistic and p value) for all partitioning variables in each of the tree's nodes. For numerical variables the Andrews (1993) supLM test is used and for categorical variables a score-based χ^2 test.

dummy, not being significant as partitioning variable after partitioning according to the capital region dummy, is in line with the fact that for many of the CEE countries the bulk of growth has occurred in the capital region. After separating the sample between capital and non-capital regions there is no evidence for initial income driven convergence clubs at the 5% significance level. Note, however, that in the terminal node of non-capital non-PIIGS regions that comprises a bulk of 176 regions there is some evidence for parameter instability at the 10% level. This can also be seen in the lower left graph of Figure 1 where a 'blurred' separation in two clusters – grouped according to initial output – is visible. Thus, at the 10% significance level there is evidence for two initial GDP driven convergence clubs in the non-capital non-PIIGS regions.[2]

There is no evidence for border effects in the sense of differing growth performance of border regions. This result can be tentatively interpreted as indicating that the European common market policies have been successful in removing trade barriers across EU member states. On the other hand it also appears that being an Objective 1 region does not lead to a differential growth process, which is in line with some of the literature that finds hardly any growth promoting effect of EU structural funds, for an early assessment see Canova and Marcet (1997).

[2] At the 10% significance level there is also evidence against parameter stability in this set of regions when partitioning according to accessrail (in addition to the discussed instability with respect to initial GDP). If one were to enforce a split according to the logarithm of initial real GDP per capita, the split point is 9.712. The estimation results between the corresponding two subsets differ substantially in that only in the high initial income regions gross fixed capital formation and the share of highly educated in the labor force are significant with positive coefficients.

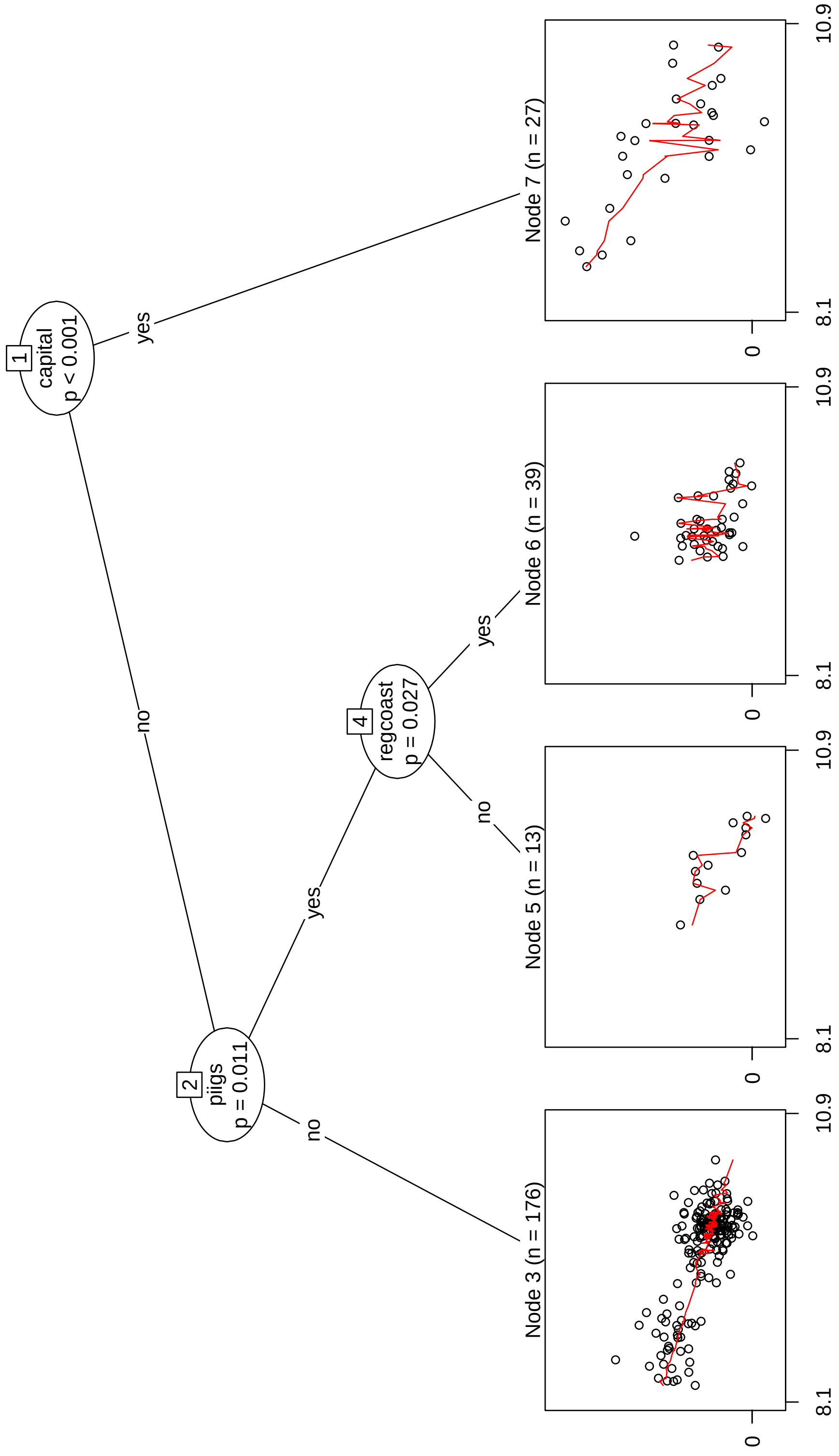

Figure 1: Fitted linear regression tree. In the inner nodes the p values from the parameter stability tests are displayed and in terminal nodes a scatter plot of GDP growth (ggdpcap) vs. initial output (ggdcap0) along with fitted values is depicted.

	Summary		Partitioning variables			Regressor variables				
	n	R^2	capital	piigs	regcoast	(Const.)	gdpcap0	shgfcf	shsh	shsm
3	176	0.505	no	no	–	0.166	−0.0159	−0.0030	0.024	0.0070
						(0.013)	(0.0014)	(0.0071)	(0.010)	(0.0063)
5	13	0.923	no	yes	no	0.199	−0.0186	−0.0379	0.090	−0.0195
						(0.067)	(0.0071)	(0.0426)	(0.031)	(0.0345)
6	39	0.560	no	yes	yes	0.120	−0.0139	0.0840	0.121	0.0089
						(0.054)	(0.0056)	(0.0401)	(0.028)	(0.0208)
7	27	0.620	yes	–	–	0.240	−0.0242	−0.0034	0.045	0.0563
						(0.063)	(0.0058)	(0.0527)	(0.041)	(0.0238)

Table 3: Fitted linear regression models for terminal nodes in the tree. Summary information (number of observations n and R^2), the partitioning variables selected and regression coefficients (with standard errors in brackets) are provided.

The second partitioning occurs with respect to the PIIGS dummy within the non-capital regions and the third with respect to coastal regions within the non-capital PIIGS regions. A graphical illustration of the regression tree is given by Figure 1.

Let us now turn to the regression results given in Table 3. The table shows the results for the 4 terminal nodes shown also in Figure 1. In all 4 sets of regions partitioned the coefficient to (log) initial real GDP per capita is negative, with the largest negative coefficient (and thus the highest associated conditional β-convergence speed) obtained for the 27 capital regions. The lowest convergence speed prevails for the coastal regions in the PIIGS countries, in line with the above discussion concerning the versatile border and trade effects experienced by capital regions. Whilst the impact of highly skilled in the working age population on growth is ubiquitously positive, it is negative (albeit not significant) for the 13 regions in the PIIGS countries that are not coastal. Surprisingly the investment share has a negative coefficient for all but the coastal PIIGS regions. However, it is only significant for this latter of the 4 groups of regions. Thus, in effect initial GDP and the share of highly skilled in the working age population are the two variables that are significant for all 4 groups of regions with coefficient signs as expected from economic theory.

4. Summary

The paper demonstrates that the growth process in the 255 NUTS2 regions of the European Union is heterogeneous across different groups of regions. Loosening up the constraint of a homogenous linear growth equation for all regions lead to a good description of the growth process by a simple human capital augmented Solow-type equation in the spirit of Mankiw *et al.* (1992). The model-based recursive partitioning procedure singles out being a capital region as most important partitioning variable, for which the null hypothesis of parameter stability is rejected with smaller p-value than for initial real GDP per capita, accessibility measures or the CEE dummy variable. Amongst the non-capital regions partitioning occurs according to whether the region is in a so-called PIIGS country and within those whether it is a coastal region or not. The coastal regions in the PIIGS countries have the lowest conditional β-convergence speed. The results indicate that allowing for heterogeneity in cross-country or regional growth studies may be an important but often neglected aspect.

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