

Wagner, Martin; Zeileis, Achim

Working Paper

Heterogeneity of Regional Growth in the European Union

Working Papers in Economics and Statistics, No. 2012-20

Provided in Cooperation with:

Institute of Public Finance, University of Innsbruck

Suggested Citation: Wagner, Martin; Zeileis, Achim (2012) : Heterogeneity of Regional Growth in the European Union, Working Papers in Economics and Statistics, No. 2012-20, University of Innsbruck, Research Platform Empirical and Experimental Economics (eeecon), Innsbruck

This Version is available at:

<https://hdl.handle.net/10419/73886>

Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

Terms of use:

Documents in EconStor may be saved and copied for your personal and scholarly purposes.

You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.

If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.

Heterogeneity of regional growth in the European Union

Martin Wagner, Achim Zeileis

Working Papers in Economics and Statistics

2012-20

University of Innsbruck
Working Papers in Economics and Statistics

The series is jointly edited and published by

- Department of Economics
- Department of Public Finance
- Department of Statistics

Contact Address:
University of Innsbruck
Department of Public Finance
Universitaetsstrasse 15
A-6020 Innsbruck
Austria
Tel: + 43 512 507 7171
Fax: + 43 512 507 2970
E-mail: eeecon@uibk.ac.at

The most recent version of all working papers can be downloaded at
<http://eeecon.uibk.ac.at/wopec/>

For a list of recent papers see the backpages of this paper.

Heterogeneity of Regional Growth in the European Union

Martin Wagner

University of Graz

Frisch Centre for Economic Research, Oslo

Achim Zeileis

University of Innsbruck

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 sup LM 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 accessibility by rail
	accessroad	Measure for potential accessibility 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

¹The 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) sup LM 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 \(1997\)](#).

²At 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.

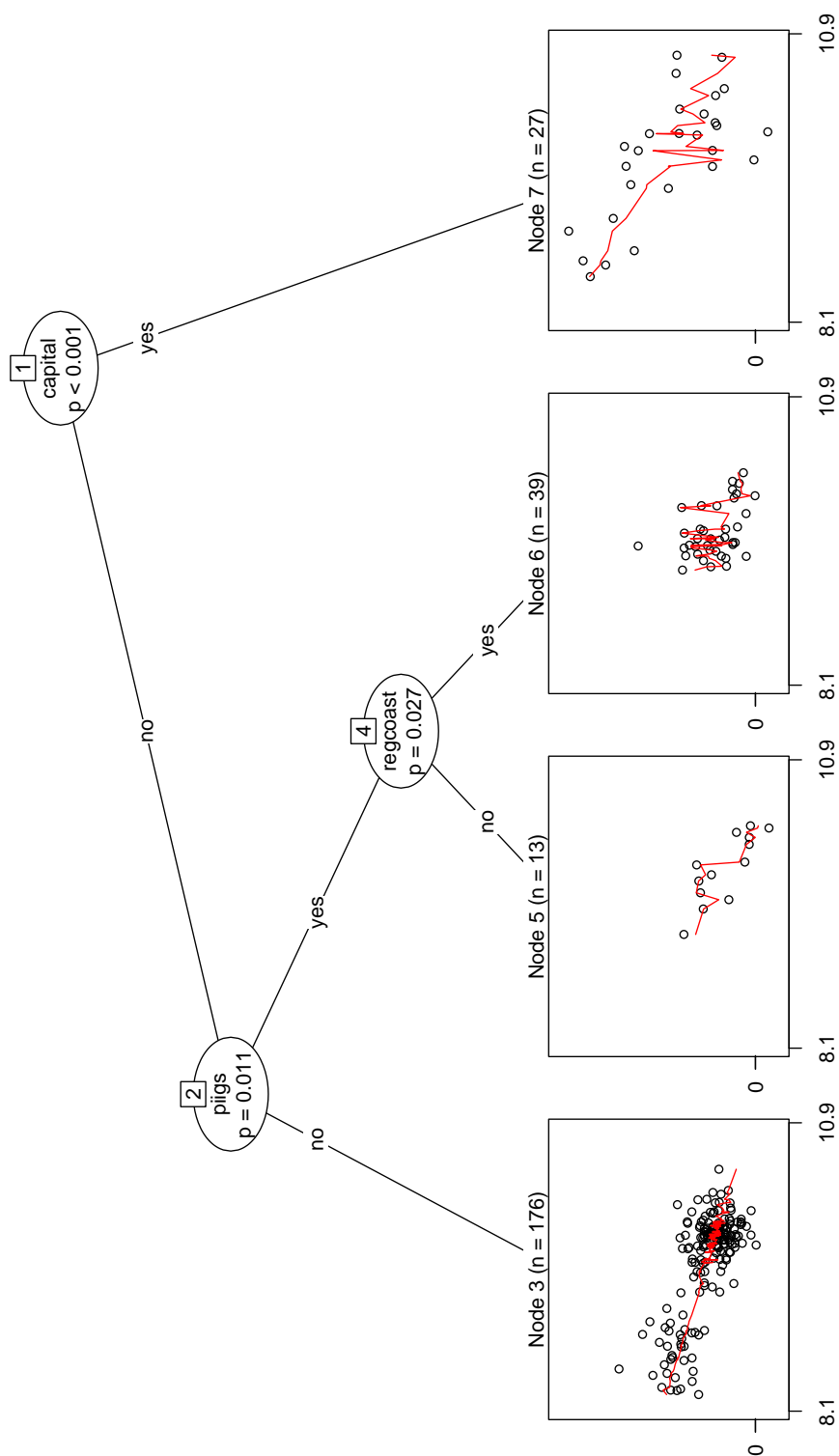


Figure 1: Fitted linear regression tree. In the inner nodes the p values from the parameter stability tests are displayed and in terminal nodes a scatter plot of GDP growth (`ggdpcap`) vs. initial output (`ggdcap0`) along with fitted values is depicted.

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

References

- Andrews, D.W.K. (1993), Tests for Parameter Stability and Structural Change with Unknown Change Point, *Econometrica* **61**, 821–856.
- Azariadis, C. and A. Drazen (1990), Threshold Externalities in Economic Development, *Quarterly Journal of Economics* **105**, 501–526.
- Barro, R.J. (1991), Economic Growth in a Cross-Section of Countries, *Quarterly Journal of Economics* **106**, 407–445.
- Barro, R.J. and X. Sala-i-Martin (1992), Convergence, *Journal of Political Economy* **100**, 223–251.
- Baumol, W.J. (1986), Productivity Growth, Convergence and Welfare: What the Long Run Data Show, *American Economic Review* **76**, 1072–1085.
- Breiman, L., Friedman, J.L., Olshen, R.A. and C.J. Stone (1984), *Classification and Regression Trees*, Wadsworth, Belmont.
- Brock, W.A. and S.N. Durlauf (2001), Growth Empirics and Reality, *World Bank Economic Review* **15**, 229–272.
- Canova, F. and A. Marcet (1997), The Poor Stay Poor: Non-Convergence Across Countries and Regions. *Mimeo*.
- Durlauf, S.N. (1993), Nonergodic Economic Growth, *Review of Economic Studies* **60**, 349–366.
- Durlauf, S.N. and P.A. Johnson (1995), Multiple Regimes and Cross-Country Growth Behavior, *Journal of Applied Econometrics* **10**, 365–384.
- Durlauf, S.N., Johnson, P.A. and J.R.W. Temple (2005), Growth Econometrics, in Aghion, P. and S.N. Durlauf (eds.) *Handbook of Economic Growth, Vol. 1A*, Ch.8. Elsevier.
- Fernandez, C., Ley, E. and M.F.J. Steel (2001), Model Uncertainty in Cross-Country Growth Regressions, *Journal of Applied Econometrics* **16**, 563–576.
- Fujita, M., Krugman, P. and A.J. Venables (1999). *The Spatial Economy: Cities, Regions and International Trade*. MIT Press.

- Hlouskova, J. and M. Wagner (2010), The Determinants of Long-Run Economic Growth: A Conceptually and Computationally Simple Approach, *Mimeo*.
- Hjort, N.L. and A. Koning (2002), Tests for Constancy of Model Parameters over Time, *Nonparametric Statistics* **14**, 113–132.
- McCallum, J. (1995), National Borders Matter: Canada-US Regional Trade Patterns, *American Economic Review* **85**, 615–623.
- Mankiw, N.G., Romer, D. and D.N. Weil (1992), A Contribution to the Empirics of Economic Growth, *Quarterly Journal of Economics* **107**, 407–437.
- Murphy, K., Shleifer, A. and R. Vishny (1989), Industrialization and the Big Push, *Journal of Political Economy* **97**, 1003–1026.
- Sala-i-Martin, X., Doppelhofer, G. and R.I. Miller (2004), Determinants of Long-Term Growth: A Bayesian Averaging of Classical Estimates (BACE) Approach, *American Economic Review* **94**, 813–835.
- Schneider, U. and M. Wagner (2012), Catching Growth Determinants with the Adaptive LASSO, *German Economic Review* **13**, 71–85.
- Wagner, M. and J. Hlouskova (2009), Growth Regressions, Principal Components and Frequentist Model Averaging, *Mimeo*.
- Zeileis, A. (2005), A Unified Approach to Structural Change Tests Based on ML Scores, *F* Statistics, and OLS Residuals, *Econometric Reviews* **24**, 445–466.
- Zeileis, A., Hothorn, T. and K. Hornik (2008), Model-Based Recursive Partitioning, *Journal of Computational and Graphical Statistics* **17**, 492–514.

Affiliation:

Martin Wagner
Department of Economics
University of Graz
Universitätsstr. 15
8010 Graz, Austria
E-mail: Martin.Wagner@uni-graz.at

Achim Zeileis
Department of Statistics
Faculty of Economics and Statistics
University of Innsbruck

Universitätsstr. 15

6020 Innsbruck, Austria

E-mail: Achim.Zeileis@R-project.org

URL: <http://eeecon.uibk.ac.at/~zeileis/>

University of Innsbruck - Working Papers in Economics and Statistics
Recent Papers can be accessed on the following webpage:

<http://eeecon.uibk.ac.at/wopec/>

- 2012-20 **Martin Wagner, Achim Zeileis:** Heterogeneity of regional growth in the European Union
- 2012-19 **Natalia Montinari, Antonio Nicolo, Regine Oexl:** Mediocrity and induced reciprocity
- 2012-18 **Esther Blanco, Javier Lozano:** Evolutionary success and failure of wildlife conservancy programs
- 2012-17 **Ronald Peeters, Marc Vorsatz, Markus Walzl:** Beliefs and truth-telling: A laboratory experiment
- 2012-16 **Alexander Sebald, Markus Walzl:** Optimal contracts based on subjective evaluations and reciprocity
- 2012-15 **Alexander Sebald, Markus Walzl:** Subjective performance evaluations and reciprocity in principal-agent relations
- 2012-14 **Elisabeth Christen:** Time zones matter: The impact of distance and time zones on services trade
- 2012-13 **Elisabeth Christen, Joseph Francois, Bernard Hoekman:** CGE modeling of market access in services
- 2012-12 **Loukas Balafoutas, Nikos Nikiforakis:** Norm enforcement in the city: A natural field experiment *forthcoming in European Economic Review*
- 2012-11 **Dominik Erharder:** Credence goods markets, distributional preferences and the role of institutions
- 2012-10 **Nikolaus Umlauf, Daniel Adler, Thomas Kneib, Stefan Lang, Achim Zeileis:** Structured additive regression models: An R interface to BayesX
- 2012-09 **Achim Zeileis, Christoph Leitner, Kurt Hornik:** History repeating: Spain beats Germany in the EURO 2012 Final
- 2012-08 **Loukas Balafoutas, Glenn Dutcher, Florian Lindner, Dmitry Ryvkin:** To reward the best or to punish the worst? A comparison of two tournament mechanisms with heterogeneous agents
- 2012-07 **Stefan Lang, Nikolaus Umlauf, Peter Wechselberger, Kenneth Harttgen, Thomas Kneib:** Multilevel structured additive regression

- 2012-06 **Elisabeth Waldmann, Thomas Kneib, Yu Ryan Yu, Stefan Lang:** Bayesian semiparametric additive quantile regression
- 2012-05 **Eric Mayer, Sebastian Rueth, Johann Scharler:** Government debt, inflation dynamics and the transmission of fiscal policy shocks
- 2012-04 **Markus Leibrecht, Johann Scharler:** Government size and business cycle volatility; How important are credit constraints?
- 2012-03 **Uwe Dulleck, David Johnston, Rudolf Kerschbamer, Matthias Sutter:** The good, the bad and the naive: Do fair prices signal good types or do they induce good behaviour?
- 2012-02 **Martin G. Kocher, Wolfgang J. Luhan, Matthias Sutter:** Testing a forgotten aspect of Akerlof's gift exchange hypothesis: Relational contracts with individual and uniform wages
- 2012-01 **Loukas Balafoutas, Florian Lindner, Matthias Sutter:** Sabotage in tournaments: Evidence from a natural experiment *forthcoming in Kyklos*
- 2011-29 **Glenn Dutcher:** How Does the Social Distance Between an Employee and a Manager affect Employee Competition for a Reward?
- 2011-28 **Ronald Peeters, Marc Vorsatz, Markus Walzl:** Truth, trust, and sanctions: On institutional selection in sender-receiver games *published in Scandinavian Journal of Economics*
- 2011-27 **Haoran He, Peter Martinsson, Matthias Sutter:** Group Decision Making Under Risk: An Experiment with Student Couples *forthcoming in Economics Letters*
- 2011-26 **Andreas Exenberger, Andreas Pondorfer:** Rain, temperature and agricultural production: The impact of climate change in Sub-Sahara Africa, 1961-2009
- 2011-25 **Nikolaus Umlauf, Georg Mayr, Jakob Messner, Achim Zeileis:** Why Does It Always Rain on Me? A Spatio-Temporal Analysis of Precipitation in Austria *forthcoming in Austrian Journal of Statistics*
- 2011-24 **Matthias Bank, Alexander Kupfer, Rupert Sendlhofer:** Performance-sensitive government bonds - A new proposal for sustainable sovereign debt management
- 2011-23 **Gerhard Reitschuler, Rupert Sendlhofer:** Fiscal policy, trigger points and interest rates: Additional evidence from the U.S.
- 2011-22 **Bettina Grün, Ioannis Kosmidis, Achim Zeileis:** Extended beta regression in R: Shaken, stirred, mixed, and partitioned *published in Journal of Statistical Software*

- 2011-21 **Hannah Frick, Carolin Strobl, Friedrich Leisch, Achim Zeileis:** Flexible Rasch mixture models with package psychomix *published in Journal of Statistical Software*
- 2011-20 **Thomas Grubinger, Achim Zeileis, Karl-Peter Pfeiffer:** evtree: Evolutionary learning of globally optimal classification and regression trees in R
- 2011-19 **Wolfgang Rinnergschwentner, Gottfried Tappeiner, Janette Walde:** Multivariate stochastic volatility via wishart processes - A continuation
- 2011-18 **Jan Verbesselt, Achim Zeileis, Martin Herold:** Near Real-Time Disturbance Detection in Terrestrial Ecosystems Using Satellite Image Time Series: Drought Detection in Somalia *forthcoming in Remote Sensing and Environment*
- 2011-17 **Stefan Borsky, Andrea Leiter, Michael Pfaffermayr:** Does going green pay off? The effect of an international environmental agreement on tropical timber trade
- 2011-16 **Pavlo Blavatskyk:** Stronger Utility
- 2011-15 **Anita Gantner, Wolfgang Höchtl, Rupert Sausgruber:** The pivotal mechanism revisited: Some evidence on group manipulation *revised version with authors Francesco Feri, Anita Gantner, Wolfgang Höchtl and Rupert Sausgruber forthcoming in Experimental Economics*
- 2011-14 **David J. Cooper, Matthias Sutter:** Role selection and team performance
- 2011-13 **Wolfgang Höchtl, Rupert Sausgruber, Jean-Robert Tyran:** Inequality aversion and voting on redistribution
- 2011-12 **Thomas Windberger, Achim Zeileis:** Structural breaks in inflation dynamics within the European Monetary Union
- 2011-11 **Loukas Balafoutas, Adrian Beck, Rudolf Kerschbamer, Matthias Sutter:** What drives taxi drivers? A field experiment on fraud in a market for credence goods
- 2011-10 **Stefan Borsky, Paul A. Raschky:** A spatial econometric analysis of compliance with an international environmental agreement on open access resources
- 2011-09 **Edgar C. Merkle, Achim Zeileis:** Generalized measurement invariance tests with application to factor analysis *forthcoming in Psychometrika*
- 2011-08 **Michael Kirchler, Jürgen Huber, Thomas Stöckl:** Thar she bursts - reducing confusion reduces bubbles *published in American Economic Review*

- 2011-07 **Ernst Fehr, Daniela Rützler, Matthias Sutter:** The development of egalitarianism, altruism, spite and parochialism in childhood and adolescence
- 2011-06 **Octavio Fernández-Amador, Martin Gächter, Martin Larch, Georg Peter:** Monetary policy and its impact on stock market liquidity: Evidence from the euro zone
- 2011-05 **Martin Gächter, Peter Schwazer, Engelbert Theurl:** Entry and exit of physicians in a two-tiered public/private health care system
- 2011-04 **Loukas Balafoutas, Rudolf Kerschbamer, Matthias Sutter:** Distributional preferences and competitive behavior *published in Journal of Economic Behavior and Organization*
- 2011-03 **Francesco Feri, Alessandro Innocenti, Paolo Pin:** Psychological pressure in competitive environments: Evidence from a randomized natural experiment: Comment
- 2011-02 **Christian Kleiber, Achim Zeileis:** Reproducible Econometric Simulations *forthcoming in Journal of Econometric Methods*
- 2011-01 **Carolin Strobl, Julia Kopf, Achim Zeileis:** A new method for detecting differential item functioning in the Rasch model

University of Innsbruck

Working Papers in Economics and Statistics

2012-20

Martin Wagner, Achim Zeileis

Heterogeneity of regional growth in the European Union

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, Romer, and Weil (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.

ISSN 1993-4378 (Print)

ISSN 1993-6885 (Online)