Growth, convergence and EU membership

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Abstract

The effect of European integration on long-term growth of the current EU member states is studied by means of panel data methods. The length of EU membership is found to have a significant positive effect on economic growth, which is relatively higher for poorer countries. While previous empirical studies tend not to find positive growth effects of regional integration, the present study suggests an asymmetric, convergence-stimulating impact of EU membership on long-term growth.

Keywords: convergence, economic growth, European Union, threshold panel data regression

JEL codes: F15, F43, C23

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1 Introduction

For the last 50 years there has been widespread discussion about the economic consequences of European integration. The basic questions are: Is economic integration growth enhancing? Are the rich getting richer and the poor getting poorer, or will the income levels of the EC/EU member countries converge as a consequence of integration? Furthermore, which countries will profit most from intensified trade among the members?

The theoretical literature on economic growth has gone through several phases, and the answers to the above questions depend on the specification of the respective growth model.

From the late 1950s to the mid-1980s the simple Solow-Swan *exogenous growth model* dominated the literature (Solow, 1956). According to the neoclassical theory, the economy converges towards a steady state due to diminishing returns to investment in physical capital. Assuming a constant population, the long-run growth rate is solely determined by the rate of technological change, which is assumed to be exogenous. As the growth rate is therefore independent of any economic behavior, economic policy changes will only have a temporary effect on economic activity.

The same is true for economic integration. Technological change is considered a public good common to all countries, so that they all share the same long-run growth rate determined by technological progress only. Therefore the integrated economy will expand along this unchanged steady state growth path in the long run, and the reallocation of resources will only temporarily have an influence on the growth rate. Hence according to the neoclassical view of growth, European integration should not have a lasting effect on growth rates. However the income levels should converge perfectly.

In the mid-1980s the so-called *endogenous growth theory* revolutionized the literature on economic growth (Romer, 1990). Technology that was formerly considered a public good and exogenous now became endogenous and subject to decision-making processes at individual firms. According to this concept, enterprises have an incentive to invest in research, as the development of new technologies assures them of the possession of temporary monopoly power. But the absorption of monopoly rents is limited, as knowledge is only partially excludable. Patent protection is limited in time, and inventions can be used as input to further research and new technological innovations. These knowledge spillovers prevent the firms from collecting the full monopoly rent for their new inventions.

The aspect of the new growth theory according to which technological progress depends on the research activities of individual firms which seek to collect monopoly rents opens a new view on the issue of economic growth in an integrated region: now an increased scale of the economy will have a lasting positive effect on growth. On the one hand, knowledge spillovers imply increasing returns to scale to capital accumulation. On the other hand, the monopoly rent increases with the number of consumers while the costs for research and development are independent of the size of the economy. The prospect of higher profits increases the incentive for further research and hence spurs economic growth. These two factors together imply that the long-run growth rate increases with the size of the economy.[1]

To sum up, the consequences of European integration are fundamentally different within the framework of endogenous growth. The more countries join the Economic Union and hence the larger the scale of the integrated economy is, the higher the incentive for R&D is and, accordingly, the higher the growth rate is. Enhanced growth is now not only a transitory, but a permanent phenomenon from which all countries profit in the long run.

In this sense, testing for a growth effect due to European integration could be seen as a strategy to prove the superiority of one of these two theoretical frameworks. There are, however, possibilities to allow for the existence of integration-driven growth effects within the neoclassical paradigm of exogenous growth, just by modelling the process of technological growth in a more complex manner (for example, by letting the growth rate of technology be a function of the overall size of the integrated unit). Therefore, evidence for integration related growth effects could thus be seen as a motivation for a more complex modelling of the technological progress variable.

Most empirical papers on economic growth aim at detecting the main determinants of long-run growth without referring explicitly to regional integration (for European regions see, e.g., Sala-i-Martin, 1996). The first papers dealing with the question of a possible growth bonus associated with European integration were all cross-country studies. Basically, they compare EU members with other countries that have not joined the European Union, mostly countries at a similar stage of development. The basic question is

[1] A countervailing effect of integration which could work in the opposite direction to the one described in the text refers to the fact that, in a larger market, competition is more intense and monopoly rents are smaller and more short-lived. However, empirical research on the effect of trade integration on growth suggests a dominant role of the growth enhancing effect. See below for some references.

whether there exists a global growth benefit from being a EU member. Most of the studies do not find any such growth bonus (see e.g., De Melo et al., 1992 or Landau, 1995).

However, panel data regression techniques opened up a new way to deal with the question of possible growth benefits associated with EU membership. Focusing exclusively on the current EU member states the basic question then can be whether in retrospect they profited from regional integration.

The line of research we will follow is based on the estimation of growth regressions using panel data methods. The superiority of panel data methods over cross-country growth regressions has been highlighted often in the empirical literature (see, e.g., Islam, 1995). The main advantage of pooled estimation is the explicit modelling of country-specific effects, removing thus part of the problem caused by the unobservability of initial levels of technical efficiency.

There are two studies which ask questions similar to the ones discussed in our paper, although they look at a wider set of countries and do not exclusively focus on EU members.

Vanhoudt (1999) tests the validity of the neoclassical implication that regional integration has no impact on long-term growth against the alternative model based on endogenous growth theory. He carries out panel data regressions on 23 OECD countries to check whether EU membership had a positive impact on growth compared to developed countries which have not joined the European Union. He does not find evidence of a significant long-run growth bonus associated either with EU membership or with membership length. Also, the results do not support the hypothesis of a scale effect on growth. The author concludes that the neoclassical hypothesis cannot be rejected by the data.

Henrekson et al. (1997), who focus on EC as well as on EFTA member countries, find the opposite result: EC/EFTA membership may increase growth rates significantly, by around 0.6 to 0.8 percentage point per year. However, apparently it does not matter whether a country is an EC or an EFTA member. Their results support the hypothesis that regional integration in Europe can have significant growth effects and suggest that further regional integration may be growth enhancing in the long run. However, the results of the paper are not completely robust with respect to changes in the model specification.

Both these studies and the present paper deal with the question of whether European integration had a positive impact on long-term growth in the member countries. Our study, however, deviates from the other two in that it exclusively focuses on the current EU member states[2] and in that it deals with the issue of convergence within the integrated European economy. Our questions are: Have per capita income levels in European countries converged towards each other since the 1960s? And if EU membership had a favorable impact on growth in these countries, can we detect subsets of countries that profited more than average from EU membership? Can we conclude from these asymmetric gains in growth that convergence was also a consequence of intensified economic involvement due to European integration?

The paper is organized as follows. Section 2 gives a short overview of the different concepts of convergence and presents some first results. In section 3 we introduce the specific econometric form of our growth model and its extensions and report the empirical results. Section 4 concludes and makes propositions for further research. Details about the data and the econometric specification can be found in the appendix.

2 Convergence and growth in the EU - concepts and first results

The term *β-convergence* was coined by Barro and Sala-i-Martin (1992) and refers to the negative correlation between initial levels of real GDP per capita and its average yearly growth rate either after conditioning for certain control variables (*conditional β-convergence*) or without conditioning (*unconditional β-convergence*). For a complete survey on the empirical literature dealing with evidence on β-convergence, see, e.g., Durlauf and Quah (1998).[3] Together with the concept of β-convergence, Barro and Sala-i-Martin (1992) introduce the complementary concept of *σ-convergence*, which refers to the decrease of the dispersion of real GDP per capita across economic units through time. It should be noted that β-convergence is a necessary but not sufficient condition for σ-convergence.

[2] Another recent contribution to this branch of literature, Badinger (2001), focuses exclusively on European countries using a somehow different approach and finding again no evidence for a growth bonus of EU membership.

[3] Notice that this approach is not free from criticism. For a critical view and alternative concepts of convergence based on the time series properties of real GDP per capita, see, e.g., Bernard and Durlauf (1998).

Figure 1 shows a scatter plot aimed at checking for (unconditional) β-convergence in the European Union for the period 1960–98: on the x axis, the initial (log) level of real GDP per capita in 1960 is represented, while the y axis shows the average yearly growth of real GDP per capita in the period 1960–98. A visual inspection points at a negative relationship between both variables.

This first indication of convergence is confirmed by dividing the data into four subperiods (1961–70, 1971–80, 1981–90, 1991–98)[4] and estimating the β parameter in the panel regression

$$[ln(y_{Tt,i}) - ln(y_{0t,i})]/n_t = \alpha + \beta ln(y_{0t,i}) + u_{t,i}, \tag{1}$$

where $y_{Tt,i}$ refers to the real GDP per capita in the last year of period t ($t = 1, 2, 3, 4$ stands for each of the subperiods described above) for country i, $y_{0t,i}$ refers to the value of real GDP per capita in the initial year of period t and n_t is the number of years in period t. Equation (1) has been estimated based on different assumptions for the error term, and the results are presented in Table 1 .[5] The first column shows the result for the assumption that the error term is independent of the cross-sectional units (countries) and iid normal (that is, the panel is estimated as if it were a cross-country regression). The second column shows the results for the assumption of fixed country effects, that is,

$$u_{t,i} = \mu_i + \epsilon_{t,i},$$

where μ_i is a country-specific constant and ϵ_t is white noise. Finally, the third column shows the estimated β under the assumption of fixed country and time effects, that is,

$$u_{t,i} = \mu_i + \lambda_t + \epsilon_{t,i},$$

where μ_i and ϵ_t are defined as above, and λ_t is an exclusively time-dependent constant effect.

[4] A minimum amount of eight years seems reasonable for studying long-term growth features, because thus business cycle fluctuations are eliminated. In the literature the estimates for the average business cycle length in European countries deviate substantially across countries and depending on the detrending method. In general, however they do not tend to exceed 8 years but remain within a range of around 3 to 5 years. For recent estimations on the euro area as well as on selected European countries see, e.g., Harding and Pagan (2001) or Artis et al. (2003).

[5] Throughout the study, Luxembourg was excluded from the estimations for two reasons: It is typically considered an outlier, and no data on average education years is available for this country in Barro and Lee (2001).

All specifications reported in Table 1 point at the existence of very significant unconditional β-convergence across the current EU members for the period 1960-98.

Figure 2 shows the evolution of the cross-country coefficient of variation of per capita GDP for the period 1960–98. By visual inspection the trend is clearly decreasing, indicating σ-convergence. Whether the standard deviation in the final period is significantly different from that of the first period can be tested using the T_2 test statistic developed by Carree and Klomp (1997),[6] which is $\chi^2(1)$ distributed under the null hypothesis of no σ-convergence. The value of T_2 for the EU data is 4.46, which indicates rejection of the null of no σ-convergence at a 5% significance level.[7]

3 Growth and EU membership

3.1 The basic model and some extensions

In order to study explicitly the determinants of long-term growth in Europe in the last four decades, equation (1) will be extended by including an augmented set of explanatory variables. The obvious candidates to form part of the group are those variables which are explicitly implied by economic theory and which have been used in virtually every empirical study on economic growth: the initial (log) level of per capita GDP – evaluated in our case at the first year of each subperiod –, the investment share – subperiod average – and some proxy for human capital – average years of education of population over 25, evaluated at the first year of the subperiod.

Together with these *basic* variables others which are considered to be relevant to economic growth have been included in the econometric specification.

[6]The T_2 test statistic is defined as

$$T_2 = (N - 2.5) \ln \left[1 + \frac{\hat{\sigma}_0^2 - \hat{\sigma}_T^2}{4(\hat{\sigma}_0^2 \hat{\sigma}_T^2 - \hat{\sigma}_{0T}^2)} \right],$$

where N refers to the number of countries, $\hat{\sigma}_0^2$ and $\hat{\sigma}_T^2$ are the cross-country variances of real GDP per capita in the initial period and the final period, respectively, and $\hat{\sigma}_{0T}$ is the covariance between initial and final real GDP per capita.

[7]Notice that the remarkable change in trend experienced since the end of the seventies could represent a structural break in the process underlying the dynamics of σ-convergence. We test this hypothesis by implementing the test procedure proposed by Hansen (1997) on the first differences of the variation coefficient, which were assumed to be represented by an AR(1) process. The results give evidence for a break in the parameters of the data generating process around 1978. This would give room for further investigation, that go beyond the scope of this paper.

The specification in which all the estimated models presented in Table 2 are nested is:

$$[ln(y_{Tt,i}) - ln(y_{0t,i})]/n_t = \beta_1 ln(y_{0t,i}) + \beta_2 ln(INV_{t,i}) + \beta_3 ED_{t,i} + \beta_4 INF_{t,i} + \\ +\beta_5 GOV_{t,i} + \beta_6 OP_{t,i} + \beta_7 YEA_{t,i} + u_{t,i}, \quad (2)$$

where $ln(y_{0t,i})$ is the (log) initial GDP per capita of country i in subperiod t, $ln(INV_{t,i})$ is the (log) investment share, $ED_{t,i}$ refers to the years of education, $INF_{t,i}$ is the subperiod-average inflation rate, $GOV_{t,i}$ is government consumption over GDP, $OP_{t,i}$ is openness of the economy defined as trade over GDP,[8] and $YEA_{t,i}$ is the average length of EU membership (in years) for country i in subperiod t.[9] The error term $u_{t,i}$ is assumed to be composed by a constant country-specific effect and a common constant time effect, although in the estimation the latter will only be included if found significant.

The specification given by (2) can be seen as a log-linearization in a neighborhood of the steady state of the Solow model augmented with human capital à la Hall and Jones (1999), as derived in Mankiw et al. (1992). They suggest the use of the logarithm in the investment share and the level of school enrollment (the human capital function put forward by Hall and Jones, 1999, is exponential on the education variable) as additional variables to initial GDP. The rest of the controls could thus be seen as explaining the growth rate of technological progress (assumed constant in the basic Solow specification).[10]

Table 2 shows the results of the estimation of the different specifications of our growth model.

[8] Due to the multidimensional nature of the concept of trade, there are many different measures for openness, most of which are found to be almost uncorrelated (see, e.g., Pritchett, 1996). The openness index developed in Sachs and Warner (1995), which has been widely used in the empirical literature on economic growth, would be of little use in this study, as the variable they propose is a dummy that would take a value of one for practically the whole sample used here.

[9] For Germany we use data for West Germany until 1991, and for the unified Germany from 1991 onwards. Initially, an additional dummy variable was included in order to account for the German unification, but it appeared insignificant in all specifications. For further details on the data, see appendix.

[10] Empirical studies dealing with a more heterogeneous set of countries tend to include population growth on the right hand side of the growth equation, as implied by the original Solow model (see, e.g., Mankiw et al., 1992). In our case, the variable appeared insignificant in every specification in which it was included and was therefore not added to final specification. The same occurred when a socio-demographic variable like female participation in the labor market was used. A possible explanation of the lack of significance of labor participation would be the high correlation between this variable and initial GDP.

In a first step, growth is regressed on initial GDP, the investment share and the years of education. All coefficients in the first column have the expected signs. Growth depends negatively on initial GDP, indicating β-convergence. The investment share enters positively (see, e.g., Barro, 1991, Levine and Renelt, 1992), although not significant at the 10% significance level. Turning to education, most authors find that the overall level of education is growth enhancing (see, e.g., Barro, 1991).[11] Our positive and significant coefficient for the average years of education seems to support this result.

In a second step, the inflation rate, government consumption over GDP and openness of the economy are added to the model as explanatory variables. The inclusion of these three variables does not change the signs of the first three factors, as can be seen in the second column. Inflation enters the equation with a negative sign, indicating the growth-hampering effect of high increases in the price level (for a detailed study on this relationship, see Barro, 1995). The minus sign of the coefficient for the government consumption ratio implies a negative relationship between government expenditures and growth. Other empirical studies, e.g., Barro (1991) and Barro (1997) also found this result. The intuition is that government spending has only a temporary influence on growth, while in the long run the growth-hampering impact of high debt levels as a consequence of excessive government spending as well as possible allocative inefficiencies predominate. In our case, however, the coefficient is not significant (a result also found by Levine and Renelt, 1992). Finally the coefficient for the openness of the economy is significant and shows the expected positive sign, supporting the view that trade stimulates growth. This result is also found by Harrison (1995), Sachs and Warner (1995).

In the final step, the model is modified by inclusion of the subperiod-average number of years since a country's accession to the European Union. The choice of this specification of the membership variable aims at reflecting the potentially time-varying nature of the growth effect of integration and it fits to the long-term orientation of EU membership. Notice that, having controlled already for openness, the EU membership variable will reflect growth effects of regional integration different from those directly related to trade.[12] The positive and significant coefficient in column 3 indicates that

[11] There is, however, some indication that primary education has a negative impact on growth, see, e.g., Barro (1997).

[12] The fact that our openness variable is defined as trade over GDP implies that trade-related technology absorption is already partly captured by the positive coefficient for $OP_{t,i}$. This is expected to actually reduce our coefficient for the impact of the EU mem-

the longer a country has been a member of the EU, the more it profits from membership. The inclusion of this new variable leaves the signs of the other coefficients unchanged. The coefficient for education is still positive, but it is now significant at the 5% level. This extended model explains approximately 78% of the variation in growth.

If the results are to be interpreted under the light of the parametrization in Mankiw et al. (1992), the point estimate of the implied factor share of physical capital (assuming a Cobb-Douglas function with labour augmenting human capital as in Hall and Jones, 1999) from the final model specification is approximately 0.46. The implied parameter of the human capital formation function is 0.035. Both values are in line with those reported in Mankiw et al. (1992) and Hall and Jones (1999).

In order to ensure the validity of our results several robustness checks were carried out. First, the model is also estimated without government consumption, as the coefficient proved insignificant in models 2 and 3. The other coefficients remain practically unchanged, some of them becoming even more significant. This strengthens the robustness of our previous results.

Another source of concern in terms of adequacy of the estimation method could be the potential endogeneity of right-hand side regressors. The usual suspects would be the investment share, education attainment and openness, which have sometimes been claimed to depend upon the growth rate of GDP per capita. In order to account for this possibility, the specification in (2) was reestimated using instrumental variables. The results of the Sargan test for validity of instruments supports the use of population growth, government consumption and the initial sub-period levels of investment and openness as instruments for the investment share. The Durbin-Wu-Hausman test cannot reject the null hypothesis of no endogeneity for the regressors considered, validating thereby the use of OLS as an estimation method.

The effect represented by the coefficient of the variable $YEA_{t,i}$ affects only countries that have been members of the EU for at least one year in a given subperiod. It could be the case, however, that a larger regionally integrated space has an effect also on the growth rates of countries that do not form part of it yet. In order to check for this possibility and to shed a light on whether membership is actually required for gaining growth benefits from regional integration, the model was reestimated by replacing $YEA_{t,i}$

bership variable and reinforces the importance of technological spillovers as a driving force for growth.

with a scale variable common to all countries but variable in time, which captures the size of the regionally integrated unit. We used three different specifications of the scale variable (aggregate population, aggregate GDP and aggregate labor force), and the coefficient always appeared positive, but insignificant. Therefore, the growth benefits associated with regional integration seem to be due to formal participation in the union.

Another objection to our conclusion could be that it is not EU membership itself that enhances growth, but that the accompanying stability measures for nominal macroeconomic variables had a positive impact on growth performance. Partly this was already accounted for by including the inflation rate as an explanatory variable. To check in addition for the impact of a potential decrease in the exchange rate volatility caused by EU membership, the standard deviation of the exchange rate against the US dollar for each country was included as an additional independent variable. However, its coefficient appeared insignificant in all specifications. This indicates that exchange rate policy does not explain the existence of a growth bonus associated with EU membership.

To sum up, our model so far explains a considerable part of the variation in growth, and the results strongly support the hypothesis of (conditional) β-convergence: poorer countries have caught up with the richer ones since the 1960s, and the rate of convergence is found to be approximately 4% and 6%, depending on the specification used.[13] Furthermore, the coefficients support the hypothesis of a positive impact of investment, education and openness on growth, as well as a negative impact of high inflation rates. Finally the results not only point at a growth-enhancing effect of EU membership, but they also show that this effect gained importance over the duration of membership.

3.2 Who profits most from EU membership?

One interesting extension to the basic models is to look in more detail at the finding that EU membership is growth enhancing and furthermore becomes even more so the longer a country belongs to the confederation. A particularly interesting question is whether a subgroup of countries profited more from EU membership than other countries. The idea is to divide the sample of countries into subsets with respect to one of the other variables

[13] The rate of convergence, λ, has been computed as $\lambda = -[ln(1 - |\hat{\beta}_1|T)]/T$, where β_1 is the coefficient corresponding to initial GDP per capita, and T is the subperiod length. The expression for λ results from the log linearization around the steady state in the Solow model as in Mankiw et al. (1992).

and to investigate whether the coefficient for the years of membership differs significantly across subgroups.

One basic way to do that would be to split the sample according to a priori defined rules. For example one could define poor, medium and rich countries by setting the borderline income levels. The threshold panel data technique, however, offers a more neutral approach. It allows to test whether such subgroups can be found at all and how many subsets are appropriate. Furthermore, it estimates explicitly the borderline income levels. The main advantage of this approach is that it avoids ad hoc definitions of subgroups, but tests the hypothesis of the existence of subsets against the alternative of no division of the sample.

In our extension of the basic model we test whether countries with a lower initial per capita income level profited more or less from EU membership than more developed countries. If subsamples according to initial income levels can be identified and the coefficient for the years of EU membership is significantly higher for initially poorer countries, this would be an indication of increased economic convergence as a consequence of European integration. If, however, we get the opposite result, this would indicate that the initially richer countries are also the ones which profit most from intensified economic involvement.

Table 3 gives the results of the threshold estimation, and Table 4 presents the parameter estimates of the threshold model. For the details concerning the threshold panel data technique see appendix. The estimation procedure identifies exactly one threshold at a level of (log) initial GDP per capita equal to 9.8 (approximately, USD 18 000). A 95% confidence interval around the threshold estimate computed using the empirical likelihood function is [9.79, 9.93]. The test for linearity rejects the null of no threshold effect at a 5% significance level, and the null of one threshold cannot be rejected when tested against the alternative of two thresholds.

Looking at the original data set, we see that at the beginning of our sample, that is in 1960, all countries had an initial income level below the threshold. In 1970 Denmark and Sweden had broken through the threshold. Ten years later, six more countries had followed and only the incomes of Greece, Ireland, Italy, Portugal, Spain and the United Kingdom remained below the threshold. In 1990, finally, the income levels in Italy and the UK exceeded the threshold income level, so that the subgroup of less developed countries was now limited to the classical catching-up countries Greece, Ireland, Portugal and Spain. Towards the very end of our data set, the income level of Ireland, which recently experienced two-digit growth rates, exceeded the threshold level.

The next step is to divide the sample in each period according to this threshold and rerun the panel regressions. The results are shown in Table 4, where we now have a separate coefficient for the length of EU membership for each subgroup. The coefficient for the years of EU membership is positive and significant for both subgroups. Furthermore we find that the coefficient differs significantly across groups and is significantly higher for the countries with lower initial income levels. All the other coefficients show the expected signs. The new model, which splits the countries into two subgroups according to their initial income levels, explains around 83% of the variation in growth.[14]

Hence while countries with a higher level of development grew faster the longer they were member of the EU, this effect is even more pronounced when it comes to the subgroup of less advanced countries.[15] This finding can be interpreted as another indication for a catching-up process of poorer towards richer countries in Europe in the sense that with two countries entering the EU at the same point in time the growth bonus is larger for the less advanced country.[16] Not only do our results show that countries with lower initial incomes grew faster than the more advanced countries (β-convergence), the estimates also imply that countries that exhibit per capita income levels below the threshold profit more from long-term EU membership than richer countries.[17]

[14]To check for robustness the model was reestimated using Switzerland as an external control country. The coefficients remained similar in terms of sign, range and significance. The goodness of fit, furthermore, improved considerably. The results are not reported in the tables and are available upon request from the authors.

[15]The exercise was repeated using the relative level of GDP per capita with respect to the average of current member states as a threshold variable. However, the test for linearity could not reject the null of linearity at any reasonable significance level. This suggests that it is the *absolute* level of development of the country that determines the asymmetric effect of EU membership on long term growth.

[16]This, however, does not imply that this growth bonus has actually led to absolute convergence of the EU member states. The different entry dates and the cumulative nature of the growth bonus has lead to several more advanced economies profiting relatively more from integration.

[17]In principle, it would be possible to model the growth effect of EU membership using a function of the $YEA_{t,i}$ variable that allows for decreasing returns in the growth bonus. Different other specifications involving log transformations and inclusion of squared terms have been tried both in the linear and nonlinear specification. Although they sometimes improved marginally the fit in comparison of the purely linear model given by (2), they were always inferior to the piecewise-linear threshold model in terms of explanatory power.

A theoretically sound interpretation of the results would be that it is the relatively less developed countries that profit most from access to the broader technological framework offered by the regionally integrated unit. The variable referring to the duration of EU membership would then be interpreted as one of the variables explaining technological progress in a theoretical framework such as in Mankiw et al. (1992). Being a part of a larger integrated union could thus be seen as speeding up the acquisition of new technologies.

4 Conclusions and prospects for further research

The empirical study performed in this paper shows that EU membership has had a positive and asymmetric effect on long-term economic growth. As the model specification uses openness as a control variable, the growth effect picked up by the regional integration variable differs from that resulting from intensified trade and would relate to the improvements in the transmission of technological knowledge among the EU member states. The results would imply that it is the relatively less developed countries that profit most from access to the broader technological framework offered by the regionally integrated unit.

Drifting away from the neoclassical specification one could, however, also argue that technology is not the only factor explaining the growth bonus associated with EU membership. One argument that may as well be used to interpret the results relies upon the assumption that financial help from the EU to relatively poorer members actually does have an effect on long-term growth (for evidence see, e.g., Pereira and Gaspar, 1995, and Pereira, 1999). In fact the EU budget generated major net financial transfers to the four cohesion countries – Greece, Portugal, Ireland and Spain. In 2000, these net transfers accounted for 3.6 per cent of Greek GNP, 1.9 per cent of Portuguese GNP, 1.8 per cent of Irish GNP and 0.9 per cent of Spanish GNP. To a lesser extent, Finland, Denmark and Italy also showed positive net balances (see European Commission, 2001). Further research would have to be done, however, to test the hypothesis that the cohesion funds were indeed successful in driving convergence.

Fölster and Henrekson (2001) find a robust and negative relationship between government size and economic growth. This could provide another possible explanation for our result that EU membership had a positive impact on growth, as due to liberalization measures inherent to the integration process the size of the government in EU member states has decreased rapidly in the last decade (an EU-average decrease of around 6% in government expenditure over GDP between 1991 and 2000, according to the OECD's Main Economic Indicators Database).[18] Possible other sources of the growth bonus could be the stabilization of expectations in the context of the European Exchange Rate Mechanism or the change in the institutional framework due to European integration.

One interesting question would be whether our results allow implications about the EU enlargement process. Our study is based on historical data for the current EU member states, so we cannot directly apply the findings to the potential accession countries. The structural and institutional differences in these economies as compared to the current member states are sometimes huge, and even the fact that the income levels of all candidate countries currently lie below our estimated threshold does not allow for the conclusion that these countries will indeed profit more than average from EU membership.

A straightforward path of extension of the results presented in the paper would imply applying a similar econometric methodology to an extended set of countries – allowing for a wider set of controls – or to other forms of regional integration in order to test for the universality of the results obtained in the present study.

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[18] The only countries that experienced an increase in this measure of government size are the ones that received substantial resources from EU structural funds. The co-financing requirement by itself would lead to an increase in government expenditure.

many helpful comments and discussions.

Appendix

Data sources

- *Real GDP per capita in 1995 USD - computed using the Atlas conversion factor -:* World Development Indicators 2001 - World Bank - except the data for West Germany (1960-91), which were built from the International Financial Statistics - International Monetary Fund - and own calculations.

- *Investment Share:* World Development Indicators 2001 - World Bank - except the data for West Germany (1960-91), which were built from the Penn World Table 5.5.

- *Average schooling years of population over 25:* taken from Barro and Lee (2001).

- *Inflation rate:* GDP deflator, taken from World Development Indicators 2001 - World Bank - except the data for West Germany (1960-91), which were built from the World Tables Database - World Bank.

- *Government consumption (% of GDP):* World Development Indicators 2001 - World Bank - except the data for West Germany (1960-91), which were taken from the OECD Macroeconomic Country-Level Databank.

- *Openness:* trade in % of GDP, taken from the World Development Indicators 2001 - World Bank - except the data for West Germany (1960-91), which were taken from the Penn World Table 5.5.

Threshold panel data models: estimation and testing

Inference in threshold panel data models has been recently developed by Hansen (1999). Let $y_{t,i}$ be the dependent variable for cross-section i at time t, which depends on a set of explanatory variables $\{x^j_{t,i}, j = 1, \ldots, k\}$ according to the following specification

$$y_{t,i} = \begin{cases} \mu_i + \sum_{j=1}^{k} \alpha^1_j x^j_{t,i} + u_{t,i} & \text{if } x^r_{t,i} \leq \gamma \\ \mu_i + \sum_{j=1}^{k} \alpha^2_j x^j_{t,i} + u_{t,i} & \text{if } x^r_{t,i} > \gamma \end{cases}, \qquad (3)$$

for $i = 1, \ldots, N$ and $t = 1, \ldots, T$; where $u_{t,i}$ is white noise with variance σ^2. The model is, thus, a piecewise-linear one, where the α parameters depend on whether the value of $x^r_{t,i}$ - the *threshold variable* - exceeds γ or not. The threshold value, γ, is treated as a parameter to be estimated. Notice that, for a given value of γ, equation (3) can be easily estimated by dividing the sample into the observations corresponding to $x^r_{t,i} \leq \gamma$ and those in the regime $x^r_{t,i} > \gamma$. The parameters can then be estimated using the *Within* method (see, e.g., Baltagi, 1995).

Estimating γ implies choosing the estimator $\hat{\gamma}$ which together with its corresponding α parameters, $\{\hat{\alpha}^1_j(\hat{\gamma}), \hat{\alpha}^2_j(\hat{\gamma}), j = 1, \ldots, k\}$, minimize the sum of squared residuals of model (3). The parameter γ only needs to be sought among the actually realized values of $x^r_{t,i}$ after trimming the initial and final tail of the distribution for identification reasons, as for a given ordered sample of the realizations of x^r for all countries $\{x^r_1, x^r_2, \ldots, x^r_{N\times T}\}$ and a threshold $\tilde{\gamma} \in [x^r_f, x^r_{f+1})$ for some $f \in \{1, \ldots, N \times T\}$, then $\{\hat{\alpha}^1_j(\tilde{\gamma}), \hat{\alpha}^2_j(\tilde{\gamma})\} = \{\hat{\alpha}^1_j(\gamma^*), \hat{\alpha}^2_j(\gamma^*)\}$ for all j and for every $\gamma^* \in [x^r_f, x^r_{f+1})$.

A most important issue in threshold models is that of testing for $\alpha^1_j = \alpha^2_j \; \forall j$. The likelihood ratio test would take the usual form

$$F(\hat{\gamma}) = [S_0 - S_1(\hat{\gamma})]/\hat{\sigma}^2,$$

where S_0 refers to the sum of squared residuals under the null of no threshold effect and $S_1(\hat{\gamma})$ is the sum of squared residuals of the model with threshold $\hat{\gamma}$. However, F_1 does not have a standard asymptotic distribution, as the parameter γ is not identified under the null of linearity.[19] However, the distribution of $F(\hat{\gamma})$ under the null can be replicated by bootstrapping, as proposed by Hansen (1999) based on Hansen (1996): Using the empirical distribution of the residuals by cross-section, a sample of T values is drawn for each one of the N cross-sections and, given those values of the error term and the observations on the $x^j_{t,i}$ variables, the bootstrap values of $y_{t,i}$ are recovered. With the bootstrap sample, the linear and the threshold model for $\hat{\gamma}$ are estimated and the test statistic $F_1(\hat{\gamma})$ is computed as indicated above. This procedure is repeated H times, the values $\{F_h, h = 1, \ldots, H\}$ are obtained and the p-value of $F(\hat{\gamma})$ is taken to be the number of times that $F_h(\hat{\gamma})$ exceeds $F(\hat{\gamma})$, divided through H. Hansen (1996) proves that the procedure renders asymptotically valid p-values.

[19] The testing problem when there is a nuisance parameter which is only identified under the alternative has been studied by, e.g., Andrews and Ploberger (1994) and Hansen (1996).

References

[1] Andrews, D.W.K. and W. Ploberger, 1994, Optimal tests when a nuisance parameter is present only under the alternative, Econometrica 62, 1383-1414.

[2] Artis, M., M. Marcellino and T. Proietti, 2003, Dating the euro area business cycle, CEPR Discussion Papers 3696.

[3] Badinger, H., 2001, Growth effects of economic integration - The case of the EU member states (1950-2000), Research Institute for European Affairs Working Paper 40, University of Economics and Business Administration Vienna.

[4] Baltagi, B.H., 1995, Econometric analysis of panel data, John Wiley & Sons, Chichester, UK.

[5] Barro, R.J., 1991, Economic growth in a cross section of countries, Quarterly Journal of Economics 106(2), 407-443.

[6] Barro, R.J., 1995, Inflation and economic growth, NBER Working Paper Series 5326.

[7] Barro, R.J., 1997, Determinants of economic growth: A cross-country empirical study, Harvard Institute for International Development Discussion Papers 579.

[8] Barro, R.J. and J.W. Lee, 2001, International data on educational attainment: updates and implications, Oxford Economic Papers 53, 541-563.

[9] Barro, R.J. and X. Sala-i-Martin, 1992, Convergence, Journal of Political Economy 100(2), 223-251.

[10] Bernard, A.B. and S.N. Durlauf, 1996, Interpreting Tests of the Convergence Hypothesis, Journal of Econometrics, 71(1-2), 161-174.

[11] Carree, M. and L. Klomp, 1997, Testing the convergence hypothesis: A comment, The Review of Economics and Statistics 79(4), 683-686.

[12] De Melo, J., C. Montenegro and A. Panagariya, 1992, L'integration regionale hier et aujourd'hui, Revue d'Economie du Developpement 0(2), 7-49.

[13] Durlauf, S.N. and D.T. Quah, 1998, The new empirics of economic growth, in: Taylor, J.B. and M. Woodford (eds.), Handbook of Macroeconomics, Volume 1A, North-Holland, Amsterdam, 235-308.

[14] European Commission, 2001, Allocation of 2000 EU operating expenditure by member states, European Commission, Budget, Own Resources, evaluation and financial programming.

[15] Fölster, S. and M. Henrekson, 2001, Growth effects of government expenditure and taxation in rich countries, European Economic Review 45, 1501-1520.

[16] Hall, R.E. and C.I. Jones, 1999, Why do some countries produce so much more output per worker than others?, Quarterly Journal of Economics 114, 83-116.

[17] Hansen, B.E., 1996, Inference when a nuisance parameter is not identified under the null hypothesis, Econometrica 64, 413-430.

[18] Hansen, B.E., 1997, Approximate asymptotic p-values for structural change tests, Journal of Business and Economic Statistics 15, 60-67.

[19] Hansen, B.E., 1999, Threshold effects in non-dynamic panels: Estimation, testing, and inference, Journal of Econometrics 93, 345-368.

[20] Harding, D. and A. Pagan, 2001, Extracting, analysing and using cyclical information, paper presented at the Banca D'Italia - CEPR Conference on Monitoring the Euro Area Business Cycle, Rome 7/8 September 2001.

[21] Harrison, A., 1995, Openness and growth: A time series, cross-country analysis for developing countries, NBER Working Paper Series 5221.

[22] Henrekson, M., J. Torstensson and R. Torstensson, 1997, Growth effects of European integration, European Economic Review 41, 1537-1557.

[23] Islam, N., 1995, Growth empirics: A panel data approach, Quarterly Journal of Economics 110, 1127-1170.

[24] Landau, D., 1995, The contribution of the European common market to the growth of its member countries: An empirical test, Review of World Economics 131(4), 774-782.

[25] Levine, R. and D. Renelt, 1992, A sensitivity analysis of cross-country growth regressions, American Economic Review 82(4), 942-963.

[26] Mankiw, N.G., D. Romer and D.N. Weil, 1992, A contribution to the empirics of economic growth, Quarterly Journal of Economics 107, 408-437.

[27] Pereira, A.M., 1999, International transfers and convergence in the European Union, Public Finance Review 27(2), 194-219.

[28] Pereira, A.M. and V. Gaspar, 1995, The impact of financial integration and unilateral public transfers on investment and growth in EC capital-importing countries, Journal of Development Economics 48(1), 43-66.

[29] Pritchett, L., 1996, Measuring outward orientation in LDCs: Can it be done?, Journal of Development Economics 49, 307-335.

[30] Romer, P.M., 1990, Endogenous technological change, Journal of Political Economy 98, S71-S102.

[31] Sachs, J.D. and A. Warner, 1995, Economic reform and the process of global integration, Brookings Papers on Economic Activity 1995(1), 1-118.

[32] Sala-i-Martin, X., 1996, Regional cohesion: Evidence and theories of regional growth and convergence, European Economic Review 40, 1325-1352.

[33] Solow, R.M., 1956, A contribution to the theory of economic growth, Quarterly Journal of Economics 70, 65-94.

[34] Vanhoudt, P., 1999, Did the European unification induce economic growth? In search of scale effects and persistent changes, Review of World Economics 135(2), 193-220.

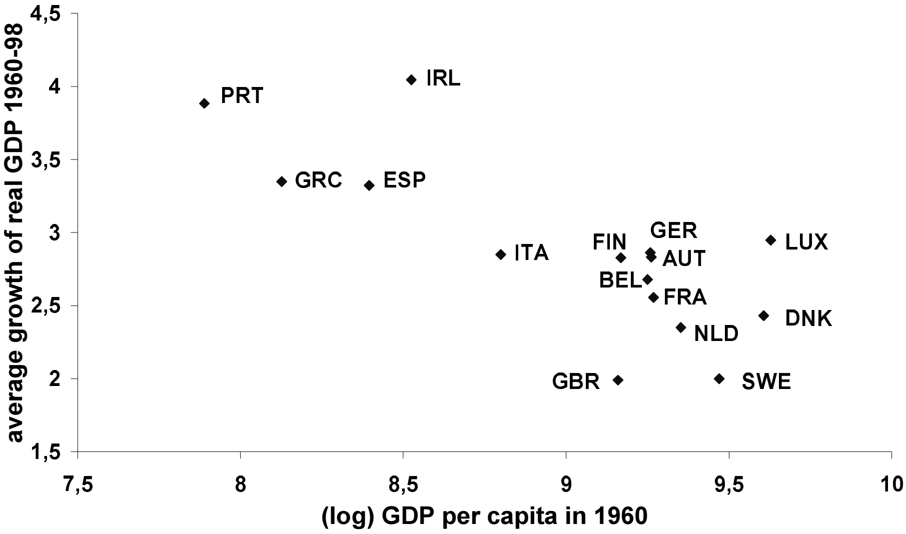

Figure 1: GDP per capita in 1960 versus growth: EU-15 countries 1960–1998

	Common intercept	**Fixed effects (one-way)**	**Fixed effects (two-way)**
β	-1.91*** (0.20)	-3.02*** (0.37)	-4.88*** (1.41)
Obs.	56	56	56
R^2_{adj}	51.3%	62.3%	62.4%

***(**)[*] stands for 1% (5%) [10%] significant.

Table 1: Unconditional β-convergence in the EU

MODEL	1	2	3	4
Initial GDP	-3.39***(0.45)	-3.84*** (0.52)	-4.74***(0.75)	-4.82***(0.78)
Investment share	0.45 (1.09)	3.16*** (0.90)	4.03***(0.96)	4.11***(0.88)
Years of education	0.24** (0.10)	0.24 (0.16)	0.36**(0.16)	0.36**(0.17)
Inflation rate		-0.13***(0.02)	-0.12 ***(0.02)	-0.12***(0.03)
Government cons.		-0.06 (0.09)	-0.01 (0.10)	–
Openness		0.06**(0.03)	0.07**(0.03)	0.07**(0.03)
Years in the EU			0.03*(0.02)	0.04**(0.01)
Observations	56	56	56	56
R^2_{adj}	61.1%	76.2%	76.9%	77.5%

All EU countries except Luxembourg included (data for West Germany until 1991, unified Germany afterwards), with data ranging from 1961 to 1998, divided into four periods: 1961–70, 1971–80, 1981–90 and 1991–98. All data in percentage points except initial GDP, years of education and years in the EU. White heteroskedasticity/serial correlation-corrected standard errors in parentheses. Fixed effects estimation with period-specific time dummies included if jointly significant. ***(**)[*] stands for 1% (5%) [10%] significant.

Table 2: Growth panel data regressions

	Single threshold	Double threshold	
	$\hat{\gamma}$	$\hat{\gamma_1}$	$\hat{\gamma_2}$
Initial GDP per capita (logged)	9.81	9.25	9.80
Bootstrap p-value	0.007	0.296	

Bootstrap p-values based on 1000 replications. Threshold values found by grid search in the central 50% of the distribution of the threshold variable.

Table 3: Testing for linearity

MODEL	3A	4A
Initial GDP	-4.10***(0.72)	-4.57 ***(0.68)
Investment share	3.05 ***(1.03)	3.55*** (0.85)
Years of education	0.17 (0.15)	0.21 (0.14)
Inflation rate	-0.13***(0.03)	-0.13 ***(0.03)
Government consumption	-0.06 (0.09)	–
Openness	0.05***(0.02)	0.06**(0.02)
Years in the EU$\times I(y_{0t} \leq \hat{\gamma})$	0.08***(0.02)	0.09***(0.02)
Years in the EU$\times I(y_{0t} > \hat{\gamma})$	0.03*(0.02)	0.04***(0.01)
Observations	56	56
R^2_{adj}	82.5%	82.6%

Table 4: Threshold panel data regressions

Figure 2: Real GDP per capita dispersion: EU-15 countries 1960–1998