The Determinants of Regional Growth in Europe: An Empirical Investigation of Regional Growth Models

by

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Abstract

In this paper we analyze regional growth processes in Europe. By using regional data at the NUTS-2-level, we investigate potential determinants of regional growth processes for the 1980 to 1996 period. This is done against the background of regional growth models, i.e. the traditional neoclassical model as well as more recent endogenous regional growth theories. The latter have been developed by combining aspects of the new economic geography with those of endogenous growth theory. The quite extensive empirical research on regional growth processes has been almost exclusively focused on the convergence-divergence-debate and its various aspects. Other aspects and factors influencing regional growth in Europe have, in contrast, attracted rather little attention. We try to - partially - fill this gap by testing different hypotheses emerging from regional growth approaches.

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1 Introduction

To understand regional growth processes and the underlying forces is an important topic for local, national, as well as supranational policy-makers. This is especially true in the EU, in which regional policy is conducted at each of the three different layers.\(^1\) The importance of regional policy has been augmented by the enlargement of the EU with the entrance of countries with on average less advanced regions (Greece, Spain, Portugal). In this context, regional policy is understood as a measure to help overcome natural or historical disadvantages of particular regions (cf. Commission (1990)). In order to pursue a proper regional policy it is, however, crucial to know more about the forces behind regional growth processes. This issue will become even more prominent with the planned enlargement and the accession of Eastern European countries.

Due to developments in growth theory and the emergence of the “new” economic geography (cf. Krugman (1991, 1992)), there has been renewed interest in regional growth theory. On the one hand, the developments in growth theory allowed to endogenize the steady-state growth rate. It has therefore become possible to investigate the potential factors underlying the very pronounced differences in observed growth rates between countries. A wide range of models has emerged, stressing a substantial set of potential factors underlying the growth processes.\(^2\) On the other hand, new economic geography approaches investigate the production and specialization patterns of regions which are open to trade and to the (partial) mobility of factors (cf. the overview in Fujita/Thisse (1997)). Combining these two strands of literature allows for endogenous regional growth approaches which focus explicitly on the determinants of long-run regional growth (see e.g. Martin/Ottaviano (1999) and Walz (1996a)). In contrast to the traditional regional growth models in the Solowian tradition (see Borts and Stein (1964), Siebert (1969), and Richardson (1973)), this

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\(^1\)For a detailed description, see Commission (1990) and Waniek (1992).

\(^2\)For an overview see Aghion/Howitt (1998) and Barro/Sala-i-Martin (1995).
allows to take a closer look at the underlying factors that affect long-run regional development and growth potentials as well as performance. Among the most prominent candidates are the local knowledge base, the regional human capital base, the access to markets, to name just a few.

Against this background, the main objective of the present paper is to investigate the factors affecting regional growth in the EU from an empirical perspective. We use data from Eurostat’s Regio data base at the NUTS-II regional level in order to investigate the regional growth patterns in the EU for the 1980-1996 period. This time period allows us to obtain regional data for the EU-12. Data for later entrants are, unfortunately, not available. With the help of these data we test the different hypotheses emerging from regional growth models, in order to explore the main determinants of regional growth in the EU.

Our study differs from the quite large body of empirical literature dealing with regional growth in the context of the convergence-divergence debate. This literature was initiated by the studies of Barro and Sala-i-Martin (1991, 1995) and followed by a number of authors looking at different time periods and regional data (see e.g. Armstrong (1995), Neven/Gouyette (1994), Broecker (1998), Walz (1999)). Whereas Barro and Sala-i-Martin find a consistent pattern of β-convergence with their famous convergence speed of 2 per cent, the other authors partially challenge this result. Quah (1993a,b) even criticizes and casts doubt on the concept of convergence used in all these studies. In contrast to the aforementioned papers, we focus on a detailed investigation and discussion of the determinants of regional growth processes in the EU. The convergence issue is raised, too, but only as one among many others. Thus, our work is also of importance for regional policy concerns by elaborating on the factors affecting regional disparities which imply potential measures to reduce these disparities. In addition, we directly analyze the effects of regional policy (at the su-

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3See e.g. Armstrong (1995) who stresses the differing degrees of convergence depending on the chosen time period and the level of regional aggregation.
pranational level) on regional growth differentials and therefore on the performance of such a policy.

We show that in the 1980 to 1996 period, there has been between-country as well as within-country convergence, but at a very slow pace. On the other hand, the predictions of the Solowian regional growth approach on the role of investment and migration are not sustained by our regression results. In contrast, we find strong evidence in favor of the hypotheses stemming from endogenous regional growth models. Human capital can be shown to have an important positive influence on the average growth rates of regions with a high human capital level. Also, the development of the regional financial sector proves beneficial for regional growth. Finally, we do find the expected agglomeration effects which by cumulative causation foster further growth of highly developed regions. The role of transport costs remains unclear, just as “new” economic geography would predict, while local knowledge spillovers seem to be too informal to capture in a quantitative indicator in our cross-regional data set in order to produce significant results in growth regressions. As to the effects of regional (transfer) policies, we find no significant influence of such measures on average regional growth rates.

The rest of the paper is organized as follows. In the next section we discuss regional growth models and empirically testable hypotheses emerging from them. This discussion - which will be followed by a short presentation of the data set in the third section - lays the groundwork for our empirical analysis in section 4. We use our regional data set to run growth regressions and test the factors that potentially affect regional growth differentials. We distinguish among different groups of factors and different groups of regions. The fifth section summarizes our main findings and concludes.
2 Theoretical Considerations

There is now a significant body of theoretical literature on regional growth within which two different strands can be distinguished: On the one hand, there are models which are based on the neoclassical growth approach in the Solowian tradition. On the other hand, more recent approaches rest on the endogenous growth approach and/or ideas stemming from “new economic geography” models. Both types of models regard regions as spatial entities which are open to factor mobility. In almost all regional growth models regions are points in space, i.e. spatial considerations within the particular region are left aside. Whereas traditional regional growth models are one-good models and therefore do not consider interregional trade, more recent models focus on interregional exchange via trade. But what is more important - at least for our purpose - is that the hypotheses on determinants of regional growth emerging from these models differ considerably.

Neoclassical regional growth models in the Solowian tradition rest on the assumption of decreasing returns to the single accumulable factor, physical capital (see e.g. Borts/Stein (1964), Siebert (1969) and Richardson (1973)). A higher capital stock implies lower returns to capital and therefore less incremental output effects of an additional unit of capital. In addition, this leads to less incentives to invest in regions with a higher per-capita income associated with a higher capital stock. Therefore, these models predict “convergence” in the sense that poor regions will grow faster than rich ones (absolute $\beta$-convergence).\footnote{This hypothesis implicitly assumes that all regions will eventually reach the same steady state growth path of per-capita income. A weaker form of convergence (conditional $\beta$-convergence) allows for differences in the steady state growth paths. It only predicts that those regions grow faster that are further away from their respective steady states.} This property of neoclassical growth models is by now a standard textbook result, most notably explored in Barro/Sala-i-Martin (1995). It can be shown that there emerges a differential equation from the Solowian growth model which depicts the relation between the
regional growth rate of per-capita income and the initial per-capita income level. In cross-regional studies this relation is estimated either by

$$ln\left(\frac{y_T}{y_0}\right) = \beta_0 - \frac{1}{T} ly_0 \left(1 - e^{\beta_1 T}\right) + u_t$$

or in a simpler (linear) form by using

$$ln\left(\frac{y_T}{y_0}\right) = \beta_0 + \beta_1 ly_0 + u_t$$

where $y_0$ ($y_T$) represents per-capita income in the initial period 0 (the final period T). The $u_t$ are the conventional error terms. The decisive parameter is the $\beta_1$ term measuring the speed of convergence. In the simplified regression equation, $-\beta_1$ equals approximately the percentage by which the difference between the actual level of per-capita income and the steady state level diminishes per year. If convergence is to hold, $\beta_1$ should therefore be negative. There has been widespread discussion and criticism with respect to the $\beta$-convergence concept as a sensible measure of convergence (cf. e.g. the discussion in Quah (1993a) and Broecker (1998)). However, since it results directly from the neoclassical regional growth model (and our purpose is to look at the hypotheses emerging from the models) we will check for $\beta$-convergence in the following, too. This also has the advantage of making our results comparable to most of the literature in this area.

If the assumption that all regions approach the same steady state is violated, conditional convergence is supposed to prevail. Growth regressions exhibiting conditional convergence can be obtained by adding to our above regression equations control variables which capture the different per-capita income levels in the steady-state. In this case, however, the existence of convergence does not constitute a discriminating test between the neoclassical approach and its alternatives anymore. Conditional convergence just states that regions move towards their steady-state growth path.

\[5\] For an explicit derivation, see e.g. Barro/Sala-i-Martin (1995, p. 36ff).
As mentioned before, the driving force of growth in the neoclassical models before reaching the steady state is (physical) capital accumulation. Thus, the saving or investment ratio should be an important explanatory variable when testing this class of models. It is indeed usually included in cross-country growth regressions (see e.g. Barro/Sala-i-Martin (1995)). When we test for it against the background of the neoclassical regional growth models, we should expect a positive influence of the investment level on the average regional growth rate.

In open economies or regions, the models in the Solowian tradition regard migration as another important way to reduce interregional income differentials: Income differentials foster migration streams, which themselves lead to a reduction of these differentials (see Braun (1993)). The fact that migration may therefore be able to absorb adverse regional shocks has also been stressed in empirical studies of shock absorption mechanisms for US regions (see e.g. Blanchard and Katz (1992)). All these considerations imply that an outflow of households from one region and into another should lead to an increase in the growth rate of the region of origin and a reduction in the destination region. Or to put it differently: migration inflows and growth rates should be negatively correlated in our growth regressions. According to the neoclassical growth model, migration should thus also speed up convergence (see Barro/Sala-i-Martin (1995)). We will approach these hypotheses on the relation between growth, convergence and migration by looking at the impact of migration on regional growth rates and the speed of convergence as well as by investigating the effect of income differentials on the level of migration flows.

The more recent regional growth models merge ideas of endogenous growth theory and regional economics. Besides internal accumulation, these models identify the location of new dynamic and innovative industries exhibiting positive growth rates as the main driving force of regional growth. The location of different industries itself and the resulting regional specialization patterns are the consequence of the interaction of agglomeration advantages and disadvantages. The main agglomeration
advantages stressed in this context date back to Marshall (cf. Krugman (1991)).

In the new regional growth models as well as in models of the new economic geography, cumulative causation plays a pivotal role for regional specialization. Against this background, core-periphery patterns with respect to specialization but also with regard to growth processes emerge. These models thus formalize the mechanisms and ideas put forward by classical regional economists such as Perroux (1955) and embed them in a consistent dynamic equilibrium framework. With cumulative causation, small differences between regions are reinforced by the dominance of agglomeration advantages (e.g. knowledge spillovers), leading to growing regional differences and larger income gaps. In such a world unconditional convergence does not take place. That is, if these forces dominate our regional growth processes we should observe divergence rather than convergence. In addition, these models suggest that center regions (i.e. regions with a higher population density) may grow faster than peripheral ones.

The accumulation of human capital is - besides endogenous technological change - the main mechanism of growth in endogenous growth models. After the seminal paper of Lucas (1988), a large number of authors have investigated various channels through which human capital accumulation leads to ongoing steady-state growth.6 All these models share the idea of some kind of spillover in the human capital accumulation process: A larger (regional) base of human capital facilitates the further accumulation of human capital and therefore leads to faster growth. In our regression, we would thus expect to find a positive influence of human capital/education on the regional growth rate.

As we have already mentioned, regional knowledge spillovers constitute an important factor of cumulative causation and therefore of regional growth dynamics. The basic idea rests on the mechanisms of growth models with endogenous technological change (see e.g. Grossman/Helpman (1991)). There, knowledge spillovers

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6For an overview see Arnold (1995).
are the driving force of ongoing technological change based on research-investments of profit-maximizing forward looking firms. Knowledge spillovers lead to constant returns in the accumulation of knowledge capital and therefore allow for positive steady-state growth rates. In a regional context the diffusion of knowledge is crucial. If new knowledge only partially spills over to other regions (see Helpman/Coe (1995) for empirical support of this), the local knowledge base becomes vital for the development path of the particular region. Localized knowledge spillovers lead to pronounced agglomeration advantages and hence to innovative growth centers (see e.g. Englmann/Walz (1995)). According to this approach, a larger local knowledge base (e.g. a larger share of innovative industries) should lead to faster growth of the respective region (see Walz (1996a)).

Transport costs, or more generally, the costs to overcome space, are another important ingredient in this body of literature (see e.g. Krugman (1991), Krugman/Venables (1995), Walz (1996a) and the overview of Fujita and Thisse (1996)). In this respect, the explicit spatial structure of these models distinguishes them from the traditional regional growth models that do not account for transport costs. However, the effects of transport costs are ambiguous. On the one hand, high transport costs strengthen the agglomeration advantage by making production more costly if productive units are spatially dispersed. In a two-region setting with high transport costs, it makes economic sense to concentrate production of intermediate and final goods in one region, preferably in the one with the larger number of customers. This region then becomes the industrial center with a higher growth rate due to cumulative causation while the other region becomes the periphery with a lower growth rate. On the other hand, high transport costs make exports from one region to the other costly. This strengthens the agglomeration disadvantage, since it makes production in the periphery worthwhile by protecting it against competition from the industrial center. Or in the words of Launhardt (1963, p. 160): “Bad streets are the most effective protection against competition from abroad.” These opposite effects
of transport costs lead in essence to a nonlinear relationship between transport costs and specialization patterns (see Krugman/Venables (1995), Puga/Venables (1997)) as well as between transport costs (or trade barriers) and growth rates (see Walz (1995)). In that sense, we should not expect to find a monotone relationship between traffic infrastructure, specialization patterns and regional growth rates in our regressions.

Only recently, a number of studies have looked at the relation of the development of the real and of the local financial sector. For instance, there are a number of empirical cross-country studies that analyze the relation between income growth and the stage of development of the financial sector (see DeGregorio/Giudotti (1995), King/Levine (1993a ) and Levine/Zervos (1995, 1996)). Based on these findings and on the developments in growth theory, theoretical models have evolved which stress the potential positive effect of the financial sector and its development stage on income growth. All these approaches stress different channels through which financial development can foster income growth. Some examples are better risk diversification (Obstfeld (1994)), better monitoring (King/Levine (1993b)) and more efficient information processing (Arnold/Walz (2000)). Most of these studies stress a positive effect of financial development on real economic growth. Based on the idea that especially small business finance and credit finance depend on the state of the regional financial sector, we expect to find a positive influence of the financial sector on regional income growth in our regression results.

3 The data set

In order to test the regional growth approaches for the European Union we mainly rest on data from Eurostat REGIO database. This database provides the most comprehensive regional data set for the countries of the European Union. Regions in this database are defined according to political-institutional demarcation lines. Since the
NUTS-3 layer in the database, providing the most disaggregated data, contains many missing data points, we decided to use the NUTS-2 layer. The NUTS-2 data set has, in addition, the advantage that distortions from pronounced commuting is by far not so much of a problem as with the NUTS-3-data. The database contains regions for all EU-15 countries. However, for the UK only very few data at the NUTS-2 level are available, therefore we had to rely on the NUTS-1 level for UK data. The regions of the late entrants (Austria, Finland and Sweden), lack many data points - most notably per capita income data for the early 1980s -, so that these data are of no use for us. For similar reasons we eliminated the NUTS-2 regions belonging to the new German Laender. Another reason for not including the latter was that we had the impression that these regions went through a rather atypical growth process due to reunification, which would have seriously distorted the results. We also dropped (West-)Berlin from our sample, since after reunification and its merger with Ost-Berlin the character of this region has changed completely - i.e. there has been a serious structural break. Since we aim at growth processes of regions in a geographical entity, we eliminated the overseas regions of France, Portugal and Spain. Finally, as do many studies in this area (see e.g. Armstrong (1995)), we neglected the region of Groningen. The GDP data for Groningen are artificially inflated due to offshore oil which is ascribed to Groningen’s income data. In order to avoid this distortion, we neglected this region completely. By doing all this we ended up with 139 regions.

Even with our restrictions on the regions used, we only have data for the 1980 to 1996 period. Data for the 1970s are available only for a smaller number of regions and for a much smaller set of potential explanatory variables for regional growth processes. However, combining our data set with data for earlier periods from different sources is quite problematic. Therefore, we decided to look at the 1980 to 1996 period only.

All GDP data are either in current ECU or in units of purchasing power parities.
In order to avoid the effects of different national inflation rates, we use the GDP per capita data in units of purchasing power parities. Due to the lack of appropriate data in the Eurostat REGIO database, we referred to the report of the European Commission (1988) for the regional transfers, to the report of the European Commission (1999) for data on regional education levels and on the report of the European Commission (1994) for the migration data.\textsuperscript{7}

The single most important problem with our database is a substantial number of missing data for some countries (even the larger ones, such as the UK and Germany) for some of the explanatory variables. We refer to this problem when discussing our results in the next section.

4 Empirical Results

The purpose of our empirical investigation is to test the hypotheses resulting from the theoretical considerations outlined in section 2. We proceed in the following manner. In a first step, we take a brief look at the convergence process of the EU regions. In a second step, we explore in some depth potential determinants of regional growth differentials in the EU. When doing this, we rely on the hypotheses given by the different regional growth approaches. In this context, we also explore the potential growth effects of regional (transfer) policies in the EU. Finally, we analyze the effects of migration on the growth process as well as the reverse link. We mostly rely on growth regressions, i.e. on OLS estimations with the regional annual growth rate between 1980 and 1996 as the dependent variable. We use White’s Heteroskedasticity Test to check for different error variances that might stem from differences between the countries from which the observations are taken. For most of our regression specifications, we can reject the null hypothesis of no heteroske-

\textsuperscript{7}The interregional migration data, although available in the REGIO database, were compiled from the Commission’s publication due to the lack of appropriate aggregation in the database.
dasticity. In order to account for the resulting bias in the estimated variances of the coefficients, we use heteroskedasticity corrected t-statistics (White-estimators) whenever indicated by the test results.

We estimate an equation similar to eq. (2) and add some additional potential explanatory variables. That is, our estimation equation has the following form:

$$ln\left(\frac{y_T}{y_0}\right) \frac{1}{T} = \beta_0 + \beta_1 ln y_0 + \beta_x x + u_t$$

(3)

where $\beta_x$ represents the column vector of regression coefficients belonging to the row vector of explanatory variables $x$.

The analysis of convergence has the advantage of making our study comparable to the literature in this field. Table 1 reports our findings.
Table 1: Convergence and Country Dummies: Dependent Variable: Average Growth Rate of GDP per Capita 1980 to 1996

<table>
<thead>
<tr>
<th></th>
<th>I</th>
<th>II</th>
<th>III</th>
</tr>
</thead>
<tbody>
<tr>
<td>constant</td>
<td>0.15 (8.59)***</td>
<td>0.12 (4.47)***</td>
<td>0.13 (3.96)***</td>
</tr>
<tr>
<td>ln(GDP 1980)</td>
<td>-0.0106 (−5.23)***</td>
<td>-0.0068 (−2.18)**</td>
<td>-0.0088 (−2.41)**</td>
</tr>
<tr>
<td><strong>Dummies for:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Germany</td>
<td></td>
<td>-0.0011 (-0.77)</td>
<td>0.0009 (0.52)</td>
</tr>
<tr>
<td>Italy</td>
<td></td>
<td>-0.0021 (-1.59)</td>
<td>-0.0005 (-0.30)</td>
</tr>
<tr>
<td>France</td>
<td></td>
<td>-0.0099 (−7.68)***</td>
<td>-0.0085 (−5.27)</td>
</tr>
<tr>
<td>Belgium</td>
<td></td>
<td>0.0011 (0.66)</td>
<td>0.0007 (0.31)</td>
</tr>
<tr>
<td>Netherlands</td>
<td></td>
<td>-0.0020 (-0.84)</td>
<td>-0.0022 (-0.90)</td>
</tr>
<tr>
<td>Portugal</td>
<td></td>
<td>0.0039 (1.51)</td>
<td>0.0078 (1.97)*</td>
</tr>
<tr>
<td>Spain</td>
<td></td>
<td>0.0005 (0.29)</td>
<td>0.0026 (1.41)</td>
</tr>
<tr>
<td>Greece</td>
<td></td>
<td>-0.0010 (-0.30)</td>
<td>0.0038 (1.17)</td>
</tr>
<tr>
<td>Luxembourg</td>
<td></td>
<td>0.0220 (17.05)***</td>
<td>0.0220 (15.12)***</td>
</tr>
<tr>
<td>Denmark</td>
<td></td>
<td>0.0056 (5.07)***</td>
<td>0.0056 (4.13)***</td>
</tr>
<tr>
<td>Ireland</td>
<td></td>
<td>0.0240 (16.15)***</td>
<td>0.0253 (17.85)***</td>
</tr>
<tr>
<td><strong>Employment-share in:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agriculture</td>
<td></td>
<td></td>
<td>-0.0076 (-0.70)</td>
</tr>
<tr>
<td>Market Services</td>
<td></td>
<td></td>
<td>0.0153 (2.00)**</td>
</tr>
<tr>
<td><strong>Number of observations</strong></td>
<td>139</td>
<td>137</td>
<td>135</td>
</tr>
<tr>
<td><strong>Adjusted R²</strong></td>
<td>0.16</td>
<td>0.50</td>
<td>0.54</td>
</tr>
</tbody>
</table>

The figures in parentheses represent the t-statistics, which, in columns II and III, are the White-corrected values, due to heteroscedasticity. The asterisks represent the significance-level: Values with one asterisk are significant at the 10 percent level, values with two asterisks are significant at the 5 percent level, while three asterisks indicate significance at the one percent level.
We estimate three regressions. In the first column of table 1, we estimate unconditional convergence. In the second column, country dummies are added, before we include the regional employment shares in agriculture and market services in the third column.\textsuperscript{8}

Our results of the unconditional convergence estimate imply that there is unconditional convergence between the EU regions. The speed of convergence is, however, very low. It takes more than 65 years ($ln2/(-\beta_1)$) for income differences to halve themselves. This finding is in line with the literature (see e.g. Armstrong (1995)). So one of the most important objectives of the European integration process, namely to achieve or foster regional convergence is met only to a very low degree, if at all.

Taking country dummies into account reduces the regression coefficient while improving the overall fit of the regression significantly.\textsuperscript{9} The considerable change in the estimated convergence coefficient implies that there exist both between-country convergence (the estimation without country dummies reflects both) and within-country convergence (estimation without country dummies, column II).\textsuperscript{10} Adding the share of employment in the aggregate categories agriculture and market services (see column III) leaves the overall picture more or less unchanged. The convergence coefficient increases (in absolute terms) in comparison to column II, suggesting that within-country convergence really accounts for more of the total convergence term than one might deduce from column II.

When turning to a broader analysis of the determinants of the regional growth process in the EU, we always incorporate the convergence term, i.e. we always include

\textsuperscript{8}Due to lack of data, these had to be calculated for 1988.

\textsuperscript{9}This equation is, by the way, the best justification for using purchasing power parity based income data. If one performs equation 2 on the basis of income data in current prices, the country dummies capture the obviously very important national inflation differences (inflation figures are not available at the regional level). The country dummies “explain” almost eighty percent in the variation of the regional growth rates, indicating the pronounced distortions stemming from the use of these income data.

\textsuperscript{10}For the concept of between- and within-country convergence, see Armstrong (1995).
the log of the initial income per capita level in the regression equations. In order to test the various hypotheses outlined in section 2, we employ the following variables as potential determinants of regional growth in the growth regressions.\footnote{Our choice of the exogenous variables, i.e. the potential candidates determining regional growth, was governed by the objective to grasp as closely as possible the hypotheses resulting from regional growth models. We were, however, limited by the availability of appropriate regional data.}

We investigate the impact of regional human capital endowment with the share of high and low education in the workforce age 25 to 59. These categories are defined by the years of schooling/education per person. The category of low education (LOWHC) measures the ratio of people with schooling up to age fifteen or less, while the category of high education (HIGHHC) measures the ratio of people with schooling up to the age of at least nineteen. Unfortunately, we have these data for 1997 only, as reported by the European Commission (1999). But, due to the rather slow adjustment of the human capital endowment of the entire regional work force, we consider this as being only quite a minor pitfall. In order to capture the influence of human capital more exactly, we differentiate between regions with an above-median share of low education and those with a below-median share. We allow for this differentiation in our regression by using a dummy (EDUM) which takes the value 0 for regions with a share of low education that exceeds 40 percent (the median of LOWHC) and 1 for those regions whose share of low education is less than or equal to 40 percent.

In order to analyze the impact of knowledge spillovers and hence the impact of the regional knowledge base on regional growth, we made use of two alternative variables. On the one hand, we used the patent rate (PRATE) in the respective region relative to population size (patents per million inhabitants) in 1989, which is the earliest year possible, i.e. the earliest year in which a sufficient number of observations is given in the dataset. On the other hand, we tested the explanatory power of a related input measure, namely the private R&D expenditure in the regions. The former variable was observed for a much larger number of regions, though. It was especially for this
lack of observations that we decided to report only the measure for R&D output (PRATE) in the following.

In order to approximate the influence of transport costs, we constructed a proxy measuring regional traffic infrastructure (TINFSTRR). It delineates the sum of total road kilometers and total rail kilometers relative to the size of the region (in square kilometers). Waterways were not considered due to a lack of data. For the same reason, we could only use data for 1990. The higher the level of TINFSTRR, the better the access of the region to the outside world and therefore the lower the transport costs originating from the particular region. In the absence of an ideal measure of transport costs, this seemed to us a reasonable approximation.

The size of the financial sector in each region is measured in the same way as the industry structure in the previous regressions, namely by the share of employment in this industry ("services of credit and insurance institutions") as a percentage of total employment (EMFIN). In this case, data are available for 1986. An alternative measure, the share of value-added at factor prices in total value-added yields similar results (but with a slightly lower number of observations) and is therefore not reported here.

In order to approach the cumulative causation hypothesis, we ask whether agglomerations tend to grow faster than peripheral regions. For this purpose, we construct an agglomeration dummy (AGGLO) by assigning the value one to all the regions in the European center (in the technological belt of Europe (see Commission (1994))) as well as to the national centers and a zero to all other regions.

Two final explanatory variables are still to be described. With the first one, MIGR, we measure the migration streams in or out of the regions under consideration. A positive value of MIGR means that there has been immigration to the respective region. We take size differences into account by expressing the migration streams as a percentage of total population size. Unfortunately, these data are not available for a broad range of regions for a larger period of time. Therefore, we have to rely on
the migration streams for 1989 which, however, depict the migrations in and out of regions in a rather typical manner. Finally, in order to analyze the growth impact of the EU’s regional policy we use data from the European Commission (1988) for the regional transfer payments at the EU level (TRANSFER) in the period of 1975 to 1988. Due to a non-matching definition of regions, these data are, however, only available for a limited sample of regions.

Furthermore, we use population density (PDENSITY) and population size (POP) as control variables. For reasons of data availability we refer to numbers of 1982 for POP and to numbers of 1989 for PDENSITY. To control for the industrial structure of the regions, we also include the share of employment in agriculture (EMAGRR); we have also included the share of employment in the services sector, but this does not alter any of the results.

Table 2 reports our findings for the different regression equations.

Due to the lack of data for the full sample for some variables, the sample size changes with the variables used in the estimation. Especially the transfer variable is only available for a small subset of countries and therefore reduces the sample size significantly. When we test for the influence of the investment rate, the sample size is even further reduced (to 43), leading to rather unreliable results which are therefore not reported here.
Table 2: Growth Regression: Dependent Variable: Average Growth Rate of GDP per Capita 1980 to 1996

<table>
<thead>
<tr>
<th></th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>constant</td>
<td>0.24 (8.01)**</td>
<td>0.21 (3.25)**</td>
<td>0.21 (3.23)**</td>
<td>0.17 (2.15)**</td>
</tr>
<tr>
<td>ln(GDP 1980)</td>
<td>-0.021 (-6.13)**</td>
<td>-0.02 (-2.46)**</td>
<td>-0.018 (-2.39)**</td>
<td>-0.01 (-1.46)</td>
</tr>
<tr>
<td>EMAGRR</td>
<td>-0.012 (-1.35)</td>
<td>-0.008 (-0.61)</td>
<td>-0.010 (-0.88)</td>
<td>-0.008 (-0.62)</td>
</tr>
<tr>
<td>PDENSITY</td>
<td>1.8E-06 (2.68)**</td>
<td>-6.4E-06 (-2.07)**</td>
<td>-6.9E-06 (-2.95)**</td>
<td>-2.9E-06 (-0.36)</td>
</tr>
<tr>
<td>POP</td>
<td>1.2E-07 (0.34)</td>
<td>-1.7E-07 (-0.38)</td>
<td>-4.5E-07 (-1.14)</td>
<td>-5.7E-07 (-1.25)</td>
</tr>
<tr>
<td>EMFIN</td>
<td>0.0029 (2.22)**</td>
<td>0.005 (2.12)**</td>
<td>0.004 (1.96)*</td>
<td>0.003 (1.40)</td>
</tr>
<tr>
<td>AGGLO</td>
<td>0.00015 (1.67)*</td>
<td>-0.0003 (-0.62)</td>
<td>-0.0001 (-0.37)</td>
<td>-6.8E-05 (-0.20)</td>
</tr>
<tr>
<td>HIGHHC</td>
<td>0.0205 (1.79)*</td>
<td>-0.0091 (-0.55)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EDUM*HIGHHC</td>
<td></td>
<td></td>
<td>0.0429 (2.00)*</td>
<td>0.0319 (2.27)**</td>
</tr>
<tr>
<td>EDUM*LOWHC</td>
<td></td>
<td></td>
<td>-0.0374 (-3.74)**</td>
<td>-0.0334 (-4.98)**</td>
</tr>
<tr>
<td>PRATE</td>
<td></td>
<td>-2.7E-05 (-0.89)</td>
<td>-6.5E-06 (-0.20)</td>
<td>2.7E-06 (0.09)</td>
</tr>
<tr>
<td>TINFSTRR</td>
<td></td>
<td>0.0007 (0.55)</td>
<td>0.0008 (0.81)</td>
<td>-0.001 (-0.51)</td>
</tr>
<tr>
<td>TRANSFER</td>
<td></td>
<td></td>
<td></td>
<td>2.5E-06 (1.13)</td>
</tr>
<tr>
<td>Number of obs.</td>
<td>131</td>
<td>63</td>
<td>63</td>
<td>54</td>
</tr>
<tr>
<td>Adjusted $R^2$</td>
<td>0.28</td>
<td>0.38</td>
<td>0.49</td>
<td>0.57</td>
</tr>
</tbody>
</table>

The figures in parentheses represent the White-corrected t-statistics. The asterisks represent the significance-level: Values with one asterisk are significant at the 10 percent level, values with two asterisks are significant at the 5 percent level, while three asterisks indicate significance at the one percent level.

Our regression results generate a number of rather clear-cut (positive as well as negative) findings. First, we find strong support for the human capital hypothesis. In our first regression, where only the ratio of high education is included, we find a positive influence on the average growth rate which is significant at the 10 percent level. When adding more variables in the second equation, however, the t-statistics...
are reduced to irrelevance. Since this phenomenon can be caused either by the in-
clusion of the additional explanatory variables or by the reduction in the number of observations, we have conducted another regression in order to isolate these in-
fluences. It turns out that human capital remains significant when only the number of observations is reduced by eliminating the appropriate regions. From this, we con-
clude that the change in the t-statistics might be due to multicollinearity be-
 tween the newly introduced variable PRATE and HIGHHC. We try to handle this prob-
lem by breaking down the human capital variable for different regions. This is done by estimating the same equation with the education dummy. We get the fol-
lowing results for the influence of human capital: For regions with a below-median percentage of low education, a higher education level implies higher growth rates while a lower education level implies lower growth rates; both coefficients are signi-
ficant. This can be interpreted as a typical case of cumulative causation: In regions with a high human capital level, more human capital leads to even higher growth rates. For the above-median regions, the results are not as clear-cut; most of the times, the coefficients have the expected signs but are insignificant. Our results on human capital are also robust to adding transfer payments, although this reduces the number of observations even further. Even in the not reported regression for the investment rate, the signs remain the same and the high education coefficient re-
mains significant at the 10 percent level, while the low education coefficient remains so at the 5 percent level. This suggests that the education and the human capital endowment of the regional labor force has played an important role in the regional growth process in the considered period.

As to the knowledge spillover story, we cannot find any evidence for its existence. The proxy for the technological base in the regions (PRATE) is always insignificant and sometimes even has a negative sign. This can be interpreted as one more indica-
tion of the fact that “knowledge spillovers leave no paper trail” (Krugman (1991)), at least at an aggregate level. In contrast, we find strong support for cumulative
causation to take place to some extent: the AGGLO variable is significant at the 5 or 10 percent level with a positive coefficient.\textsuperscript{12}

The infrastructure variable does not depict a clear-cut sign, nor is the coefficient ever significant. This is, however, in line with what we would expect against the background of the new models of regional growth and economic geography. As has been argued in section 2, transport costs (and hence transport infrastructure) has positive as well as negative effects. This is just what we observe in our data.

The impact of the financial service sector (EMFIN) turns out to be always positive and highly significant.\textsuperscript{13} That is, our results suggest that a larger regional financial sector fosters regional growth and development. This result is astonishingly robust with respect to various estimations and the change in the sample size associated with a change in the variables in the estimation.

Before turning to migration in more detail later on, we can already state that the impact of migration on regional growth is hardly significant and the signs of the coefficients are sometimes in clear contrast to the hypothesis resulting from the neoclassical growth model.

In the regressions reported here, we find no significant relationship between regional transfers and regional growth. The positive sign, though, might lead us to suspect that the relation could be significant, if only we had more observation points. This, however, is not verifiable - in contrast, when we include the investment ratio, the coefficient remains insignificant but changes its sign. That there is no significant relationship between transfer payments and regional growth is not very surprising, given the structure of regional transfers and the theoretical considerations (cf. Walz (1996b)): Regional policy often hindering structural change does not foster regional growth and may even stand in the way of the development of the subsidized regions.

\textsuperscript{12}Due to the low number of observations, the fourth equation should be interpreted with some caution.

\textsuperscript{13}We find the same qualitative results if we use the share of total value-added in this sector rather than the employment share.
In order to get a better intuition of the impact of the significant explanatory variables on growth, we have taken a closer look at the size of the corresponding regression coefficients from Table 2, Column III. For the whole sample, our dependent variable - the average growth rate of GDP - lies between 0.040 and 0.088, with a median of 0.059. Since the coefficient of the natural logarithm of the 1980 GDP has already been discussed, and AGGLO can only take the value one or zero, we concentrate on the coefficients for EMFIN, EDUM*HIGHHC and EDUM*LOWHC. EMFIN, which ranges from 0.01 to 0.12, has a median of 0.027. Given the value of the coefficient, a rise of one percentage point above the median (i.e. to 0.037) results in a rise of the growth rate by 0.00390. For the regions with a below-median percentage of low education, the median of HIGHHC lies at 0.20 (with values of HIGHHC between 0.14 and 0.45). A rise of one percentage point to 0.21 lets the growth rate rise by 0.00043. For the same regions, LOWHC ranges from 0.18 and 0.40 and has a median of 0.26. Here, a rise of one percentage point above the median leads to a decrease in the growth rate by 0.00037. In comparing these results, it is important to bear in mind the different sizes in percentage changes that result from the different medians being used as basis values (such that the rise by one percentage point implies a 37 percent rise in EMFIN but only a five percent rise in HIGHHC\textsuperscript{14}).

Finally, we take a brief, closer look at the relationship between migration and regional growth. We begin with the relation between migration and convergence. For this purpose we compare two regressions. We first restate the unconditional convergence estimate and compare the \( \beta \)-coefficient of the initial income variable with the one resulting from a regression where we add the migration variable to the unconditional convergence estimates. We use the same migration data as before. Table 3 reports the results.

\textsuperscript{14}A 37 percent rise of HIGHHC would lead to a rise in the growth rate by 0.00318.
Table 3: Migration and Convergence: Dependent Variable: Average Growth Rate of GDP per Capita 1980 to 1996

<table>
<thead>
<tr>
<th></th>
<th>I</th>
<th>II</th>
</tr>
</thead>
<tbody>
<tr>
<td>constant</td>
<td>0.15 (8.59)***</td>
<td>0.16 (7.9)***</td>
</tr>
<tr>
<td>ln(GDP 1980)</td>
<td>-0.0106 (-5.23)***</td>
<td>-0.0115 (-4.96)***</td>
</tr>
<tr>
<td>MIGR</td>
<td>0.00011 (1.24)</td>
<td></td>
</tr>
<tr>
<td>Number of observations</td>
<td>137</td>
<td>133</td>
</tr>
<tr>
<td>Adjusted $R^2$</td>
<td>0.16</td>
<td>0.16</td>
</tr>
</tbody>
</table>

The figures in parentheses represent the White-corrected t-statistics, which are the White-corrected values in column II, due to heteroscedasticity. The asterisks represent the significance-level: Values with one asterisk are significant at the 10 percent level, values with two asterisks are significant at the 5 percent level, while three asterisks indicate significance at the one percent level.

The migration variable does not have a significant effect on regional growth (this was already suggested by our previous estimates). The sign of the migration variable is positive, while neoclassical theory would lead us to expect it to be negative. In addition, the convergence coefficient remains almost unaltered. This implies that at least for the period of 1980 to 1996, migration has not sped up convergence in a significant manner. In a nutshell, the relationship between migration and convergence does not follow the pattern suggested by neoclassical growth theory.

As a last step we take a look at the determinants of the migration streams. For that reason, we run an OLS regression with migration flows as the dependent variable and initial income and the employment shares in agriculture and market services as exogenous variables. The results are as theoretically expected. We find a positive and highly significant impact of initial income on migration. Households migrate from low to high income regions. Furthermore, our estimates suggest that especially regions with larger shares of agriculture and local services are the ones
loosing people, while industrial centers are the receiving regions.\textsuperscript{15} Hence, we can sum up by stating that the determinants of migration streams are as assumed in neoclassical approaches but that the same is not true for our data sample for the impact of migration on convergence and regional growth.

5 Conclusion

In this paper we explore the determinants of regional growth against the background of theoretical regional growth approaches. Two strands of literature are distinguished: the neoclassical growth approach in the Solowian tradition and the endogenous regional growth models which combine elements of the endogenous growth theory and those of the “new” economic geography. We derive testable hypotheses from this literature and run growth regressions with our data on the European regions at the NUTS-2-level.

As to the hypotheses resulting from the traditional models, we do find absolute and conditional $\beta$-convergence for the considered time period, but at a very slow pace. This is in line with the results of earlier studies concerned with convergence (e.g. Armstrong (1995)). However, investment cannot be shown to have an important influence on average growth rates. Although the exact results of this estimation are not reported here due to the small sample size, this finding is really consistent with the results of cross-country regressions, where data on investment-ratios are easier to obtain (see Barro and Sala-i-Martin (1995)). When it comes to the issue of migration, neoclassical predictions again cannot be fully confirmed: Although the determinants of migration streams are as assumed (income differences and industrial structure), we do not find the predicted effects on regional growth rates and on convergence.\textsuperscript{15}

\textsuperscript{15}The precise result of the regression turns out to be: Migration ratio = -39.05 (-1.43) + 7.13 (2.53)** in GDP per capita 1980-19.37 (-2.30)** employment share in agriculture -30.00 (-3.82)*** employment share in services industry. The figures in parentheses represent the White-corrected t-statistics. The asterisks represent the one, five and 10 percent significance levels.
While the predictions of the traditional regional growth approaches do not perform very well in our empirical investigation, the hypotheses that result from endogenous regional growth models cannot be rejected for a quite a number of explanatory variables. Human capital turns out to be a significant growth motor, especially in regions with higher human capital levels. The predicted agglomeration effect also holds, as does the prediction of some more recent models in this field: The size of the regional financial sector has a highly significant and robust positive influence on average regional growth rates. In line with the theoretical predictions on the ambiguous role of transport costs, we find that the coefficient of our transport-infrastructure dummy neither has a clear-cut sign nor is it significant in any of our regressions. We run into more difficulties when testing for the influence of the regional knowledge base, as measured in patent rates. The fact that there are no significant results might however rather be due to the fact that “knowledge spillovers leave no paper trail” (Krugman (1991)) than to knowledge simply not having any influence.

To sum up, we find the same results on convergence as does the earlier empirical work on regional growth, but at the same time we are able to distinguish quite a few additional relevant factors that influence average regional growth rates. Clearly, there is more to regional growth than what traditional approaches would predict.
References


